Landscape Functions and Ecosystem Services

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Ecosystems Goods and Services

Definitions

In recent decades, the multiple benefits provided by ecosystems and landscapes have been described in a large number of studies, which provided the basis for a recent global assessment of ecosystem goods and services (de Groot, 1992; Costanza et al., 1997; Daily, 1997; de Groot et al., 2002; Millennium Ecosystem Assessment, 2005). In spite of the large body of literature on ecosystem (or landscape) functions, goods and services, there is still no clear consensus on final definition and typology and considering the complexity of man-environment interactions, there probably never will be (de Groot and Hein, 2007).

Many different types of environmental functions performed by natural, semi-natural and man-made ecosystems can be identified. Wande´n and Schaber (1998) identify functions which have information values (aesthetic, educational, scientific, orientation, signal), functions which have ethical values (e.g. right to existence for all living creatures), functions which have production values (e.g. production of food, fibre, fruits) and functions which have life support values (e.g. carbon fixation by green plants, protection of the soil against erosion, the maintenance of soil structure and fertility by a healthy soil flora and fauna, biological control of crops and fruits by insects). De Groot (1992), de Groot et al. (2002) and others (e.g. Millennium Ecosystem Assessment, 2005), provide slightly different lists of environmental functions.

According to Daily (1997), '*Ecosystem services* are the conditions and processes through which natural ecosystems, and the species which make them up, sustain and fulfil human life. They maintain biodiversity and the

Figure 2.1. Possibility to pick mushroms and berries and enjoy wildlife and outdoor life are important ecosystem services provided by the forest. Photo: Ingrid Karlsson.

production of *ecosystem goods*, such as seafood, forage, timber, biomass fuels, natural fibres, and many pharmaceuticals, industrial products, and their precursors. In addition to the production of goods, ecosystem services are the actual life-support functions, such as cleansing, recycling, and renewal, and they confer many intangible aesthetic and cultural benefits as well.'

Daily's definition makes an important distinction between ecosystem services and ecosystem goods. Ecosystems goods are the generally tangible, material products that result from ecosystem processes, whereas ecosystem services are in most cases improvements in the condition or location of things of value. Daily explains that ecosystem services are generated by a 'complex of natural cycles', from large-scale biogeochemical cycles (such as the movement of carbon through the living and physical environment) to the very small-scale life cycles of micro-organisms. Daily's (1997) definition makes another key point about ecosystem services: they 'sustain and fulfil human life'. The emphasis here is squarely on human well-being, and thus in keeping with an economic perspective. Some might say that such an anthropocentric focus is too limiting – that it devalues the importance of ecosystem structure and processes to species other than humans, or that it runs the risk of ignoring ecosystem processes that contribute to human welfare but are not yet recognised as doing so.

Daily (1997) listed several ecosystem services, such as purification of water, mitigation of floods, and pollination of plants. As she mentions, these services 'are absolutely pervasive, but unnoticed by most human beings going about their daily lives'. Unlike these ecosystem services, most ecosystem goods do not go unnoticed, as they are the basic natural resources that we consume on a regular basis. Ecosystem goods have long been recognised as key elements of wealth; it is the grand contribution of the modern ecological and hydrological science to more fully recognise and appreciate the services that nature also provides (Brown et al., 2006).

The tidy distinction between ecosystem services and ecosystem goods was later obscured by Costanza et al. (1997), who, after noting the difference between goods and services, proceeded to lump them into the class of 'ecosystem services'. This lumping had the advantage of brevity, but tended to blur the distinction between the functional nature of ecosystem services and the concrete nature of ecosystem goods. This lumping was adopted by others, including de Groot et al. (2002) and the Millennium Ecosystem Assessment (Alcamo et al., 2003).

Figure 2.2. Provision of renewable energy from wind, water and sun are also ecosystem services. Photo: Lars Rydén.

The Millennium Ecosystem Assessment (MA, 2005) stated that ecological goods and services are the benefits people derive from the ecological functions of healthy ecosystems. Such benefits accrue to all living organisms, including animals and plants, rather than to humans alone. To avoid lengthy texts, MA (2005) also decided to use the term 'services' for goods and services, as well as the underlying functional processes and components of the ecosystems providing them. However, many authors see a principal difference between the use of the terms

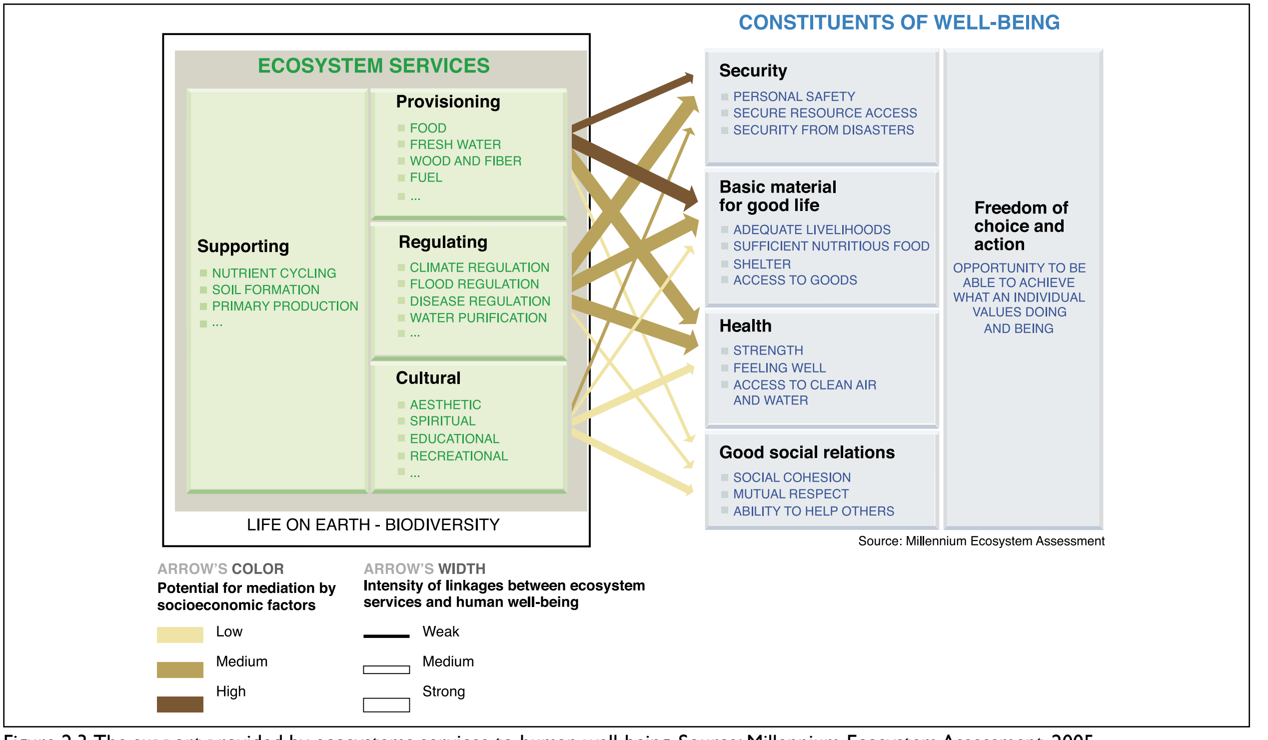

Figure 2.3. The support provided by ecosystems services to human well-being. Source: Millennium Ecosystem Assessment, 2005.

'functions' and 'service' as reflected in the definition by de Groot et al. (2002), which says that ecosystem (or landscape) functions are '… the capacity of ecosystems to provide goods and services that satisfy human needs, directly or indirectly.' Thus 'function' can be seen as the actual (functional) processes and components in ecosystems and landscapes that provide the goods and services that have, direct or indirect, benefit to human welfare (de Groot and Hein, 2007). There are situations where the distinction between function and services is difficult (regulation versus supporting services) and considering the complexity of ecological systems and their interactions with human society, a satisfying classification of functions, goods and services will probably never be found.

Although the difference between processes and services is more than semantic, it may not always seem so, especially when the terms used to summarise the processes are only slightly different from the terms used to characterise the service. For example, the function in which water infiltrates into watershed soils, is stored in those soils, and is later released downstream, has been called 'regulation of hydrological flows,' and produces the service called 'water regulation' (Costanza et al., 1997). The shorthand labels we attach to processes and services must not be allowed to blur the distinction between processes and the services they perform.

Figure 2.3 drawn from the Millennium Ecosystem Assessment (2005), illustrates how the biosphere supports the survival of society and the execution of economic activities, including agriculture, by pointing out that social and economic dimensions are dependent on the functioning of the ecological systems.

Four Kinds of Ecosystems Services

Four groups of functions (or services) are primarily distinguished by the Millennium Assessment: provisioning, regulating, cultural and supporting services, roughly corresponding to the production, regulation, information and habitat functions distinguished by de Groot et al. (2002).

The typology includes four categories: (1) provisioning functions; (2) regulation functions; (3) habitat functions; and (4) cultural and amenity functions (Groot et al., 2002).

1. *Provisioning functions* comprise functions that supply 'physical services' in terms of resources or space. This category has been divided into two classes: production and carrier functions. *Production functions* reflect resources produced by natural ecosystems, for example the harvesting of fish from the ocean. *Carrier functions* reflect the goods and services that are provided through human manipulation of the natural productivity (e.g. fish from aquaculture). In these cases, the function from nature is the provision of suitable substrate or space for human activities, including agriculture, mining, transportation, etc.

2. *Regulation functions* result from the capacity of ecosystems and landscapes to influence ('regulate') climate, hydrological and biochemical cycles, earth surface processes, and a variety of biological processes. These services often have an important spatial (connectivity) aspect; e.g. the flood control service of an upper watershed forest is only relevant in the flood zone downstream of the forest.

3. *Habitat functions* comprise the importance of ecosystems and landscapes to maintain natural processes and biodiversity, including the refuge and the nursery functions. The refuge function reflects the value that landscape units have to provide habitat to (threatened) fauna and flora, the nursery function indicates that some landscape units provide a particularly suitable location for reproduction and thereby have a regulating impact on the maintenance of populations elsewhere.

4. *Cultural and amenity functions* relate to the benefits people obtain from landscapes through recreation, cognitive development, relaxation and spiritual reflection. This may involve actual visits to the area, indirectly enjoying the area (e.g. through nature movies), or gaining satisfaction from the knowledge that a landscape contains important biodiversity or cultural monuments.

Contrary to Millennium Ecosystem Assessment (2005), the typology does not include the category 'supporting services/functions', which represents the ecological processes that underlie the functioning of ecosystems and landscapes. Their inclusion in valuation may lead to double counting, as their value is reflected in the other types of services (de Groot and Hein, 2007).

Agriculture and Ecosystem Services

Benefits and Problems of Agriculture

Covering over one-third of total global land area (FAOSTAT, 1999), agriculture represents humankind's largest engineered ecosystem. Among the Earth's major ecosystems, agriculture is that most directly managed by humans to meet human goals. As Tilman et al. (2002) state: 'Agriculturalists are the de facto managers of the most productive lands on Earth. Sustainable agriculture will require that society appropriately rewards ranchers, farmers and other agriculturalists for the production of both food and ecosystem services.' However, appropriately rewarding ranchers, farmers and other agriculturalists will require the ability to accurately measure ecosystem services in a verifiable quantitative manner.

Even though the problems agriculture has created for nature conservation are well-known, the acquisition of natural resources for immediate human needs neglecting the long-term view, development of urban areas, intensive use of agricultural lands, and population pressures continue to mount, more often than not at the expense of degrading environmental conditions.

The rural landscape has until recently been regarded simply as a positive externality of the productive activity, taken for granted and not further examined. Now, however, it is being realised that the agricultural landscape has also other functions − the environmental/ecological, the cultural/heritage and the amenity/scenic. Agricultural ecosystems both provide and rely upon important ecosystem services. Agriculture is in the midst of a change of conditions, which may cause it to change dramatically and in as yet unforeseen directions. So these other functions are coming under close scrutiny, such as producing separate public goods of increased value to society

Table 2.1. Examples of environmental functions, critical attributes and associated goods and services (Adapted from De Groot et al. 2002).

Examples of environmental functions	Critical attributes and characteristics (e.g. ecosystem processes and components	Examples of goods and services
1. Biodiversity-related functions (habitat functions: providing suitable living space for wild plants and animals, regulation functions: maintenance of essential ecological processes and life support systems)		
Refugium functions	Suitability to provide food, shelter and reproduction habitat	Maintenance of biological and genetic diversity. Nursery functions for wild species
Life support functions	Role of biota in movement of floral gametes.	Pollination of crops
	Population control through trophic-dynamic relations	Control of pests and diseases
		Reduction of herbivory (crop damage)
Genetic resources	Maintenance of wild relatives for plant species and animal breeds	Improvement and adaptation of cultivated plants and domestic animals
2. Landscape-related functions (information functions: providing opportunities for cognitive development)		
Aesthetic information	Attractive landscape features	Enjoyment of scenery (scenic roads, housing, etc.)
Recreation	Variety of landscapes with (potential) recreactional uses	Travel to natural ecosystems for ecotourism, outdoor sports, etc.
Cultural and artistic information	Variety of nature with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc.
Spiritual and historic information	Variety of nature with spiritual and historic value	Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features)
Science and education	Variety of nature with scientific and educational value	School excursions etc.
		Scientific field laboratories, etc.
3. Soil complex related functions (regulation functions: maintenance of essential ecological processes and life support systems)		
Soil erosion control	Role of vegetation root matrix and soil biota in soil retention	Maintenance of arable land
		Prevention of damage from erosion/siltation
4.Water complex related functions (regulation functions: maintenance of essential ecological processes and life support systems)		
Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers)	Provision of water for consumtion (e.g. drinking, irrigation and industrial use)

as they become scarcer, and whose value should be made to play a role in the decision-making of the farmers. In environmental planning and decision-making, however, these benefits are often not fully taken into account and productive, multi-functional landscapes continue to be converted into more simple, often single-function land use types or turned into wastelands. Yet, increasingly studies are showing that the total value of multifunctional use of natural and semi-natural landscapes is often economically more beneficial than the value of the converted systems (Balmford et al., 2002). Food, fibre, and fuel production have been the overwhelmingly dominant goal of agriculture. Yet, as a managed ecosystem, agriculture plays unique roles in both supplying and demanding other ecosystem services (Swinton et al., 2007). Agriculture supplies all four major categories of ecosystem services – provisioning, regulating, habitat and cultural services – while it also demands supporting services that enable it to be productive.

In order to allow for the performance of environmental functions by (semi-) natural and agricultural ecosystems, certain ecological conditions have to be present. These ecological conditions are critical ecological processes, abiotic and biotic components of ecosystems and their inter-relationships. Identifying these critical ecological conditions by use of indicators is a possible way to systematically analyse which attributes and characteristics are necessary for the performance of environmental functions (i.e. provision of environmental goods and services) in a specific ecosystem (see Table 2.1).

Agriculture and ecosystem services are interrelated in at least three ways (Dale and Polasky, 2007):

(1) Agro-ecosystems generate beneficial ecosystem services such as soil retention, food production and aesthetics.
(2) Agro-ecosystems receive beneficial ecosystem services from other ecosystems such as pollination from non-agricultural ecosystems.
(3) Ecosystem services from non-agricultural systems may be affected by agricultural practices.

In some cases, tracing the interrelationships between agriculture and ecosystem services is fairly direct, as when pollinators increase agricultural crop yields or conservation easements on agricultural lands provide habitat for bird species enjoyed by birdwatchers. In other cases, the contribution may be more indirect or complex, for example when wetlands reduce the load of nitrogen in surface water originating from agricultural fields and destined for a coastal estuary where eutrophication causes hypoxic conditions and reduced fish productivity.

Agriculture's Ecosystem Disservices

Agriculture both provides and receives ecosystem services (ES) that extend well beyond the provision of food, fibre and fuel. In the process, it depends upon a wide variety of supporting and regulating services, such as soil fertility and pollination that determine the underlying biophysical capacity of agricultural ecosystems (MA, 2005). Agriculture also receives an array of ecosystem disservices (EDS) that reduce productivity or increase production costs (e.g. herbivores and competition for water). Some are planned, but most are indirect, unmanaged, underappreciated and unvalued − in effect, serendipitous (Swinton et al., 2007). A wide variety of ES and EDS confer benefits and costs, respectively, to agriculture. These are supplied by varied species, functional groups and guilds over a range of scales and influenced by human activities both intentionally and unintentionally.

These unwanted effects of agriculture − agriculture's ecosystem disservices − are not minor. Land use change associated with agricultural development results in habitat loss, cropland irrigation leads to the diversion of rivers and groundwater depletion, overgrazing results in rangeland erosion and can initiate desertification, invasive pests are introduced with the movement of agricultural commodities, accelerated nitrogen and phosphorus loading of surface waters results in aquatic and marine eutrophication − the list goes on and is well known (Swinton et al., 2007). However, ecosystems in agricultural landscapes can also ameliorate these problems, as can changes in agricultural management per se. Cropland can be managed to be more nutrient and water efficient, riparian zones can be managed to effectively remove nutrients and sediments before runoff reaches surface water bodies, and native communities and wetlands can be restored within a matrix of agricultural lands to provide habitats for beneficial insects and birds (Robertson et al., 2007).

Only in their absence do most become apparent. Pollination services, which have recently become threatened by honeybee colony collapse disorder, contribute to fruit, nut and vegetable production worth $75 billion in 2007 (USDA, 2007) − five times the cost of expected US farm subsidies. Wetlands and streams in agricultural watersheds can transform leached nitrate into a non-reactive form that keeps it from harming downstream ecosystems (Whitmire and Hamilton, 2005). These sorts of services (and disservices, in the case of effects that are deemed undesirable) place agriculture in a web of other services provided by ecosystems to society, a web formed by linkages within and inherent to the agricultural landscape (Figure 2.4).

We now recognise that agriculture is not so much a field-based enterprise as a landscape-based enterprise: Crops in individual fields are dependent on services provided by nearby ecosystems, whether native or managed, and nearby ecosystems are often influenced by their agricultural neighbours (Swinton et al., 2007). Neighbouring ecosystems provide food, refuge and reproductive habitat for pollinators and bio-control agents; they provide wildlife habitat; and they help to attenuate some of the unwelcome effects of agricultural production, including the escape of nitrogen, phosphorus and pesticides into non-agricultural ecosystems where they may produce undesirable impacts.

Ecosystem services (ES) and dis-services (EDS) to agriculture influence both where and how people choose to farm. For example, many major fruit-producing regions in temperate climate zones are located downwind of large bodies of water that help to regulate local atmospheric temperature changes (Ackerman and Knox, 2006) and reduce the probability of late frosts that might damage fruit blossoms. ES to agriculture affect not only the location and type of farming, but also the economic value of farmland. While determined in part by crop price, the value of agricultural land also depends on production costs linked to ES such as soil fertility and depth, suitable climate and freedom from heavy pest pressure (Roka and Palmquist, 1997).

The scales at which services are provided to agriculture are also critical to how management decisions are made. Many key organisms that provide services and dis-services to agriculture do not inhabit the agricultural fields themselves. Rather, they live in the surrounding landscape or they may move between natural habitats, hedgerows and fields. Table 2.2 summarises the major actors and scales of provision for the ES and EDS described.

The scales at which ES and EDS are rendered determine the relevant management units for influencing their flows to agriculture (Zhang et al., 2007). If they respond to factors on a small scale then it may be possible to manage them within a single farm. However, if they respond to factors on a larger scale, then the management actions of individual farmers must be coordinated with several different other decision-makers involved (Weibull et al., 2003). Table 2.2 reveals that scarcely any ES or EDS are provided only at the field level, so management will be more effective if performed at larger scales. The appropriate scale at which to manage will depend upon each specific provisioning ES and the supporting and regulating ES on which it relies. Table 2.2 also highlights the importance of a farm's landscape context in managing many of the supporting and regulating ES and EDS.

Services and Disservices Provided to and by Agriculture

Crops and Soil Fertility

The most important service provided by agriculture is its provision of food, fuel and fibre. Grain, livestock, fuel, forage and other products are used to meet subsistence or market needs, usually without regard to the provision of other services. Nevertheless, a number of other services are also provided.

The most important supporting service is the maintenance of soil fertility, which is fundamental to sustain agricultural productivity. Agronomic management that maintains or improves soil fertility, when employed in place of less sustainable practices, can be viewed as providing a mitigation service. A number of factors comprise soil fertility, and all of these are potentially influenced by agronomic practices. Micro-organisms (bacteria, fungi, actinomycetes) are critical mediators of this ecosystem service. For example, bacteria enhance nitrogen availabil-

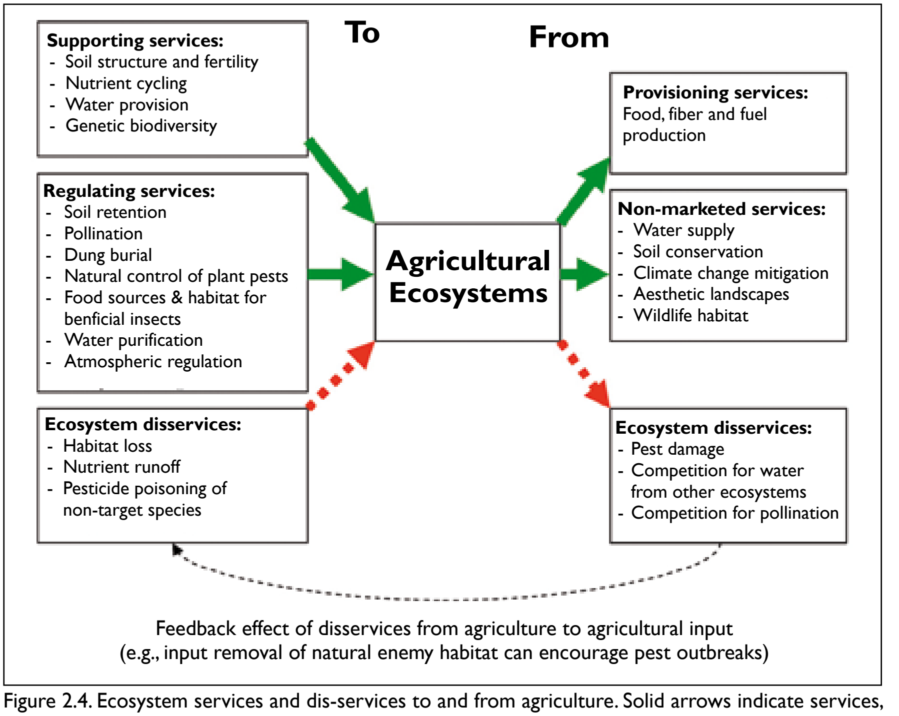

Figure 2.4. Ecosystem services and dis-services to and from agriculture. Solid arrows indicate services, whereas dashed arrows indicate dis-services. Source: Zhang et al., 2007.

Table 2.2. Major ecosystem services (ES) and dis-services (EDS) to agriculture, the scales over which they typically are provided, and main guilds or communities whose activities typically supply them (Zhang et al., 2007).

ES or EDS Services	From fields[a]	From farm[b]	From landscape[c]	From region/globe[d]
Soil fertility and formation, nutrient cycling		Vegetation cover		
Soil retention	Cover crops	Cover crops	Riparian vegetation; floodplain	Vegetation cover in watershed
Pollination	Ground-nesting bees	Bees; other pollinating animals	Insects; other pollinating animals	
Pest control	Predators and parasitoids (e.g., spiders, wasps)	Predators and parasitoids (e.g., spiders, wasps, birds, bats)		
Water provision and purification		Vegetation around drainages and ponds	Vegetation cover in watershed	Vegetation cover in watershed
Genetic diversity	Crop diversity for pest and disease resistance			Wild varieties
Climate regulation	Vegetation influencing microclimate (e.g. agro forestry)	Vegetation influencing microclimate	Vegetation influencing stability of local climate; amount of precipitation; temperature	Vegetation and soils for carbon sequestration and storage
Disservices	**From fields[a]**	**From farm[b]**	**From landscape[c]**	**From region/globe[d]**
Pest damage	Insects; snails; birds; mammals; fungi; bacteria, viruses; weeds	Insects; snails; birds; mammals; fungi; bacteria, viruses; weeds	Insects; snails; birds; mammals; range weeds	
Competition for water from other ecosystems	Weeds	Vegetation cover near drainage ditches	Vegetation cover in watershed	Vegetation cover in watershed
Competition for pollination services	Flowering weeds	Flowering weeds	Flowering plants in watershed	

a Services provided from within agricultural fields themselves.
b Services provided from farm property, but not necessarily in active fields themselves.
c Services provided from landscape surrounding typical farms, not from farmer's property.
d Services provided from broader region or globe.

ity through the fixation of nitrogen from the atmosphere. This occurs most often in plants that have symbiotic relationships with N-fixing bacteria, but free-living soil bacteria can fix nitrogen as well (Vitousek et al., 2002). Micro-organisms also enhance soil fertility by liberating nutrients from detrital organic matter (e.g. plant leaves) and retaining nutrients in their biomass that might otherwise be lost downstream (Paul and Clark, 1996).

ES and Insects – Crop Pollination and Pest Control

Regulating services are among the most diverse class of services provided by agriculture. Agricultural landscapes have the capacity to regulate the population dynamics of pollinators, pests, pathogens and wildlife, as well as fluctuations in levels of soil loss, water quality and supply, and greenhouse gas emissions and carbon sequestration (Swinton et al., 2007). Insects provide vital ES to agriculture including dung burial, pest control and pollination. Beetles in the family *Scarabaeidae* are especially efficient at providing dung burial services (Ratcliffe, 1970). They decompose wastes generated by large animals (a potential EDS from agriculture), thereby recycling nitrogen, enhancing forage palatability, and reducing pest habitat, resulting in significant economic value for the cattle industry (Losey and Vaughan, 2006).

Crop pollination is perhaps the best known ES performed by insects (Losey and Vaughan, 2006). The production of over 75% of the world's most important crops that feed humanity and 35% of the food produced is dependent upon animal pollination (Klein et al., 2007). There is increasing evidence that conserving wild pollinators in habitats adjacent to agriculture improves both the level and stability of pollination, leading to increased yields and income (Klein et al., 2003).

Natural control of plant pests is provided by generalist and specialist predators and parasitoids, including birds, spiders, ladybugs, mantis, flies and wasps, as well as entomopathogenic fungi (Naylor and Ehrlich, 1997). This ES in the short term suppresses pest damage and improves yield, while in the long-term it maintains an ecological equilibrium that prevents herbivore insects from reaching pest status. This important ES, however, is increasingly threatened by biodiversity loss (Wilby and Thomas, 2002) and modern agricultural practices (Naylor and Ehrlich, 1997).

For beneficial insects to provide the above direct ES to agriculture, a number of subsequent supporting and regulating services are required. For example, predators and parasitoids rely on a variety of plant resources such as nectar, pollen, sap or seeds (Wilkinson and Landis, 2005) as alternative food sources to fuel adult flight and reproduction. Non-crop areas can provide habitat where beneficial insects mate, reproduce and overwinter. Evidence shows that increased landscape complexity, which typically means increased availability of food sources and habitat for insects compared with mono-culture landscapes, is correlated with diversity and abundance of natural enemy populations (Thies and Tscharntke, 1999).

Water

Water provision and purification fulfil requirements for water of sufficient quantity, timing and purity for agricultural production. Vegetation cover in upstream watersheds can affect the amount, quality and stability of the water supply to agriculture (Zhang et al., 2007). Forests stabilise water flow to reduce differences in flow between wet and dry seasons (e.g. Yangtze basin; Guo et al., 2000). Forests can also stabilise soil to reduce sediment load in rivers. Wetlands and riparian vegetation can also improve water quality and attenuate floods (Houlahan and Findlay, 2004).

Genetic Diversity and Other Regulating Functions

Genetic diversity provides the raw material for natural selection to produce evolutionary adaptations. Similarly, breeders of crops and domestic animals utilise existing genetic variation to select artificially for desirable traits.

Figure 2.5. Pollination is one of the most threatened ecosystem services. Photo: Marcin Bajer.

Genetic diversity is important not only in avoiding catastrophic losses, but also in improving or maintaining agricultural productivity. Many important crops could not maintain commercial status without the regular genetic support of their wild relatives (de Groot et al., 2002). Genetic diversity at the species level can also enhance biomass output per unit of land through better utilisation of nutrients and reduced losses to pests and diseases.

Another (abiotic) form of ES to agriculture involves climate, including temperature and precipitation regimes but also the frequency and severity of extreme weather, droughts, floods, etc. Favourable climate confers a cost advantage to those who farm there. Suitable and stable climate relies on atmospheric regulation, which like many other ES is influenced by the functioning of multiple ecosystems.

Cultural Benefits of Agriculture

Additional services provided by agricultural landscapes include cultural benefits, the valuation of which can be especially difficult. These include open-space, rural viewscapes and the cultural heritage of rural lifestyles.

Crop pests, including herbivores, seed-eaters, and pathogens (specifically, fungal, bacterial and viral diseases) decrease productivity and in the worst case can result in complete crop loss. Revenue loss from insect pests and pathogens can be disproportionately high for crops for which the price depends heavily on quality, such as fresh produce (Babcock et al., 1992). Non-crop plants can re-

Box 2.1. Nature Protection

The Conservation Movement

As man enters and uses the landscape its original shape and functions are altered, sometimes with serious consequences for wildlife, environmental services and, not the least, culture and beauty. The conservation movement has been fighting this since a century or more, by promoting national parks and other protected areas. The first national park was established in United States in 1872; in Europe Sweden was first with a protected area in 1909 (in the archipelago) and a large national park in the mountains (fjell) in 1910.

As the disastrously rapid decline of diversity, loss of species and nature, were understood strong steps were made towards international criteria and standards for active nature conservation. The International Conservation Union, IUCN, was formed in 1948, best known for its red lists of threatened species. At the UN Rio Conference in 1992 the Convention on Biological Diversity, CBD, was signed by 192 nations. As its 10th Conference of the parties assembled in Nagoya, Japan, in 2010, biodiversity was still decreasing at an alarming speed, at least some 100 times the background value. The countries adopted a new ten-year strategic plan to protect biodiversity and committed themselves to protect 10% of the world's oceans and 17% of all land mass no later than 2020.

Protection and Conservation of Sites

The majority of legislative regulations for nature conservation in the European countries, including those in the Baltic Sea basin, support goals such as:

- maintenance of ecological processes and ecosystem stability,
- conservation of biodiversity,
- conservation of geological heritage,
- conservation and long term survival of species and ecosystems,
- creation of proper human attitudes towards nature, and
- rehabilitation of resources and areas of nature to the proper stage.

The IUCN (1993) defines a protected area as "land and/or sea especially dedicated to the protection of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means." Countries around the Baltic Sea understand this definition in different ways. In Europe, more than 40,000 sites are protected. Some of these are very small, known as nature reserves. A national park is defined as an area of at least 1,000 ha of specific and wilderness value with richness of diverse nature phenomena, nature monuments and beautiful, often primeval environment. Many protected areas are suffering from intensive agriculture, from air and water pollution, and a lack of sufficient sources for proper management, and also from intensive tourism.

Protected land covers 9.8% area of Denmark, but true national parks are lacking. In Finland, 30 national parks cover nearly 8,000 km^2. In Sweden, 23 national parks cover about 6,300 km^2. Some of them are unique, and the only "Arctic" national park within the European Union is found there. Nature reserves in Poland are divided into strictly protected and partially protected areas where certain kinds of human activity are allowed. The most spectacular and important National Park, the Bieloveza Forests, is divided about equally between Poland and Belarus. The only remaining traces of the European original deciduous forest are found here.

Figure 2.6. Camping at Abisko, Sweden. Photo: Tomas Hellberg.

Conservation and Restoration of Wetlands, Meadows, Old Forests

The nature conservation value of wetlands got the highest recognition when the Convention of Wetlands of International Importance, especially as Habit for Water Fowl, also known as the Ramsar Convention, was signed in 1971 in the Iranian city of Ramsar. The signatories, the convention says, share a common belief in the value of wetlands as valuable and irreplaceable economic, cultural, scientific and recreational resources and commit themselves to proper management of wetlands for the present and future benefit of their people.

In addition to protection of wetlands, some countries have made great efforts to restore the once lost wetlands, where birds are quick to occupy the "new" territory. Artificial wetlands play an increasing role in wastewater management, as a cheaper alternative to clean water.

A traditional manure-driven agriculture with species rich natural hay-meadows and grazing areas dominated in the whole region into the early 19th century. Almost all these meadows, totally dependent upon mowing or grazing, have been lost in an even faster pace, especially if new forest is planted on it. However, there are also projects where the old meadows are conserved. The include restoration of the important bird area Matsalu bay in Estonia, Biebrza National Park in Poland.

Nature Protection

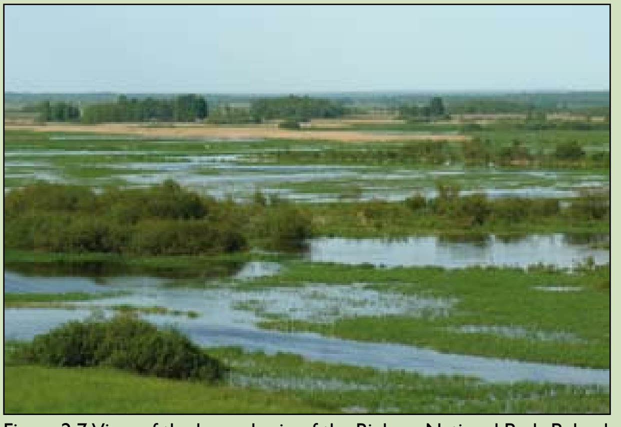

Figure 2.7. View of the lower basin of the Biebrza National Park, Poland. Photo: Frank Vassen.

Figure 2.8. Forest trail in Bialowieza National Park, Poland. Photo: Chad Chatterton.

European Union Biodiversity Policies

The European Union's 27 Member States includes a vast range of natural habitats and a great diversity of flora and fauna. Yet Europe is the most urbanised and, together with Asia, the most densely populated continent in the world. These factors have exacted a toll. EU's precious 'biodiversity' continues to be under serious threat, 42% of our native mammals 15% of birds, 45% of butterflies, 30% of amphibians, 45% of reptiles and 52% of freshwater fish are threatened. In Northern and Western Europe, some 60% of wetlands have been lost. Two-thirds of trees in the EU are under stress, while forest fires in the south continue to pose a problem.

The EU has been involved in efforts to protect the continent's natural heritage for the past 30 years. The Sixth Environmental Action Plan (EAP) 2002-12 highlights nature and biodiversity as a top priority. Under the EU Sustainable Development Strategy launched in Gothenburg in 2001, halting the loss of biodiversity in the EU by 2010 is a priority. As this ambition failed, as it did in the world as a whole, EU is now behind the new vision formulated at COP10 of the CBD in Nagoya.

European Union Directives and Conservation Policies

Two EU Directives deal with the conservation of European wildlife, focusing on the protection of sites as well as species. Council Directive 79/409/EEC on the conservation of wild birds, the Birds Directive, identified 193 endangered species and sub-species for which the Member States are required to designate Special Protection Areas (SPAs). As a result of this action, some severely threatened species are now beginning to recover. Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, the Habitats Directive, aims to protect other wildlife species and habitats. Each Member State is required to identify sites of European importance and to put in place a special management plan to protect them, combining long-term conservation with economic and social activities, as part of a sustainable development strategy.

The sites of the Habitats and Birds Directives make up the Natura 2000 network - the cornerstone of EU nature protection policy. The Natura 2000 network in 2010 included 22,529 sites, covering 719,015 km^2 or 13.7 % of EU27 terrestrial territory. It is co-financed through the Commission's LIFE programme and other Community finance instruments. The Natura 2000 Networking Programme will create a series of training events, themed workshops and practical tools to promote Natura 2000, good practice in site management and the benefits of networking, across Europe.

The European Landscape Convention is part of the Council of Europe's work on natural and cultural heritage, spatial planning, environment and local self-government. It sees the landscape as an essential consideration in striking a balance between preserving the natural and cultural heritage as a reflection of European identity and diversity, and using it as an economic resource. The convention was developed within the Conference of Regional and Local Authorities of Europe, CRLAE, and later adopted by the Council of Europe in 2000. The landscape is important as a component of the environment and of people's surroundings in both town and country, whether it is ordinary or outstanding landscape. The public is accordingly encouraged to take an active part in landscape management and planning, and to feel it has responsibility for what happens to the landscape.

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duce agricultural productivity via competition for resources and allelopathy (Stoller et al., 1987). In fields, weed competition for sunlight, water and soil nutrients can reduce crop growth by limiting access to required resources (Welbank, 1963). Competition for ecological resources of value to agriculture also occurs at landscape scale. Water consumed by other plants can reduce water available to agricultural production. For example, trees can reduce the recharge of aquifers used for irrigation. Competition for pollination services from flowering weeds and non-crop plants can also reduce crop yields (Free, 1993).

The Monetary Value of Ecosystem Services

Being able to place values on ecosystem services is fundamental to designing policies to induce agricultural land managers to provide (or maintain) ES at levels that are desirable to society. Of course, food, fibre and fuel have markets that provide incentives to produce those ES, as well as measures of their value to society. However, many other ES lack markets. The value of those ES may differ between farmers and the consumers of the ES. Farmers (or producers in general) would often lose income by changing production practices to generate more ES.

Policy and Management of Agricultural Landscapes

Not Only Providing Harvest

Nowhere is the need for the application of ecological principles more acute than in agriculture. Agriculture is the world's largest industry and has had an overwhelming effect on structuring the landscape. The Millennium Ecosystem Assessment (2005) found that several ecosystem services that relate to agriculture are in decline. Particularly noticeable are the worldwide declines in wild fish and fresh water. In many cases, declines in wild-fish stocks can be traced to over-harvesting (Jackson et al., 2001; Myers and Worm, 2003). Decreases in the supply and quality of fresh water in many parts of the world can be traced to increasingly intensive agriculture, both in terms of withdrawal of water from rivers for irrigation, and lower water quality from the flow of nutrients, sediments, and dissolved salts from agricultural lands.

Figure 2.9. Sheep managing the landscape. Photo: Ingrid Karlsson.

The global increase in crop production may also account for declines in air quality regulation, climate regulation, erosion regulation, pest regulation and pollination (MA, 2005). A major concern is that the increased agricultural production over the past 50 years has come at the cost of the ecological sustainability that will be necessary to maintain productivity in the future.

Current cropping systems focus on a single ecosystem service, the production of food, yet many other services (e.g. clean water and air, pollination, disease suppression, habitat for other organisms, carbon storage, maintenance of biogeochemical cycles, etc.) are possible and needed. Soil loss can also be regulated by agricultural management. Conservation tillage and the maintenance of plant cover year-round can reduce runoff and associated soil, nutrient and pesticide losses. The reduction of runoff also serves to increase infiltration, which increases the water available to plants and can improve groundwater recharge. At its heart, this is an ecological challenge: agronomic yield is in essence an ecological productivity, and the ways that organisms interact among themselves and with their abiotic environments determine the productive capacity of the agricultural ecosystem, the proportion of ecological productivity that can be harvested as plant or animal products, and the biological diversity and stability of agro-ecosystems. Thus, the good understanding of ecological principles among farmers and agriculture policy-makers is highly critical. The future adequacy and environmental impact of agriculture depends on how effectively we understand and manage the ecological, but also the social elements of agricultural ecosystems (Tilman et al., 2002).

Policy-makers have responded to the alarm launched by researchers with regard to the need for 'biodiversity conservation'. A reference to 'the conservation of biodiversity' is present in almost all conservation, land use management and environmental protection policies proposed at local, national and international scale. As can be seen from some reports and projects written at European Community (EC) level, policy-makers use biodiversity for various goals and objectives without much specification.

Farmers as Landscape Managers

A large number of countries have legislation that explicitly recognises the importance of the recreational, cultural, heritage, aesthetic and other amenity values embodied in agricultural and other landscapes. The European Union agro-environmental measures (EU Regulation 2078/92) include aid to farmers who adopt 'farming practices compatible with the requirements of protection of the environment and natural resources, as well as maintenance of the countryside and the landscape'. Within the EU, the national agricultural legislation of member states typically sets objectives for the protection and restoration of landscapes and also for providing public access to these landscapes.

Sustainable agriculture will require that society appropriately rewards ranchers, farmers and other agriculturalists for the production of both food and ecosystem services, but this will require the ability to accurately measure ecosystem services in a verifiable quantitative manner.

Measures adopted by OECD countries for agricultural landscape conservation and restoration can be categorised into three main types:

- *Economic incentives*, such as through area payments (e.g. Norwegian area and cultural landscape payments) and management agreements based on individual agreements between farmers and regional/national authorities, where payments are provided in compensation for restrictions on certain farming practices and maintenance of key landscape features (e.g. the EU Environmentally Sensitive Area Schemes).
- *Regulatory measures*, which may set certain minimum standards on the whole agricultural area and can designate certain areas of 'high' landscape value as national parks or reserves, and impose restrictions on certain management practices for farmers in these areas (e.g. the national park system created in France, see Bonnieux and Rainelli, 1996); or protect specific landscape features (e.g. the Hedgerow Regulations in the United Kingdom).
- *Community and voluntary based systems*, which set out to devolve the responsibility and management of natural resources, the environment and landscapes to farm families, rural communities and local governments.

Measuring the ***costs of landscape provision*** can help policy-makers determine the outlay by farmers in maintaining and/or restoring certain landscape elements. These costs may relate to cultural and heritage features, such as spending by farmers on the conservation of historic sites and/or buildings on farmland. However, expenditure could also involve costs incurred in hedge or stone wall maintenance that, while providing a positive externality in terms of the landscape, may also generate benefits for the farmer, for example, by providing a windshield for crops and livestock.

The difficulty for policy-makers is that there are few precise rules that indicate the 'correct' or optimal provision of landscape. Questions include how much is optimal, precisely which landscape features does society value, and to what extent do changes in policies and policy mixes affect landscape (Sinner, 1997). To help answer these questions, indicators of agricultural landscapes provide a tool to better inform future policy decisions by recording the stock of landscape features, determining how these features are changing over time, establishing what share of agricultural land is under public/private schemes for landscape conservation, and measuring/evaluating the 'cost' or effort of landscape provision by farmers and the value society attaches to agricultural landscapes.

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