CHAPTER **2**

NATURE'S CONTRIBUTIONS TO PEOPLE AND QUALITY OF LIFE

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EXECUTIVE SUMMARY

Nature's contributions to people in Europe and Central Asia have changed markedly since the 1950s, promoting changes in the quality of life of its societies (*well established*). The ecosystems of Europe and Central Asia are currently delivering multiple contributions, although there is evidence of negative trends between 1960 and 2016 in the majority of regulating and some non-material contributions (*well established*) (2.2.1, 2.2.3, 2.2.5). Of nature's contributions to people in Europe and Central Asia, about 44% have been assessed as declining, particularly regulating contributions and learning derived from indigenous and local knowledge (*well established*) (2.2.1, 2.2.3, 2.2.5). The increasing trends in the delivery of specific material contributions, such as food and biomass-based fuels, have come at the expense of the long-term deterioration of regulating contributions (*well established*) (2.2.1, 2.2.2, 2.2.5). Some key regulating contributions, such as habitat maintenance, pollination, regulation of freshwater quantity, regulation of freshwater quality, formation and protection of soils, and regulation of floods decreased due to intensified management practices designed to produce more crops, livestock, aquaculture, woodfuels and cotton. Furthermore, the increasing demand in Western and Central Europe for food, wood products and biofuels is causing the impairment of ecosystems and nature's contributions to people in other regions of the world (*established but incomplete*) (2.2.2.3, 2.2.4, 2.3.4).

Trends of nature's contributions to people are consistent across the subregions of Europe and Central Asia. Declining trends are reported in Central Europe (61% of the scientific evidence), Western Europe (55%), Eastern Europe (54%) and Central Asia (48%). Increasing trends are mostly reported for Western Europe (35% of scientific evidence) (*established but incomplete*) (2.2.5).

Across all subregions of Europe and Central Asia, continuing declines in nature's capacity to provide regulating contributions to people since the 1960s are of particular concern, especially in the cases of nursery habitats of fish species and breeding and overwintering areas for migratory species, pollination, freshwater flow regulation, freshwater quality regulation, regulation of floods, soil quality and erosion control (*well established*) (2.2.1). However, since the 1990s an improvement in some of these and other regulating contributions from nature to people (i.e. air quality regulation and removal of animal carcasses) in Western and Central Europe occurred due to the implementation of European Union policies (*established but incomplete*) (2.2.1). Since the 1960s, the impacts of land-use change on natural ecosystems and inappropriate management practices in agriculture and fisheries have caused declines in pollinators (2.2.1.2), in regulation of freshwater quality (2.2.1.7), in erosion control and soil quality (2.2.1.8) and in fluvial flood regulation (2.2.1.9) in the four subregions (*well established*). The increases in forest area since the 1960s across parts of Europe and Central Asia have increased carbon storage in those areas, contributing to climate regulation. Increased urban green infrastructure improved the regulation of air temperature in cities and air quality regulation (2.2.1.3, 2.2.1.4). The declines of seagrass beds and kelp forests due to global warming, fishing pressure and marine pollution in the Atlantic, Baltic and Mediterranean Seas have negative consequences for the provision of nursery habitats for fish (2.2.1.1) and regulation of ocean acidification (2.2.1.5) (*established but incomplete*). Nevertheless, these marine habitats may increase in the Arctic Ocean led by seawater warming and will possibly enhance the regulation of ocean pH in the future (2.2.1.5) (*established but incomplete*). After the sharp declines of vultures since the 1950s, the recent recovery of vertebrate scavengers mainly due to natural recovery of populations and also the reintroduction and conservation programmes in Western Europe, has enhanced the removal of animal carcasses (2.2.1.5) (*established but incomplete*).

Nature's material contributions to people in Europe and Central Asia are highly diverse, including food, energy supply, materials that enter industrial processes, and medicinal resources (*well established*) (2.2.2.1). There are inherent trade-offs amongst those material contributions derived from different forms of land use and management. Trends in the use of material contributions reflect socio-economic change and market forces, but also limits to natural capacity (2.2.2.1) (*established but incomplete*). Intensification of management practices, technology, and investment have led to higher production levels for particular material contributions with high market value, including food and biofuels (2.2.2, 2.3.5). The production of some products has experienced substantial growth in the region, particularly in Eastern Europe and Central Asia, including maize, cereals, fruits and vegetables, and meat (*well established*) (2.2.2.1.1). Capture of marine wild fish in the region reached a peak in the 1990s and since then has reduced by about 30% to permit recovery of stocks (*established but incomplete*) (2.2.2.1.2). This reduction was compensated for by a rapid expansion of aquaculture (*well established*) (2.2.2.1.2). Intensive extraction of food and materials combined with policy failures has driven the decline of natural resources, particularly of wild fish and maerl (2.2.2.1.2, 2.2.2.3.3). Also, the loss of indigenous and local knowledge has affected the use of medicinal plants and guard dogs for protecting livestock (2.2.2.3.4, 2.2.2.4). As a result of management for sustainable use, wood production in Europe and Central Asia has been stable since the 2000s and currently about 23% of this production is used as woodfuel (2.2.2.2). Production of biofuel and biodiesel remains small relative to woodfuel and the potential for expansion is limited due to impacts on ecosystems (*established but incomplete*) (2.2.2.2).

Nature's non-material contributions to people in Europe and Central Asia have implications for quality of life by providing opportunities for learning, inspiration, identity development, and physical and psychological experiences (*well established*) (2.2.3). Different measures for these contributions show contrasting trends and geographical unevenness across Europe and Central Asia (*well established*) (2.2.3). There are contrasting trends in measures for learning and inspiration. Informal learning based on interactions with nature has expanded partly due to increases in recreation and tourism linked to sustainable environmental management that promotes knowledge of nature (*well established*) (2.2.3.1.1). Other forms of informal learning and knowledge are in decline and can be linked to a loss of indigenous and local knowledge and linguistic diversity which is the basis of different forms of indigenous and local knowledge relating to nature. Across Europe and Central Asia, 12% of all languages are categorized as critically endangered and 14% as vulnerable (*well established*) (2.2.3.1.2). The overall evidence for physical and psychological experiences indicates an increasing trend. The demand for nature-based recreation and leisure has grown in Western Europe and in 2015 31% of European Union adults surveyed indicated that nature is their main reason for going on holiday, up from under 10% in 2008 (*well established*) (2.2.3.2, 2.3.3). Thirty-eight per cent of the European Union is characterized by a high outdoor recreation potential, but the places that can be used for nature-based recreational and aesthetic experiences in Western Europe are becoming fewer due to land use changes including urbanization, land-use intensification, rural abandonment, disappearance of common lands and water pollution (*well established*) (2.2.3.2). The support of identities relates to virtues and principles rather than to enjoyment resulting from physical and psychological experiences, but it is not possible to identify clear trends for this contribution from nature (*well established*) (2.2.3.3). Nevertheless, it is reflected in attitudes towards nature and, in the European Union, 76% of people agreed with the statement that "we have a responsibility to look after nature" (*well established*) (2.2.3.2). In support of their identities, people attribute an existence value to species and ecosystems, especially iconic and emblematic species (*well established*) (2.2.3.3). Species found in European and Central Asian forests, such as moose; and in marine waters, such as whales, are particularly highly valued (*established but incomplete*) (2.2.3.3). The maintenance of options is a contribution that depends on the existence of biodiversity, and its status and trends are reflected by those of biodiversity measures, including phylogenetic diversity. Society's appreciation of maintenance of options is only moderate, as indicated by previous assessments of Europe and Central Asia, and by the recent call for greater appreciation of maintenance of options from conservation NGOs (*established but incomplete*) (2.2.3.4).

Europe and Central Asia is currently food secure despite a decline in pollination; degradation of agricultural soils; decreases in water availability; increases in floods and droughts; decreases in wild fish catch; competition from agriculture with other land uses such as forests and urbanization; and loss of supporting farmer identity and food-related indigenous and local knowledge (*well established*) (2.3.1.1, 2.2.1.2, 2.2.1.5, 2.2.1.7, 2.2.1.8, 2.2.2.1, 2.2.3.1). This has been possible because of the mechanization and intensification of agriculture and because the region depends partly on imports of food and agricultural inputs as well as on large-scale land acquisition abroad (*established but incomplete*) (2.3.1.1). Food availability depends on different contributions from nature, particularly food production, protection of soils, regulation of water quantity and pollination. Food production from agriculture in Europe and Central Asia increased by 56% between the 1960s and the 1990s until the dissolution of the Soviet Union, the Yugoslav wars and the MacSharry reform of the European Union Common Agricultural Policy. Because of efforts to reduce surplus production in Western Europe between the 1960s and the 1990s, agricultural production has declined by 33% since the 1990s (*well established*) (2.2.2.1.1). This has been offset by an increase in imports from outside of Europe and Central Asia, primarily from South America and Africa (2.2.2.1.2, 2.2.4) and by large-scale acquisition of land in other regions of the world (0.63% of croplands worldwide, 0.57% acquired by countries from Western Europe) (2.3.1.1). There has also been a decrease in wild fish catches since the 1990s, partly due to more sustainable management practices. This decrease was compensated by an increase of 2.7% in fish production from aquaculture since 2000 (*established but incomplete*) (2.2.2.1.2).

Food quantity and quality depend upon soil quality, regulation of water flows and floods, pollination and food-related indigenous and local knowledge. Erosion of agricultural soil affects about 25% of agricultural land in Europe and Central Asia, and a decline of organic matter in agricultural soils has triggered decreased productivity in Central Asia (*established but incomplete*) (2.2.1.8). However, between 2000 and 2010, erosion control in the EU-27 increased by an average of 9.5%, and by 20% for arable lands, partly due to agricultural practices promoted by the Common Agricultural Policy (2.2.1.8). Since 1980, frequency and severity of floods have increased across Europe and Central Asia due to heavy precipitation events and decreased capacity to regulate fluvial floods (*established but incomplete*) (2.2.1.9), thus impacting crop productivity. Since 1961, Mediterranean and Central Asian countries have become more pollinator dependent due to their substantial production of highly pollinator-dependent fruits (*established but incomplete*) (2.2.1.2). However, the diversity, occurrence and abundance of wild insect pollinators have declined since the 1950s and severe losses of western honey bee populations have occurred in many Western European countries and former-USSR countries since 1961 (*established but incomplete*) (2.2.1.2). The loss of indigenous and local knowledge related to farming can affect food security by undermining intergenerational knowledge exchange within farming communities and contributing to the depopulation of rural areas (*established but incomplete*) (2.2.3.1.2, 2.2.3.2.1, 2.3.1.1).

Nature contributes in a range of ways to safe drinking water that is currently ensured for 95% of the people in Europe and Central Asia, despite a 15% decrease in water availability per capita since 1990 (*well established*) (2.3.1.3). Access to clean water depends strongly on the regulation of both water quality and water quantity. These two regulating contributions have been impaired by pollution and overexploitation of freshwater bodies and the decrease in the areal extent of floodplains and wetlands (*well established*) (2.2.1.6, 2.2.1.7). However, the rate of decrease in water quality has lessened in the last decade in Western Europe, due to the implementation of the Water Framework Directive (*established but incomplete*) (2.3.1.3, 2.2.1.7). Access to drinking water is currently sufficient in Western and Central Europe (>99% of people), while Eastern Europe (95%) and Central Asia (85%) have had lower, but increasing, access to drinking water since 1995 (*well established*) (2.3.1.3). Water extraction as a percentage of renewable water resources decreased from 30 to 15% between 1993 and 2012 (*well established*) (2.3.1.3). However, overall water availability per capita has decreased by 15% since 1990, while this decrease was 42% since 1960 in Western Europe (*well established*) (2.2.1.5). Water scarcity in most countries of the European Union has decreased slightly since the 1990s, but over-exploitation still threatens freshwater resources (*established but incomplete*) (2.3.1.3). The Mediterranean region is facing scarcity of water (*established but incomplete*) (2.3.1.3).

Access to sufficient quantities of clean water also depends on water quality and water flow regulation (*well established*) (2.2.1.6, 2.2.1.7). Water quality regulation has decreased in the region since the 1950s, due to the declining naturalness of freshwater ecosystems and areal extent of wetlands (*well established*) (2.2.1.7). Between 2009 and 2015, the coverage of water bodies in the European Union with a “good ecological status” decreased from 43% to 32% (2.2.1.7). However, water quality in Western Europe has improved during the last decade due to the implementation of the Nitrates and Water Framework Directives (*well established*) (2.2.1.7). In Central and Eastern Europe, water quality is decreasing (*well established*) due to increased water pollution and the conversion of natural ecosystems (2.2.1.7). Water flow regulation shows mixed, but generally decreasing trends for the region, particularly in Western and Central Europe between 2000 and 2011 (*established but incomplete*) (2.2.1.6).

Some areas of research into linkages between nature and health have illustrated the value of biodiversity and most of nature’s contributions to people for human health (*well established*) (2.3.2). These linkages include the contribution of biodiversity and nature’s contributions to people to contemporary and traditional medicine, and to healthy nutrition through dietary diversity and support for food security (*well established*) (2.2.2.4, 2.3.2, 2.3.2). Dietary diversity, however, is not necessarily a good indicator of healthy nutrition: a relatively high diversity of unhealthy diets in Western Europe through increases in fat and protein supply can contribute to increases in obesity rates (*well established*) (2.3.1.1). Other linkages between nature and health include the influence of biodiversity and nature’s contributions to people on infectious disease risk (*unresolved*) (2.3.2.2), and the value of green spaces in promoting mental health and physical fitness (*established but incomplete*) (2.3.2.1). There has been a decline in indigenous and local medical knowledge across Europe and Central Asia (*well established*) (2.2.2.4), but medicinal plants have been increasingly used in complementary and alternative medicine outside of local and indigenous communities in recent decades (*established but incomplete*). Unsustainable patterns of exploitation threaten the survival of some medicinal plants (*established but incomplete*) (2.2.2.4).

Urban dwellers across Europe and Central Asia value green spaces for health, psychological well-being and emotional attachment (*well established*) (2.2.3.2). Increased urbanization poses significant challenges for human health – including a rise in non-communicable diseases associated with modern lifestyles, such as obesity, cardiovascular diseases, depression and anxiety disorders, and diabetes (2.3.2). Efforts to increase access of urban dwellers to green space and open countryside may help address some of these health issues through beneficial physical and psychological experiences (*established but incomplete*), though more research is needed into differentials between communities and social groups in terms of access to greenspace and the health benefits obtained from them (*unresolved*) (2.3.2).

The value of nature's contributions to cultural heritage, identity and stewardship is indicated through people's engagement with nature for leisure and tourism, spiritual and aesthetic experiences, gathering of wild food, learning, developing indigenous and local knowledge and also by the desire of people, social groups and governments to protect and conserve areas and iconic species even when they do not use them (*well established*) (2.2.3). There has been a loss in knowledge of ecosystems and species linked to a marked general decline in indigenous and local knowledge and linguistic diversity (*well established*) (2.2.3.1.2). Protected areas, as indicators of valued and iconic places, have grown in number and extent so that globally the proportion of the Earth's surface protected has risen from 8% in 1990 to 14.7% in 2016 (*well established*) (2.2.3.2). The designation of protected areas, however, is geographically uneven in Europe and Central Asia with relatively few areas in Central Asia (2.2.3.3, 2.3.4) (*well established*). Protected areas and other green spaces have increasingly been used since 1950 for tourism, leisure, formal and informal learning with outdoor learning often providing additional value for skill and knowledge development for teachers and learners (*well established*) (2.2.3.1, 2.3.3). In some countries interactions between material and non-material contributions to cultural practices enhance identity, such as berry and mushroom picking (*well established*) (2.3.3). Shepherds attach considerable identity value to guard dogs, especially to breeds associated with particular geographical areas (*well established*) (2.2.2.3.4). The belief systems of many peoples are strongly influenced by spiritual and religious interactions and ecosystems are viewed as alive in many indigenous and local knowledge systems in Europe and Central Asia (*well established*) (2.3.3). The decline in linguistic diversity weakens indigenous peoples' stewardship, heritage and identity especially among young members of these communities as it results in a loss of knowledge of ecosystems and species (*well established*) (2.2.3.1.2, 2.3.3.). Indigenous and local knowledge has significant value for some local communities in Europe and Central Asia contributing to land rights claims, fisheries management and economic development linked to visitors consuming local products and experiencing lifestyles linked to indigenous and local knowledge (*established but incomplete*) (2.3.3).

Nature in Europe and Central Asia is important for delivering a wide range of contributions, which are valued by people. These values are expressed in multiple dimensions, including through economic markets, willingness to pay or cultural preferences (*well established*) (2.3.5). Integrated valuation approaches demonstrate that nature's contributions have substantial monetary and non-monetary values that can inform policy goals (*well established*) (2.3.5). Regulating and non-material contributions are as important in terms of value as material contributions (*established but incomplete*) (2.3.5.2, 2.3.5.3). Traditionally, nature's material contributions have been valued based on market prices and in this assessment monetary values are standardized to a common currency and base year (International $ 2017). Mean net profits of nature's material contributions to people from agricultural production across EU-28 countries ranged from $233 / ha / yr (cereals) to $916 / ha / yr (mixed crops), while wood supply from forests was $255 / ha / yr (*established but incomplete*) (2.3.5.1). Evidence from Europe and Central Asia demonstrates that nature's regulating contributions to people also have significant non-market monetary values and these are higher than non-market values for material and non-material contributions (*established but incomplete*) (2.3.5.2, 2.3.5.3). For example, habitat creation and maintenance is estimated to have a median value of (2017) International $ 765 / ha / yr (*unresolved*) and regulation of freshwater and coastal water quality is estimated at (2017) International $ 1965 / ha / yr (*established but incomplete*) (2.3.5.2). Nature's non-material contributions to people, such as physical and psychological experiences have a median value of (2017) International $ 1117 / ha / yr (*unresolved*), while other non-material contributions were demonstrated to be the most valued contributions by people in social-cultural valuations (*established but incomplete*) (2.3.5.2, 2.3.5.3). The (often large) ranges in values of nature's contributions reflect heterogeneity of preferences across regions, social groups, local contexts and methodological differences (*established but incomplete*) (2.3.5.2, 2.3.5.3). This assessment has demonstrated the importance of nature's contributions to people in terms of their market, non-market monetary and socio-cultural values. Hence, there is strong evidence to support the inclusion of the plurality of values in policy goals such as the Aichi Biodiversity Targets and Sustainable Development Goals (2.3.5.4).

Nature's contributions to quality of life of societies in Europe and Central Asia are not equally experienced

across different locations and social groups across the region, resulting in distributional inequity (*established but incomplete*) (2.3.4). The benefits derived from nature's contributions and the harm from a loss of nature's contributions are geographically uneven, which creates distributional inequity as the impacts on quality of life of changes in ecosystems are linked to where beneficiaries live (*established but incomplete*) (2.3.4). There is also a time component as ecosystem service utilization today may destroy the basis for future service provision (*established but incomplete*) (2.2.3.4). 15% of people in Central Asia lack access to safe drinking water compared to only 1% in Western Europe (*well established*) (2.3.1.3, 2.3.4.2). However, intra-regional equity in the access to food and a balanced diet is increasing (*well established*) (2.3.1.1). Equal access to food can be threatened by large scale land-acquisition mainly by organizations from both Western European and outside the region in Central and Eastern Europe and Central Asia as it compromises the right of people in these areas to control their own food systems (*established but incomplete*) (2.3.1.1). In the European Union, access to green spaces is not equally distributed among the inhabitants of cities (*established but incomplete*) (2.2.3.2, 2.3.4.2). Public access to forests for recreational experiences is uneven across the countries of Europe and Central Asia with high levels of access to 98-100% of forest and other wooded land in Nordic and some Baltic countries as well as in several Central Europe countries including Bosnia and Herzegovina, Slovenia and Serbia. Lower levels of access are found in some Western Europe countries such as UK (46%) and France (25%) (*well established*) (2.3.4.2).

Europe and Central Asia uses more renewable natural resources than are produced within the region, either through overuse or net import, as indicated by the negative difference (deficit) between biocapacity (production) and ecological footprint (consumption) (*well established*) (2.2.4). The region depends on net flow imports of renewable natural resources and material contributions from nature (*well established*) (2.2.4). Western and Central Europe and Central Asia have a biocapacity deficit while Eastern Europe has a reserve (*well established*) (2.2.4). Western Europe's ecological footprint is 5.1 global hectares per person, while its biocapacity is 2.2 hectares. Central Europe's footprint is 3.6 hectares (2.1 ha biocapacity); Eastern Europe's is 4.8 hectares (5.3 ha biocapacity) and Central Asia's is 3.4 hectares (1.7 hectares biocapacity) (*well established*) (2.2.4). The regions footprint negatively affects biodiversity, food security and other contributions from nature to people in other parts of the world (*established but incomplete*) (2.2.4, 2.3.4). Human appropriation of net primary productivity (HANPP) is a measure that assesses biomass extraction from ecosystems for food, fodder, fibres and bioenergy and for large parts of Western Europe, HANPP is lower than HANPP embodied in consumption indicating a reliance on regions outside of Western Europe (*well established*) (2.2.4). HANPP for Central and Eastern Europe and Central Asia is similar or slightly higher than HANPP embodied in consumption, but the European Union has been increasingly importing embodied HANPP especially from South America (*well established*) (2.2.4). There are significant differences in interregional flows of nature's contributions to people across subregions: Central and Western Europe import more contributions than Eastern Europe and Central Asia (*well established*) (2.2.4). Food availability in Central and Western Europe relies significantly on land for crop production in Brazil, Argentina, China and the United States of America (*well established*) (2.2.4). Central and Western Europe depends on food and feed imports equivalent to the annual harvest of 35 million hectares of cropland (2008 data), a land area the size of Germany. Western Europe became less self-sufficient in crop production between 1987 and 2008, while the rest of Europe and Central Asia has become more self-sufficient (*well established*) (2.2.4).

FOREWORD TO CHAPTER 2

"This is like home, you can't tell it. It has to be felt. This is the single sentence you can say. You don't have to add anything else. In springtime when you go out and smell the fresh air, it cannot be told, the feeling of how wonderful it is." (Sandor Barta, cattle herder, in Kis *et al.*, 2017).

In this chapter, we provide an assessment of each of nature's contributions to people (NCP) and to the quality of life of societies in Europe and Central Asia. We recognize that these contributions are diverse, reflecting the multiple societies that inhabit the region and the multiple interlinked dimensions of nature and society. For that reason, the present chapter seeks to respect and to represent the multiple values of nature's contributions to people and to include the different knowledge systems that provide understanding of our relationship with nature.

2.1 INTRODUCTION

2.1.1 How this Chapter 2 relates to the IPBES conceptual framework

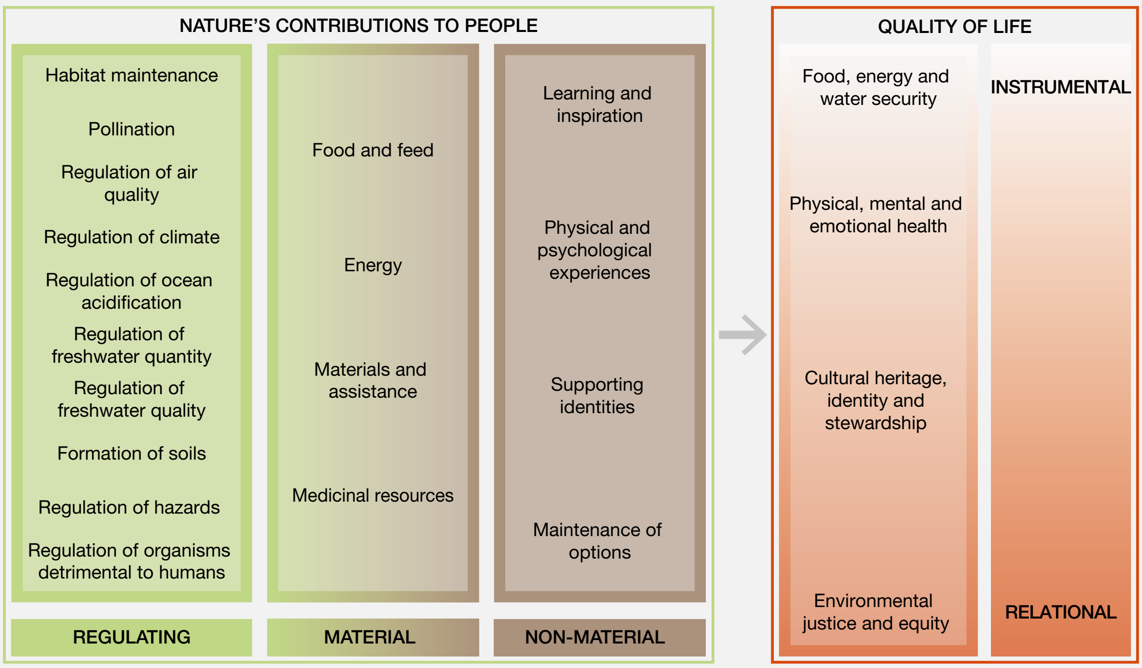
This chapter addresses the boxes of the IPBES conceptual framework "nature's contributions to people" (NCP) and "good quality of life" and the interactions between them. Therefore, it assesses the status, trends and future dynamics of nature's material, regulating and non-material contributions to people (IPBES, 2017a). We use the term "ecosystem services" when referring to the literature that uses this term, and "nature's contributions to people" when synthesizing, summarizing and assessing information. This chapter also assesses the implications of changes in nature's contributions to people for the quality of life of people in terms of instrumental and relational values (see Section 1.5.2), including food, energy and water security, health, cultural heritage, identity and stewardship, and equity **(Figure 2.1)**. The chapter also examines the multiple values of nature's contributions to people by presenting an integrated valuation, including monetary and non-monetary valuation. Assessing the link between nature's contributions to people and quality of life requires diverse valuation methods that include market-based and non-market monetary methods as well as socio-cultural valuation methods (Jacobs *et al.*, 2017; Pascual *et al.*, 2017). In this chapter, we provide an assessment of nature's contributions to people and their relationships with values and quality of life in Europe and Central Asia, bringing together scientific, technical and indigenous and local knowledge (ILK) systems.

2.1.2 Contextual dimensions of nature's contributions to people within the IPBES Regional Assessment for Europe and Central Asia

In this assessment, three generic social and ecological dimensions of nature's contributions to people are distinguished –capacity, use and value-, and different indicators assigned to them. The aim was not a systematic assessment of indicators for all dimensions, but rather to provide an overview of indicators of nature's contributions

Figure 2 1 **Representation of the focus of Chapter 2: status and trends of nature's contributions to people (NCP) (Section 2.2) and their quality of life (Section 2.3) in terms of multiple values.**

The grading of green and brown colours indicates whether the different contributions (regulating, material and non-material) are more associated with natural or with cultural systems, respectively, and to highlight that values are intertwined with both systems.



to people that relate to one of these dimensions. **Table 2.1** gives an overview of which particular dimension of nature's contributions to people is assessed in this chapter for each contribution.

The first dimension is *ecosystem service capacity* - the potential of a system to make a particular contribution to people. The second dimension is *ecosystem service use* - the actual appropriation or appreciation of nature's contributions to people by a beneficiary. The third dimension is *ecosystem service value* - the importance attached to contributions by different groups of beneficiaries. While nature's contributions to people can be valued in different ways (Jacobs *et al.*, 2017; Pascual *et al.*, 2017), the presence of such values determines to which elements in nature, e.g. a species, a population or an ecosystem, they are attributed.

Table 2 1 **Indication of which dimension is assessed in this chapter per contributions from nature to people.**

	Nature's contributions to people	Ecosystem service capacity	Ecosystem service use	Ecosystem service value
1	Habitat creation and maintenance	• Nursery capacity of habitats • Surface of habitats with nursery function	• Breeding and overwintering areas for migratory species	• Non-market monetary values • Non-monetary values
2	Pollination	• Wild insect pollinators diversity and occurrence • IUCN red lists status for wild pollinators • Number of honey bee colonies	• Agriculture's dependence on pollinators • % supply of honey bees relative to demand	• Annual market value of production that is directly linked with pollination services • Non-market monetary values • Non-monetary values
3	Regulation of air quality	• Reduction in concentration of the pollutant by nature • Balance between emissions and vegetation capture • NO_2 and other pollutants removed by ecosystems	• Reduction in concentration of the pollutant • Premature deaths due to air pollution • Years of life lost due to air pollution	• Non-market monetary values • Non-monetary values
4	Regulation of climate	• Carbon storage and sequestration by different land uses • Temperature decrease (reduced heat stress)	• CO_2 (and greenhouse gas) concentrations	• Non-market monetary values • Non-monetary values
5	Regulation of ocean acidification	• Marine vegetated habitats (e.g. seagrasses, kelp forests) surface and performance • Rates of pelagic primary production	• Increases in ocean pH • Existence of refugia for calcifying organisms	
6	Regulation of freshwater quantity and flow	• Freshwater quantity regulation • Freshwater availability (for human use) • Freshwater flow regulation • Water retention • Water regulation • Stream flow, base flow	• Freshwater extraction • Surface water extraction • Freshwater use	• Non-market monetary values • Non-monetary values
7	Regulation of freshwater quality	• Surface of floodplains and wetlands • Ecological status of water bodies • Nitrate removal rate in a river	• Concentration of nitrogen and phosphorous in inland freshwater ecosystems • Quality of drinking water and bathing water • Winter means of dissolved inorganic nitrogen (nitrate + nitrite + ammonium), oxidized nitrogen (nitrate + nitrite) and phosphate concentrations in seas	• Non-market monetary value • Non-monetary values
8	Formation and protection of soils	• Capacity of ecosystems to avoid erosion: C factor of USLE erosion model • Soil fertility • Maintenance of soil structure • Soil organic carbon content • Available nutrients, available organic contaminants	• Erosion rates	• Non-market monetary value • Non-monetary values

	Nature's contributions to people	Ecosystem service capacity	Ecosystem service use	Ecosystem service value
9	Regulation of hazards and extreme events	• Habitats designated for flood protection • Flood mitigation capacity of wetlands • Flood regulation	• Number and intensity of coastal and fluvial flood events • Damage caused by flood events	• Non-market monetary value • Non-monetary values
10	Removal of carcasses	• IUCN red lists status for vertebrate scavengers • Population trends of vertebrate scavengers	• Amount of animal and livestock carcasses removed by vertebrate scavengers • Emissions of CO_2 resulted by the substitution of natural scavenging with artificial removal of carcasses	• Avoided costs • Non-market monetary value
11	Food and feed	• Agriculture area per capita • Cultivated area per agricultural population • Organic agricultural area	• Production of cereals, fruit, vegetables, maize • Production of crops processed: olive oil, rapeseed oil, sunflower oil, wine • Livestock primary production: eggs, meat, milk • Marine wild capture seafood • Inland wild fish captures • Aquaculture production	• Market values • Non-market monetary value • Non-monetary values
12	Energy		• Woodfuel production stocks • Annual production of biofuel • Biodiesel and ethanol production • Woodfuel consumption stocks • Trade balance of biofuels • Trade balance of biodiesel and ethanol	• Market value of woodfuel • Non-market monetary value • Non-monetary values
13	Materials and assistance	• Density of timber stocks • Surface of cork oak forests • Status of mearl bed habitats	• Production of roundwood • Production of cotton • Cork harvested • Production of turpentine, resin and rosins • Production of kelp • Extraction of maerl	• Market value of some materials • Non-market monetary value • Non-monetary values
14	Medicinal, biochemical and genetic resources	• Number of medicinal plants • Endangered status of medicinal plants	• Use of medicinal plants	• Non-market monetary value of genetic resources • Non-monetary values
15	Learning and inspiration	• Protected areas and outdoor spaces used for learning	• Linguistic Diversity Index • Level of endangerment of languages • Transmission of indigenous and local knowledge	• Non-market monetary value • Non-monetary values
16	Physical and psychological experiences	• Surface of Protected Areas • Recreational potential index • Percentage of forest area designated or managed for recreation purposes • Richness of species collected for wild food or hunted	• Nature as the main reason for going on holidays • Number of marine and freshwater anglers • Participant rates (%) in nature-based recreation activities	• Market value of mushrooms • Market value of berries • Non-market monetary value • Non-monetary values

	Nature's contributions to people	Ecosystem service capacity	Ecosystem service use	Ecosystem service value
17	Supporting Identities	• Protected Areas (IUCN categories Ia Strict Nature Reserve, Ib Wilderness Area, II National Park and IV Habitat/species management area) • Sacred Natural Sites per country • Forest area primarily designated or managed for spiritual or cultural values (Food and Agriculture Organization of the United Nations)	• Species appearance in news articles • Attitudes towards nature preservation	• Non-market monetary value • Non-monetary values
18	Maintenance of options	• Total number of endemic species • Phylogenetic diversity	• Use of genetic diversity by pharmaceutical companies • Recent and unanticipated benefits from biodiversity	• Avoided costs of unanticipated benefits from biodiversity

2.2 STATUS AND TRENDS OF NATURE'S CONTRIBUTIONS TO PEOPLE IN EUROPE AND CENTRAL ASIA

This section assesses the status (from 2011 to 2016) and trends (from 1950) of nature's contributions to people in Europe and Central Asia based on a systematic literature review conducted in three main stages: (i) generation of search strings (see supporting material Appendix 2.1[1]); (ii) systematic search of primarily published peer-reviewed scientific articles, grey literature and indigenous and local knowledge; and (iii) the extraction of information from 25 relevant papers per contribution in each subregion of Europe and Central Asia. The assessment also included indicators available at regional and subregional levels and indigenous and local knowledge derived from a Europe and Central Asia "ILK dialogue workshop" held in January 2016 in Paris (Roué & Molnar, 2017) (see supporting material Appendix 2.2[2]). We report on the general status and trends in Europe and Central Asia and in its subregions of Western, Central and Eastern Europe, and Central Asia; however, a detailed list of references can be found in supporting material Appendix 2.3[3].

It is important to point out that, across the region, there are many examples where indigenous and local knowledge is

1. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.1_protocol_of_the_systematic_review_used_for_chapter_2_of_the_eca_assessment.pdf
2. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf
3. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.3_extra-references.pdf

Box 2 1 The role of indigenous and local knowledge of transhumance shepherds for preserving some of nature's contributions to people.

Transhumance is a traditional farming practice of moving livestock from one grazing ground to another in a seasonal cycle. It is based on indigenous and local knowledge that has proven to be a determinant for the provision of nature's regulating contributions to people (seed dispersal, fire prevention or soil fertility), as well as nature's material and non-material contributions to people, such food, wood, ecotourism or local identity (Oteros-Rozas *et al.*, 2013a; Oteros-Rozas *et al.*, 2014). The use, conservation and transmission of transhumance-related local knowledge has been shown to be mostly linked with the practice of transhumance on foot. Transhumance on foot would not be possible without ancestral knowledge and collaborative practices. Drove roads, maintained for and by transhumant shepherds through the migration of their herds, are biodiversity reservoirs (Azcarate *et al.*, 2013) as well as corridors contributing to landscape connectivity (Galvin, 2008). Seeds can be dispersed along hundreds of kilometres by transhumant sheep on their migration (Manzano & Malo, 2006).

In Spanish "dehesas" (open woodlands resulting from the clearing of original evergreen oak woodland and shrubland areas), shepherds' seasonal management of grasslands allows for holm oak regeneration in a context where tree ageing is a major challenge for biodiversity conservation and overall sustainability (Carmona *et al.*, 2013). Fire prevention, as a result of livestock consumption of flammable biomass has also been tightly linked with transhumance management (Oteros-Rozas *et al.*, 2013a; Zumbrunnen *et al.*, 2012). The customary practice of "redileo" and the enclosure of animals in changing resting areas along the drove roads, contribute to soil fertility (Oteros-Rozas *et al.*, 2012).

essential for preserving nature's contributions to people, for example in the case of transhumance shepherds (see **Box 2.1**). Other examples of the relevance of indigenous and local knowledge to the maintenance of nature's contributions to people, such as pollination, habitat maintenance, food and feed, medicinal resources and physical and psychological experiences are those derived from the management of cultural landscapes, such as "dehesas", "montados" or "bocages" **(Box 2.1)**.

2.2.1 Status and trends of nature's regulating contributions to people

2.2.1.1 Habitat creation and maintenance

2.2.1.1.1 Nurseries

Habitat as a nursery for juveniles of a particular species refers to where "its contribution per unit area to the production of individuals that recruit to adult populations is greater, on average, than production from other habitats in which juveniles occur" (Beck *et al.*, 2001). An overview of the nursery function as a contribution from nature to people is provided by Liquete *et al.* (2016a) who conclude that it is a concrete benefit to people, especially through food provision or recreation. For example, a positive effect has been demonstrated between the presence of nursery habitat and fish stocks of sole (*Solea solea*) in the Seine estuary in France (Cordier *et al.*, 2011). The importance of conserving nursery areas has also been demonstrated for commercially important invertebrate species, such as queen scallops (*Aequipecten opercularis*), soft-shell clam (*Mya arenaria*) and sea urchin (*Psammechinus miliaris*). The importance of nursery habitat for juveniles is also relevant in the cases of maerl grounds, kelp forests, *Cystoseira* forests, seagrass meadows and reefs, among others.

Maerl beds harbour significantly higher numbers of juveniles of these species than impacted areas (Kamenos *et al.*, 2004). However, maerl beds have been undergoing a decline in condition and extent across most of their range in European Union (Hall-Spencer *et al.*, 2008; JNCC, 2007; OSPAR, 2010), mainly due to commercial extraction (see Section 2.2.2.3), as well as negative impacts of mussel farming, dredging for scallops and bivalves, aquaculture and eutrophication (Grall & Hall-Spencer, 2003; Hall-Spencer & Bamber, 2007; Hall-Spencer *et al.*, 2008; JNCC, 2007).

In the European Union marine environment, kelp forests also provide important habitat for a wide range of species (Araújo *et al.*, 2016; Smale *et al.*, 2013), including commercially important ones such as European lobster (*Homarus gammarus*). They also act as nurseries for invertebrates and fish, such as Atlantic cod (*Gadus morhua*), as well as key mating and feeding grounds for many North Atlantic fish species, such as Ballan Wrasse (*Labrus bergylta*) and Goldsinny Wrasse (*Ctenolabrus rupestris*) (Bertocci *et al.*, 2015; Casal *et al.*, 2011; Smale *et al.*, 2013). While knowledge gaps exist in terms of demonstrating the actual effect of kelp forest abundance and density on associated fisheries, most studies show a positive kelp-fisheries relationship (Bertocci *et al.*, 2015). Recent studies show a dominant decreasing trend in kelp forest distribution and abundance across parts of Western, Central and Eastern Europe due to global warming, sea urchin grazing, harvesting, pollution and fishing pressure (see **Figure 2.2**)

Table 2 2 **Kelp species in UK and Irish waters and their predicted change in abundance or range of each species in response to continued environmental change. Source: Smale *et al.* (2013).**

Species	Distribution	Depth range (m)	Length (m)	Lifespan (years)	Predicted change
Laminaria hyperborea	Arctic-Portugal	0-30	1-3	5-18	Decrease
Laminaria digitata	Arctic-France	0-15	1-2	4-6	Decrease
Laminaria ochroleuca	UK-Morocco	0-30	1-3	5-18	Increase
Saccharina latissima	Arctic-France	0-30	1-3	2-4	Decrease
Alaria esculenta	Arctic-France	0-35	1-2	4-7	Decrease
*Saccorhiza polyschides**	Norway-Morocco	0-35	2-3	1	Increase
Undaria pinnatifida	Global NIS	0-15	1-3	1	Increase

* *S. polyschides* is not a true kelp of the order Laminariales (being of the order Tilopteridales), but is included as this "pseudokelp" can perform a similar ecological role as the dominant canopy former.

(Araújo *et al.*, 2016; Casal *et al.*, 2011). Distribution and abundance of some kelp species is predicted to further change in response to ocean warming in the Atlantic (see **Table 2.2**) (Smale *et al.*, 2013) (see Section 2.2.1.5).

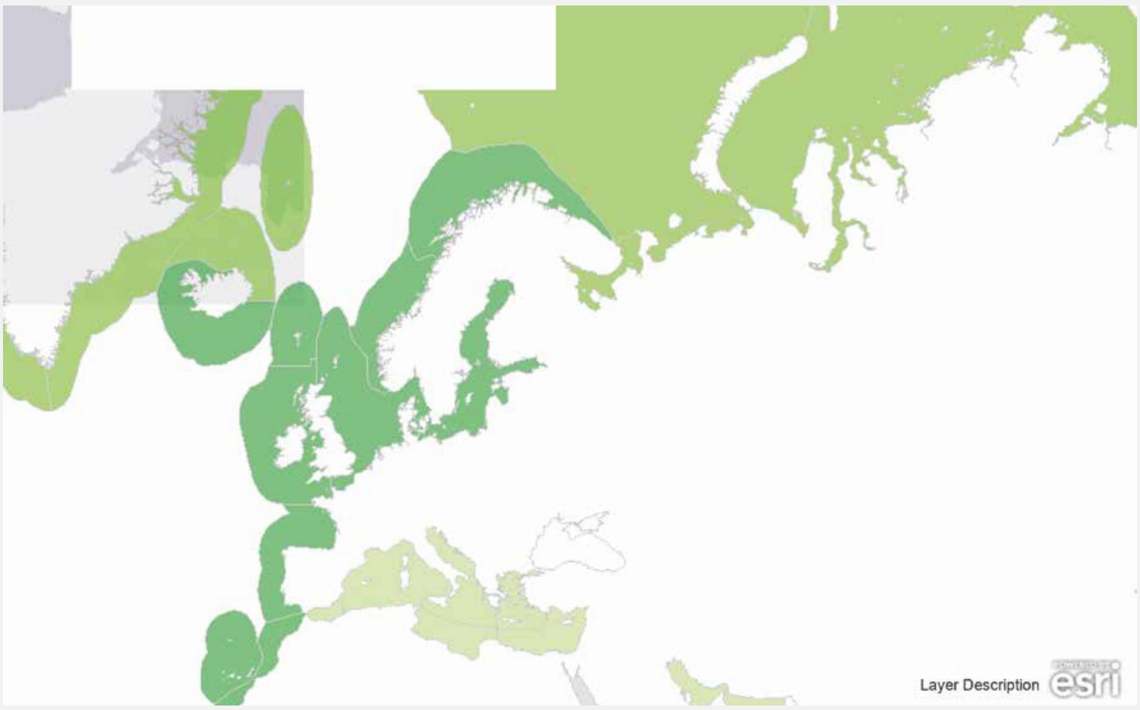
Cystoseira brown algae also provide biogenic structure, food and shelter for many organisms including fish. These habitats have, however, been declining or disappearing throughout the Mediterranean Sea due to a decrease in water quality and building development on the coast (Cheminée *et al.*, 2013; Mangialajo *et al.*, 2013). In Corsica, the depletion of large and continuous forests of *C. balearica* with a surface area of more than 2,500 m^2 could result in a significant loss of Wrasse (*Symphodus spp.)* juveniles, which are dependent on this habitat (Cheminée *et al.*, 2013).

Also in the Mediterranean Sea, many commercial fish species rely on seagrass beds which provide permanent habitat, allowing full life cycle completion and providing temporary nurseries for juvenile development, feeding areas for various life cycle stages and refuge from predation (Jackson *et al.*, 2001). Eelgrass (*Zostera marina*) meadows play a similar role in the Baltic and North Atlantic (Boström *et al.*, 2014). Seagrasses have declined worldwide and particularly in the Mediterranean, Baltic and Atlantic Seas, with negative consequences for the provision of nursery habitats (Boström *et al.*, 2014; Mccloskey & Unsworth, 2015; Waycott *et al.*, 2009).

Biogenic reefs, i.e. reefs where structure is created by the animals themselves, are also important fish habitats, as their complex structures provide refuge for fish and substrate for benthic fauna and macroalgal forests which, in turn, provide refuge and feeding areas for fish species (Støttrup *et al.*, 2014). A positive relationship between reef habitats and fish species abundance was demonstrated by a study on reef restoration in Denmark on the example of commercially important species cod and saithe (Støttrup *et al.*, 2014). Many biogenic reef habitats on the European coasts of the Atlantic Ocean and the North Sea have been in decline due to various anthropogenic pressures (OSPAR, 2010).

Other nursery and spawning habitats have also been reported in national assessments. For example, in Finland the most important nursery habitats include bladderwrack (*Fucus vesiculosus*) and common eelgrass (*Zostera marina*) meadows for fish species, wooded mires for many forest grouse species and spawning rivers for salmon (Boström *et al.*, 2014; Jäppinen & Heliölä, 2015). The state of Atlantic salmon (*Salmo salar*) spawning rivers in the Baltic Sea has

Figure 2 2 **Kelp abundance in parts of Western, Central and Eastern Europe. Source: TNC (n.d.).**



KELP ABUNDANCE BY PROVINCE

4 — ABUNDANT | 3 — WIDESPREAD | 2 — COMMON | 1 — PRESENT | 0 — NONE | NO DATA

also been assessed by the Helsinki Commission, showing that the number of salmon spawners had increased since the mid-1990s in some rivers of the Bothnian Bay (ICES, 2013).

2.2.1.1.2 Breeding and overwintering areas for migratory species

A number of scientific publications discuss population declines in a range of migratory species, including migratory birds of Western, Central and Eastern Europe *(Berthold et al., 1998; Sanderson et al*., 2006). This includes European breeding birds wintering in Sub-Saharan Africa (Sanderson *et al.*, 2006). Over half (50.4%) of fully migratory species were reported to be in decline between 1990 and 2000, falling, however, to 35.7% between 2000 and 2012 (Gilroy *et al.*, 2016). Despite this decline in wintering populations, overall waterbirds show an increasing trend in the European Union, being higher for those listed on Annex I of the Birds Directive (**Figure 2.3**) (Wetlands International, 2015).

2.2.1.2 Pollination

Pollination by animals plays a vital role as a regulating contribution from nature to people with the majority of wild flowering plant species (Ollerton *et al.*, 2011) and crop types (Klein *et al.*, 2007) benefitting from it, at least in part. Both wild and managed pollinators play significant roles in crop pollination, and crop yield or quality depend on both the abundance and diversity of pollinators (IPBES, 2016).

Pollinator diversity contributes to crop pollination even when managed species are abundant, and a diverse community of pollinators generally provides more effective and stable crop pollination than any single species.

Pollinators provide a wide range of material contributions, such as the food, fibre, building materials, medicines and other products derived from pollinator-dependent plants (see Section 2.2.2). Other products are directly produced by some species of bees such as honey, pollen, wax, propolis, resin, royal jelly and bee venom (IPBES, 2016). These are important for nutrition, health, medicine, cosmetics, religion and cultural identity and so contribute to a good quality of life (IPBES, 2016).

Since the 1950s wild insect pollinators in Europe and Central Asia have declined in diversity and occurrence, and also in abundance for some taxa where data are available (see Chapter 3). IUCN Red Lists for continental Europe (here extending from Iceland in the west to the Urals in the east) show that 37% of bee and 31% of butterfly species have declining populations (excluding data deficient species) and 9% of both taxa are classified as threatened (Nieto *et al.*, 2014; Van Swaay *et al.*, 2010). Severe losses of managed colonies of the western honey bee have been reported in many Western European countries and former-USSR countries since 1961 (Aizen & Harder, 2009).

Agriculture in Europe and Central Asia has become more pollinator dependent since 1961, with Mediterranean and Central Asian countries being the most reliant on pollination

Figure 2 3 **Trends in wintering populations of 50 waterbird species in the European Union according to their status on the Birds Directive. Source: Wetlands International (2015).**

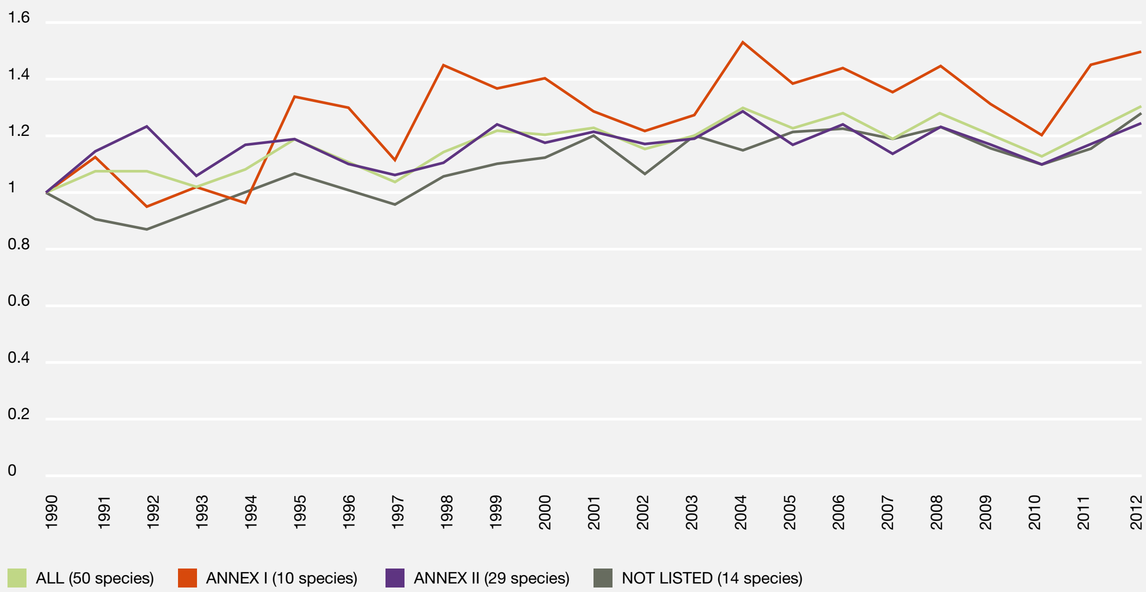


Figure 2 4 **Agriculture's dependence on pollinators (i.e., the percentage of expected agriculture production volume loss in the absence of animal pollination (categories depicted in the coloured bar) in 1961 Ⓐ and 2012 Ⓑ. Source: Based on data from FAO (2013a) and following the methodology of Aizen *et al.* (2009).**

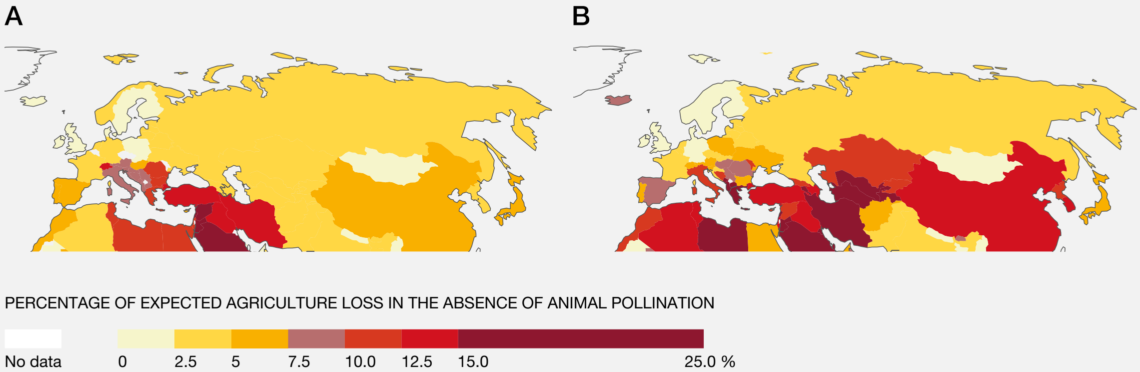
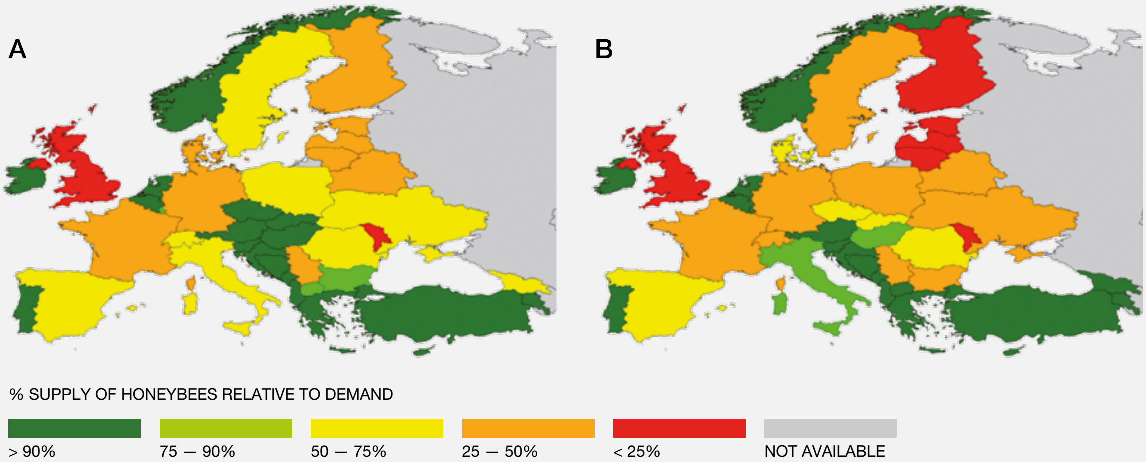


Figure 2 5 **A comparison of the pollination service capacity of honey bees in 2005 Ⓐ and 2010 Ⓑ in Western Europe (except Israel), Central Europe and parts of Eastern Europe. Source: Breeze *et al.* (2014).**



services for crop production, due to the substantial production of highly pollinator-dependent fruits (see **Figure 2.4**). The potential capacity of managed honey bees in Western, Central and Eastern Europe to supply pollination services to pollinator-dependent crops is insufficient to meet demand in many countries and the shortfall has increased between 2005 and 2010 because of changes in crop markets (see **Figure 2.5**; Breeze *et al.*, 2014). This suggests a high and increasing reliance on wild insects for crop pollination services. Without a systematic monitoring scheme, however, it is not possible to accurately assess the importance of wild pollinators at a local scale (e.g. April *et al.*, 2016). Although some attempts have been made to model available pollinator natural capital (e.g. Schulp *et al.*, 2014a), to date they have not considered pollinator behaviour. More suitable models have been developed (Olsson *et al.*, 2015; Ricketts & Lonsdorf, 2013) but have not yet been applied beyond case study or hypothetical sites. In addition, a variety of indicators have been used for mapping pollination, however, almost all are based on very indirect (e.g. land cover variables) or relative measures of pollination and lack empirical validation of reliable representation of pollination delivery.

Pollination contributes to a *good quality of life* through: the role of pollinators underpinning the productivity of many of the world's crops which contribute to healthy diets; beekeeping, pollinator-dependent plant products and honey which support livelihoods; and pollinator-dependent landscapes which help provide a rich and meaningful cultural and spiritual life (IPBES, 2016). Throughout Europe and Central Asia there has been a 14% increase in honey production (from 314,874 to 358,191 tonnes per year) between 1992 and 2012. This change has, however, been uneven between regions, presenting a decline of 27% in Western Europe and 63% in Central Asia, while an increase of 29% in Eastern Europe and 31% in northern Central Europe (FAO, 2017). In addition to honey and other direct calorific value of products derived from pollinator-dependent food crops, these products also benefit human health via supply a major proportion of micronutrients such as vitamin A, Iron and Folate; the fractional dependency of these micronutrient production on pollination is particularly high in southern areas of Western and Central Europe (Chaplin-Kramer *et al.*, 2014).

2.2.1.3 Regulation of air quality

The regulation of air quality by ecosystems is complex, depending on the atmospheric pollutant in question, emission levels, scale, and ecosystem characteristics. The contribution of vegetation varies according to multiple plant factors including species, leaf area, height, presence of wax or hair, evergreen versus deciduous lifeform and surface roughness. This needs to be balanced against their pollution resilience, as well as their potential to decrease air quality by trapping pollutants, emitting gases including biogenic volatile organic compounds (BVOC) and methane (Janhäll, 2015; Sæbø *et al.*, 2012), and producing allergens (Asam *et al.*, 2015). In many countries, greenhouse gas emissions are decreasing as countries seek to comply with commitments (EEA, 2015a) and the European Union Air Quality Directive (Directive 2008/50/EC)[4], but trends in air quality regulation by ecosystems vary according to the balance between emissions and capture by vegetation. Between 2000 and 2010, in the European Union, nitrogen dioxide (NO_2) removal by urban green areas increased by 0.8% (European Commission, 2015b). In Spain air quality has slightly decreased overall, but air quality regulation by forests improved between 1960 and 2010 as forest area increased due to land abandonment, with mountain areas showing mixed trends of forest area and rivers, lakes and wetlands showing decreases of forest area (Spanish NEA, 2013).

Three aspects of the regulation of air quality by ecosystems are briefly reviewed here: (i) the broad contribution of different ecosystems; (ii) the impacts of parks and trees at the local scale in cities; and (iii) ecosystem contributions to emissions. Forests and trees are particularly important at both the regional and local level, especially in cities, for capturing pollutants through both wet and dry deposition. A simple estimation of air pollution capture and removal, based only on dry deposition velocity[5] (as a measure of capacity of removal by vegetation) shows that for nitrogen oxides (NO_x), mountains with forests and natural grassland have a high capacity (primarily due to the higher level of pollutant capture by forests), while forests in Sweden and Finland and vegetation in parts of Central and Western Europe have intermediate capacity **(Figure 2.6 A)**. When combined with local pollution concentrations in urban and peri-urban areas, it shows that trees in southern Scandinavia and parts of Central and Southern Western Europe are particularly important **(Figure 2.6 B)**. However, this can vary according to factors including pollutant (type and emission level), topography and location. For example, in Limburg Province, Netherlands, the vertical capture of PM_{10}[6] (mean kg km^{-2} yr^{-1}) was estimated as: heath 2056, forest 2001, peat 968, cropland 956 and urban 535 (Remme *et al.*, 2014), with heaths capturing more than forests, as they are closer to the emission sources.

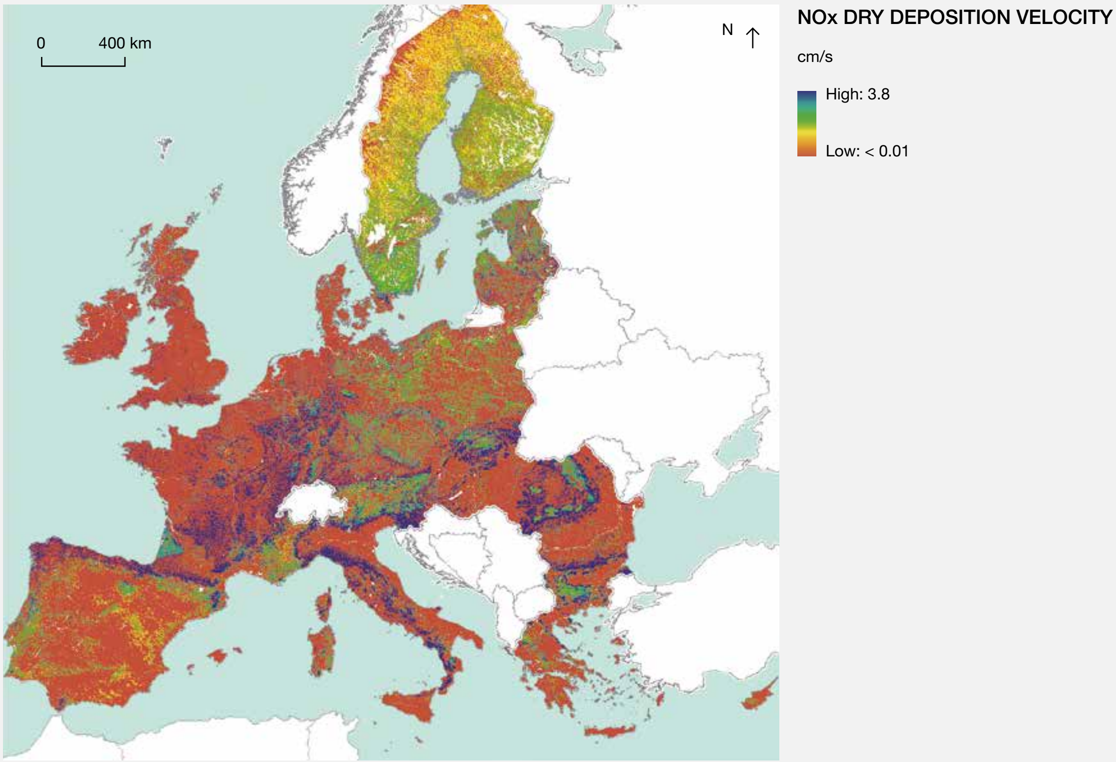
The total net benefit of vegetation in cities for capturing pollutants can be small relative to total emissions. For example, urban forests in Barcelona in 2008 removed 305.6 t of air pollutants and 19,036 t CO_2eq, representing 2.66% of PM_{10} (particulate matter 10 micrometers or less in diameter), 0.43% of NO_2, and 0.47% of CO_2eq of emissions (Baró *et al.*, 2014). The tree canopy in Greater London is estimated to remove between 0.7% and 1.4% of PM_{10} from the urban boundary layer (Tallis *et al.*, 2011). Measurements of NO_2, anthropogenic volatile organic compounds (VOCs) and particle deposition in two Finnish cities suggest that urban vegetation removes little pollution in northern areas (Setälä *et al.*, 2013). Nevertheless, the amounts locally removed can be very important.

Several studies demonstrating the removal of different pollutants by trees or parks in cities of the European Union show similar patterns, although quantitative results are mostly not directly comparable since the studies use different units. Studies of different Italian cities showed that generally evergreen broadleaved forests capture more ozone (O_3) than coniferous forest, followed by mixed broadleaved and coniferous forest, with deciduous broadleaved forest capturing the least (e.g. Bottalico *et al.*, 2016; Manes *et al.*, 2016). For PM_{10} the sequence decreases from mixed broadleaved and coniferous forest, to coniferous forest, evergreen broadleaved forest and deciduous broadleaved forest (Manes *et al.*, 2016). Seasonal differences include deciduous trees capturing more PM_{10} and O_3 in summer when in leaf (e.g. Manes *et al.*, 2016; Marando *et al.*, 2016), while evergreens captured more in autumn and winter (Marando *et al.*, 2016). Research on European urban trees found that *Quercus* and *Platanus spp.* have the highest PM removal efficiency (Grote *et al.*, 2016). Thus, the selection of species planted can affect air quality regulation. In cities, trees can also reduce the dispersion of pollutants, leading to increased local concentrations (Janhäll, 2015).

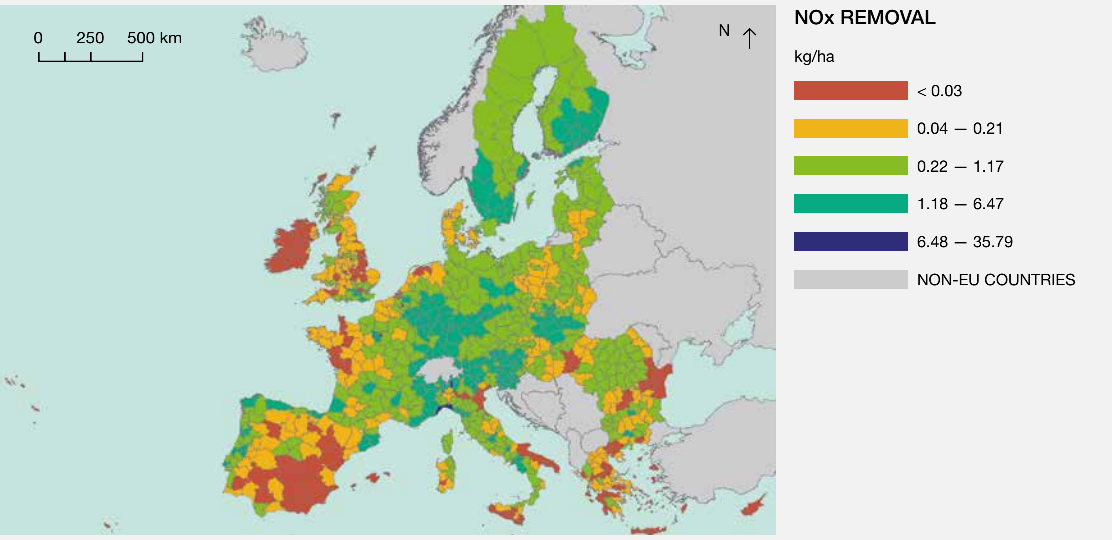
4. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0050
5. Rate of deposition of particles and gases (in this case) on vegetation
6. PM_{10} is particulate matter 2.5 to 10 micrometers in diameter

Figure 2 6 **A Velocity of dry deposition of nitrogen oxides in cm/sec in parts of Western and Central Europe. Source: European Commission (2011).**
B Removal of nitrogen oxides (kg/ha) by trees in urban and peri-urban areas. Source: European Commission (2011).

A

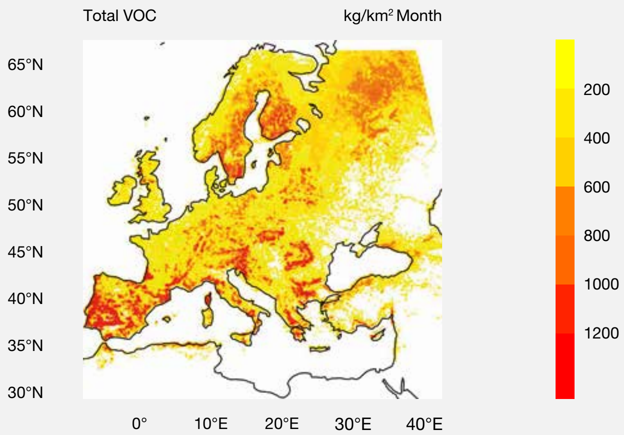


B



Ecosystems can be sources or precursors of gases, which affect air quality. For example ammonia and methane are involved in the photochemical formation of O_3, with agricultural fertilizer application and livestock contributing to ammonia emissions and livestock and wetlands to methane emissions (Kayranli *et al.*, 2010). Trees can emit biogenic volatile organic compounds (BVOCs), especially isoprenes, as well as allergens such as pollen (Grote *et al.*, 2016). Modelling of BVOC emissions shows particularly high levels in parts of southern parts of Western Europe due to a combination of species and high temperatures, while in Scandinavia it is a result of the forest cover **(Figure 2.7)**.

Figure 2 7 **Modelled emissions of biogenic volatile organic compounds (VOC) from terrestrial vegetation in the western parts of Europe and Central Asia in 2000. Source: Steinbrecher *et al.* (2009).**



Air pollution can also indirectly affect ecosystems, through soil and water acidification, eutrophication, or crop and vegetation damage from O_3 (EEA, 2016a), which all can reduce the ability of ecosystems to cope with particulate and gaseous pollutants. For example, in forests the critical O_3 level (20,000 µg/m³/h during the summer season) was exceeded in 2013 in 66% of the 33 member countries of the European Environment Agency (EEA) (except in Turkey), with more northern countries in that area falling below this level, while in southern parts of Western Europe the critical level may be exceeded by a factor of four or five (EEA, 2016a).

Air quality impacts quality of life, especially human health in cities (Queenan, 2017). For example, for 40 countries of Western and Central Europe in 2012, exposure to PM2.5[7], O_3 and NO_2 was responsible for 432,000, 75,000 and 17,000 premature deaths, respectively. The highest rates of years of life lost per 100,000 inhabitants due to PM2.5 were in Central and Eastern European countries, and for O_3 the Western Balkans, Hungary and Italy (EEA, 2015a). Its direct and indirect impacts on processes, such as eutrophication and acidification, affect ecosystem health and species composition (Jones *et al.*, 2014), which can influence their ability to supply other contributions from nature to people.

2.2.1.4 Regulation of climate

Ecosystems are important in climate regulation as they affect greenhouse gas fluxes, contributing both to emissions and storage, which could enhance climate warming or climate mitigation, respectively. Nearly all countries in Europe and Central Asia have submitted "intended nationally determined contributions" under the Paris Agreement, with ecosystems playing a role in their mitigation plans. Ecosystems can also influence heat transfers by reflecting or absorbing incoming solar radiation and moisture transfers through modifying water flows and evapotranspiration, as well as affecting microclimate, primarily through reducing temperature extremes (Edmondson *et al.*, 2016).

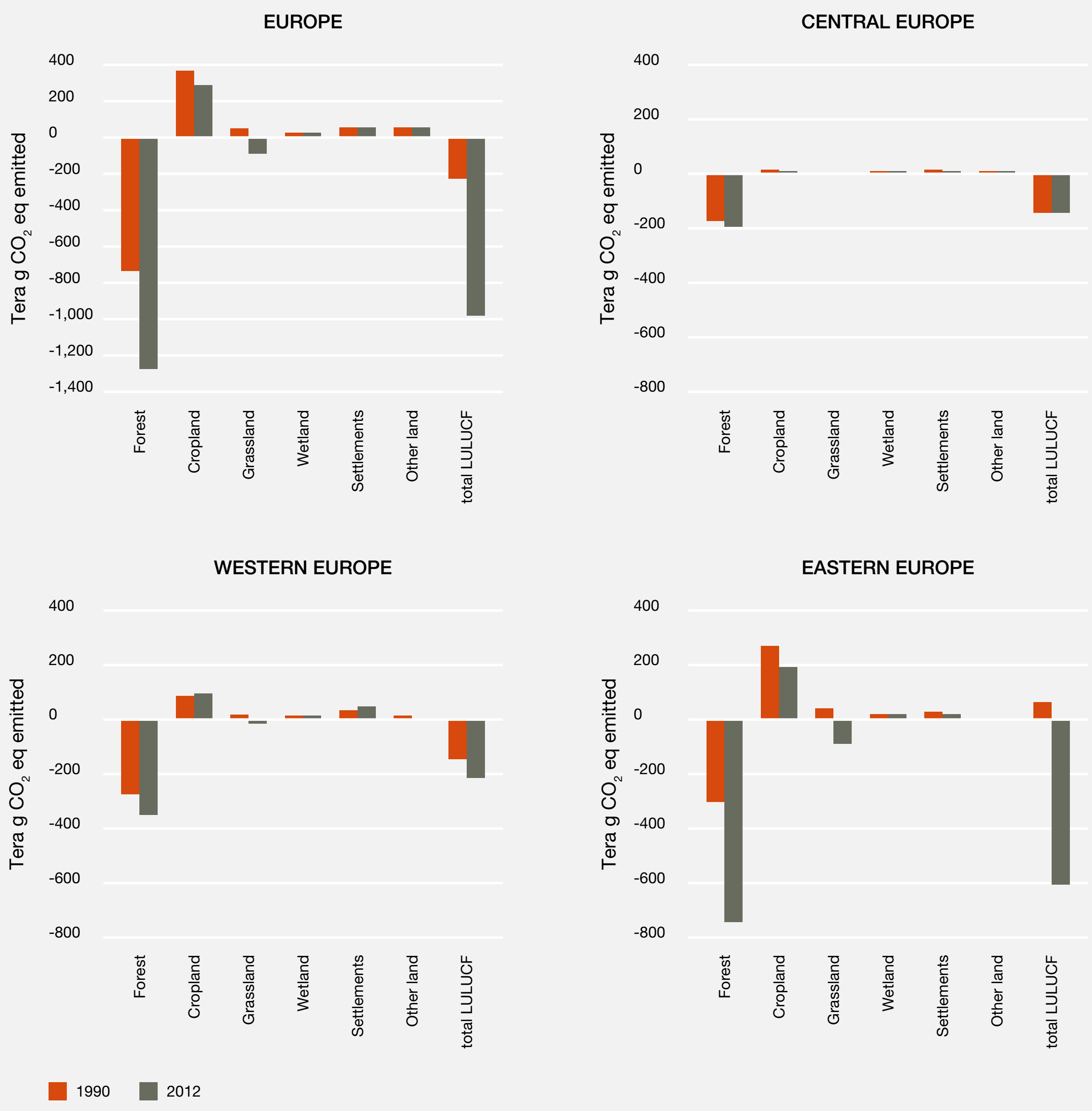
There is considerable uncertainty about the changes in carbon flux and balance. It has been estimated that, between 1950 and 2007, increased carbon biomass stocks in Europe's forests represented 10% of the EU-15[8] cumulated fossil fuel emissions (Ciais *et al.*, 2008), while between 1990 and 2012 there was a net decrease in greenhouse gas emissions from land use, land-use change and forestry (LULUCF) changes due to increased carbon storage **(Figure 2.8)**, primarily as a result of increases in forest area, with 87% of the positive balance coming from Eastern Europe, 19% from Central Europe and 9% from Western Europe. It has been estimated, based on models and observations, that in continental Europe between 2000 and 2005, the balance of greenhouse gases was –29 ± 194 TgC yr^{-1} for croplands, forests and grasslands, as CO_2 taken up mostly by forests and grasslands nearly balanced CH_4 and N_2O emissions (mostly from cropland), while for the 25 member States of the European Union at that stage the balance showed emissions of 34 ± 99 TgC yr^{-1} (Schulze *et al.*, 2009). In Central Asia, net removals of greenhouse gases by land use, land-use change and forestry (LULUCF) between 1992 and 2012 increased from -5.3 to -25.1 Tg CO_2eq (FAO, 2017), mostly due to increased area of grasslands.

7. PM2.5 is particulate matter 2.5 micrometers or less in diameter

8. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom

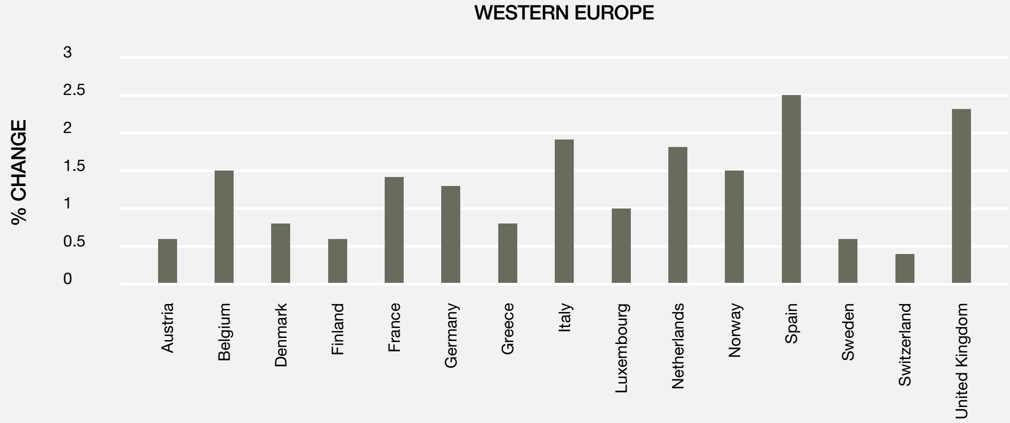
Figure 2 8 **Net annual greenhouse gas emissions and removals for the land use, land-use change and forestry (LULUCF) sector (1990–2012) for Western, Central and Eastern Europe in $TgCO_2$ equivalent.**

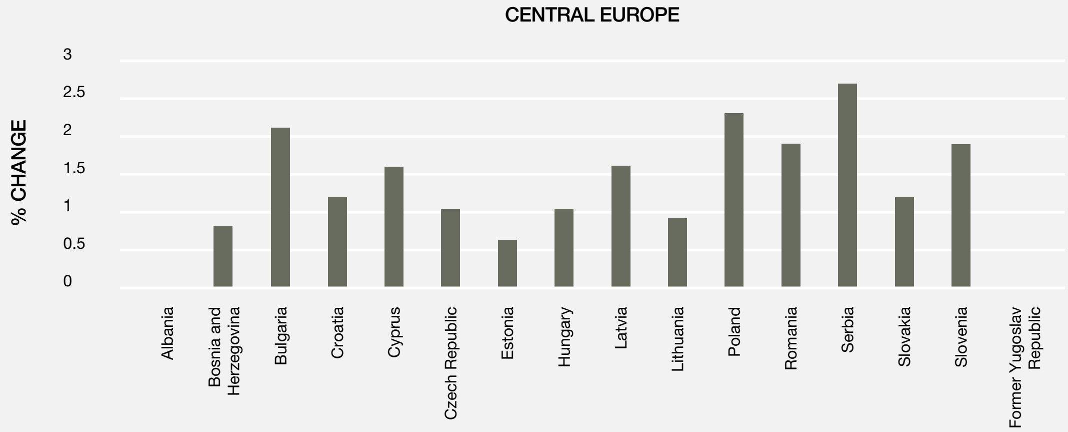
Source: Based on reporting by the United Nations Framework Convention on Climate Change (UNFCCC, 2014). Central Asia countries are not included as they have not reported for the entire period. Note that the vertical axis for Europe (Western, Central and Eastern Europe combined) has a different scale.

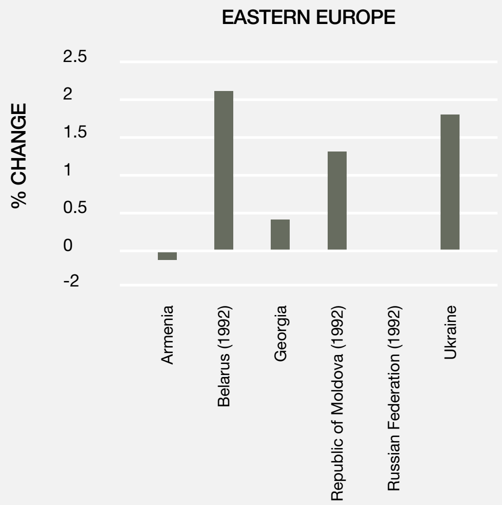


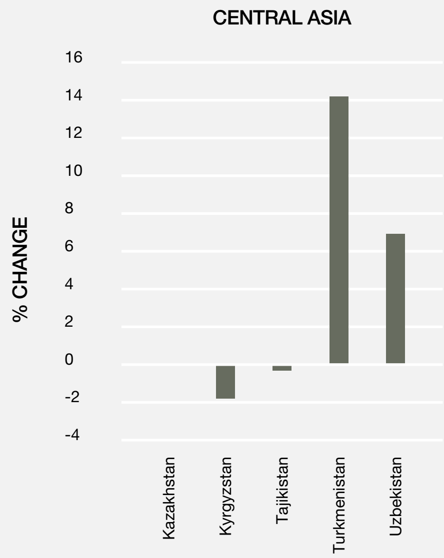
Net increases in emissions and decreases in carbon storage could have several causes, including wetland drainage, loss of wetlands and forests due to urban expansion, agricultural intensification, other land use changes, and emissions from northern peatlands due to climate change. In nearly all countries of Europe and Central Asia, forests are the most important net carbon sink and carbon stocks in living forest biomass between 1990 and 2015 were increasing or stable (see **Figure 2.9**). For some countries, however, wetlands can be more important in regulating climate but, given the decrease in wetland area in many parts of continental Europe (Dixon *et al.*, 2016; EEA, 2016c) (see Section 2.2.1.6), they may not be able to maintain this contribution from nature to people into the future. In Russia, vegetation (primarily boreal forests and peatlands) and soils hold 16% (336 Gt) of the world's carbon stores, with soils making the greater contribution. With climate change, the tundra zone could become a net emitter, especially of methane (Bukvareva *et al.*, 2015).

Figure 2 9 **Annual rate of change (%) in carbon stock in living above-ground and below-ground forest biomass in Europe and Central Asia between 1990 and 2015. Source: Own representation based on FAO (2015c).**









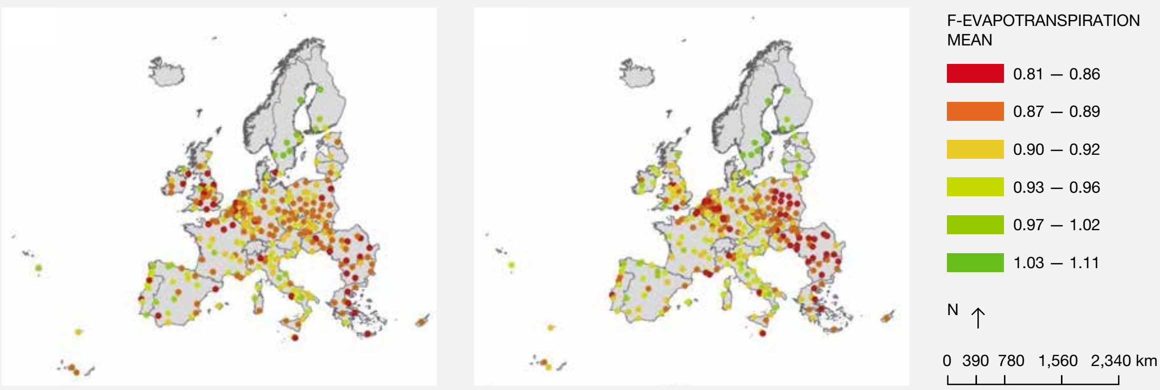
In Europe and Central Asia, soils represent a large carbon stock (Jones *et al.*, 2012; Schulze *et al.*, 2010) but the storage capacity varies depending on land use and soil type. Peat soils are undergoing major carbon losses due to drainage and cultivation (Akker *et al.*, 2016). Cropland soil organic carbon is also declining in many areas of Europe and Central Asia (see Section 2.2.1.7), but agricultural soils represent a large potential sink if appropriate management practices are applied (Lugato *et al.*, 2014). Figures vary for the area of cropland abandoned following the dissolution of the USSR (Schierhorn *et al.*, 2013), but authors agree that this led to major carbon sequestration in soils (Kurganova *et al.*, 2015). A process-driven ecosystem model (Vuichard *et al.*, 2008) estimated that the conversion of 20 million ha of cropland to grassland resulted in an accumulated carbon sink of 64 TgC between 1991 and 2000. Estimates vary, however, due to the use of different methods and data and allowing for the conversion to forests, with the range being from –64 to –694 TgC sequestered (Dolman *et al.*, 2012). Schierhorn *et al.* (2013), using a different process-based model, estimated that between 1990 to 2009 the 31 million ha of abandoned cropland in Western Russia, Ukraine, and Belarus combined, provided a net carbon sink of 470 TgC. In Central Asia, between 1982 and 2000, there was a decrease of soil organic carbon stocks of about 828 TgC, mainly due to the conversion of native rangelands into agricultural land, and to a lesser extent (5% of carbon losses) due to rangeland degradation (Sommer & de Pauw, 2011). Nitrogen deposition can increase terrestrial carbon sequestration and its effect is greatest in Central Europe, although across all subregions of Europe this effect is decreasing due to reduced deposition (Zaehle *et al.*, 2011).

Ecosystems, especially in urban areas, can be effective in microclimate regulation, through reducing local surface temperatures by shading, and air temperatures by evaporative cooling and albedo effects. Local climate regulation has been estimated for 301 large urban zones in the EU-27, using the amount of energy emitted by a surface (surface emissivity) and an approximation of the evaporation potential of the land surface (f-evapotranspiration) to calculate the effect of different land covers on urban air temperatures (Larondelle *et al.*, 2014). Climate regulation was found to be low across most of Western, Central and Eastern Europe, but high in Sweden, Finland and some cities in Spain, France and Italy, with a more heterogeneous pattern elsewhere (see **Figure 2.10**). This primarily reflects the percentage of forest and tree cover in the core urban area and its hinterland.

A global meta-analysis of the cooling potential of urban parks found an average reduction of ambient daytime temperature by 0.94°C and of nighttime temperature by 1.15°C (Bowler *et al.*, 2010), although a few studies found small increases in temperature. The magnitude of the effects varies according to climatic region, size of park or forest (Bowler *et al.*, 2010) and the species involved (e.g. Leuzinger *et al.*, 2010). For example, a comparison of temperatures in a street and the National Garden in Athens, Greece, found the greatest differences at night of up to 6.3°C cooling by the park (Zoulia & Santamouris, 2008), while in Manchester, UK, tree shading was found to reduce air temperatures by 1–2°C (Armson *et al.*, 2012) and in an intra-urban park in Moscow, winter temperatures can be 0.74°C higher and summer temperatures 1.64°C lower than in the city centre (Shahgedanova *et al.*, 1997).

Climate regulation by ecosystems contributes to other contributions from nature to people (e.g. habitat maintenance (Section 2.2.1.1), erosion control (Section

Figure 2 10 **Urban heat regulation in cities in the EU-27, based on an approximation of the evaporation potential of the land surface (f-evapotranspiration). Low values indicate greater cooling. Core city areas on the left; larger urban areas on the right. Source: Larondelle *et al.* (2014).**



CORE CITY AREAS

LARGER URBAN AREAS

2.2.1.8), water quality (Section 2.3.1.6)), while carbon sequestration in soils can increase food security (Section 2.3.1.1). Furthermore, the reduction of urban temperatures in hot weather (Section 2.3.2) can lower rates of heat-related mortality and morbidity, especially in elderly and chronically ill individuals and socially vulnerable people and those with respiratory diseases (Hajat *et al.*, 2010). A study of 12 Western and Central European cities suggested that this is particularly important in the Mediterranean region (Michelozzi *et al.*, 2009).

2.2.1.5 Regulation of ocean acidification

Ocean acidification has been shown to affect marine organisms, having especially negative effects in calcifying organisms such as bivalves, brittle stars, sea urchins, coralline algae and corals (Cornwall *et al.*, 2017; Cornwall *et al.*, 2015; Kroeker *et al.*, 2013) and on the contributions they provide to people (Lemasson *et al.*, 2017). Some of these organisms live in or nearby coastal vegetated ecosystems, which have been shown to regulate atmospheric CO_2 concentrations and seawater pH (Cornwall *et al.*, 2013; Hendriks *et al.*, 2014) with effects on calcification processes of marine organisms important to humans (e.g. corals, bivalves or sea urchins) (IPBES, 2017a). Marine macrophytes, such as large brown macroalgae and seagrasses, are net CO_2 consumers, and their metabolism creates pH fluctuations in seagrass meadows and kelp forests where they are dominant species and very abundant. This regulation of pH can entail increases of 1 pH unit during the day (Middelboe & Hansen, 2007). This up-regulation can depend on many factors, such as plant biomass and structure, hydrodynamics, irradiance and day-length (Krause-Jensen *et al.*, 2016). Vegetated habitats may, therefore, contribute to regulating ocean acidification and creating refugia for calcifying organisms (Hurd, 2015; Krause-Jensen *et al.*, 2016). There is increasing evidence that pH increase can lead to an overall buffering of ocean acidification (Buapet *et al.*, 2013; Hendriks *et al.*, 2014; Krause-Jensen *et al.*, 2015; Krause-Jensen *et al.*, 2016). Nevertheless, pH in these habitats typically fluctuates, with higher pH during daytime due to CO_2 uptake by photosynthesis and lower pH at night due to respiration and release of CO_2. In fact, some studies postulate that macrophytes may amplify the negative effects of ocean acidification, at least for some organisms (Pettit *et al.*, 2015; Roleda *et al.*, 2015). The potential role of regulating ocean acidification of marine vegetated habitats may depend on the balance between positive effects in the daytime and negative effects during the night (Krause-Jensen *et al.*, 2016). For example, long days in the Arctic vegetated habitats have been shown to promote the provision of refugia for calcifying organisms during summer (Krause-Jensen *et al.*, 2015; Krause-Jensen *et al.*, 2016), when organisms reproduce and are most vulnerable to ocean acidification (Kroeker *et al.*, 2013; Lemasson *et al.*, 2017). However, the long polar nights should result in a down-regulation of pH, potentially amplifying negative effects of ocean acidification during winter. However, calcifying organisms are likely less susceptible to low pH in the later conditions (Kroeker *et al.*, 2013).

Despite the importance of marine vegetated habitats, declines of seagrass beds and kelp forests have been reported in many parts of Europe and Central Asia (Araújo *et al.*, 2016; Boudouresque *et al.*, 2009) (see Sections 2.2.1.1. and 3.3.2.3). For example, decline of the seagrass *Posidonia oceanica* has been reported across the entire Mediterranean Sea, and during the last 50 years between 11 and 52% of the documented surface area originally occupied by the species has been lost, with many existing meadows deteriorating (Telesca *et al.*, 2015). It is predicted that this trend will continue and the functional extinction of *P. oceanica* meadows is foreseen by the middle of this century (Jorda *et al.*, 2012), even if seagrasses are likely to benefit from increased CO_2 worldwide (Zimmerman *et al.*, 2017). Therefore, organisms associated with seagrass communities that are deteriorating may be exposed in the future to lower pH regimes due to the loss of pH-buffering capacity (Hendriks *et al.*, 2014). By contrast, these marine vegetated habitats may increase in the Arctic Ocean, led by warming of seawater (Krause-Jensen & Duarte, 2014). The predicted poleward expansion of macrophytes with seawater warming and reduced sea-ice cover (Jueterbock *et al.*, 2013) may increase the potential for pH up-regulation during summer in Arctic marine systems (Krause-Jensen *et al.*, 2016). Similarly, increased pelagic primary production, as forecast for parts of the Arctic Ocean, may also create local niches of high pH (Arrigo *et al.*, 2008; Popova *et al.*, 2012).

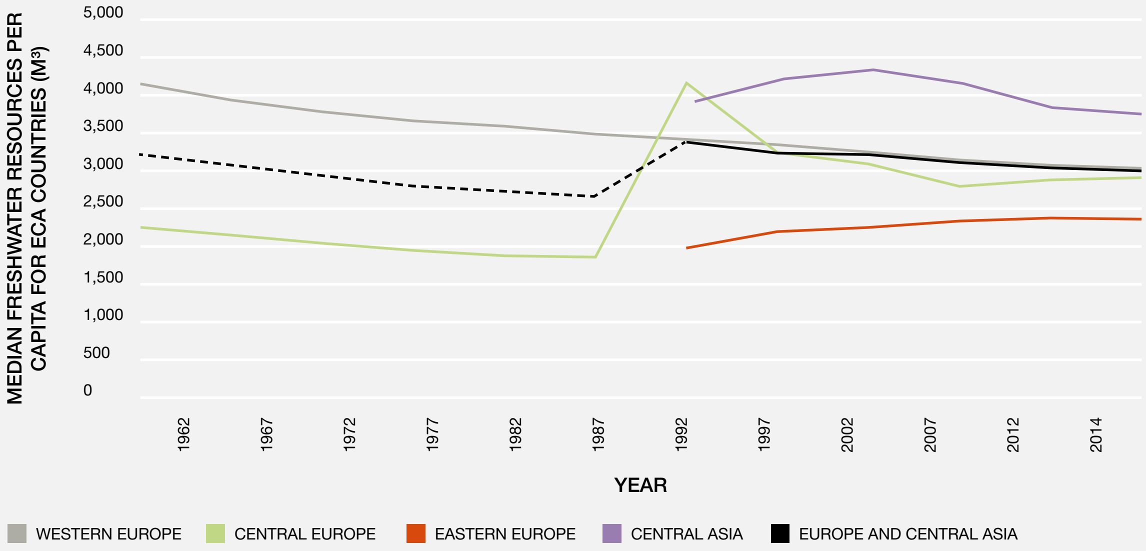
2.2.1.6 Regulation of freshwater quantity and flow

This contribution from nature to people involves the contribution of ecosystems to the regulation of the quantity and flow of surface and groundwater used for drinking, irrigation, and industrial purposes. Besides contributing to direct use, ecosystems can also regulate water flow to water-dependent natural habitats that in turn affect people downstream, including via floods and droughts. See supporting material Appendix 2.2[9] with quotes from indigenous and local knowledge holders describing this contribution, in relation to seasonal water flows.

This section distinguishes between freshwater provision and water flow regulation. Freshwater supply describes freshwater available for human use. Water flow regulation,

9. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

Figure 2 11 **Trend of renewable internal freshwater resources per capita (median, in cubic meters) for Europe and Central Asia (ECA) and the four subregions. Note that the trend for Europe and Central Asia until 1992 (dashed lines) is based on Western and Central Europe only. Source: Own representation based on FAO (2016).**



on the other hand, is described in terms of supply through the indicators of water retention, stream flow and base flow.

The general trend in freshwater supply in Europe and Central Asia, taking into account renewable internal freshwater resources per capita provided by the Food and Agriculture Organization of the United Nations (FAO, 2016), shows an overall decrease since 1992 **(Figure 2.11)**. Freshwater demand, taking into account water use and water abstraction, shows a mixed but overall decrease for all subregions of Europe and Central Asia (EEA, 2015e; FAO, 2013) since the 1990s. Between 2000 and 2011, water abstraction has decreased for countries in the European Union (European Commission, 2015b).

Generally mixed but mostly decreasing trends in water flow regulation were found for parts of Western, Central and Eastern Europe (Stahl *et al.*, 2010; UNEP & UNECE, 2016). Between 2000 and 2011, water flow regulation decreased for most ecosystems in the European Union (European Commission, 2015b). Regions with increased or stable water flow regulation are characterized by large areas of natural vegetation or extensive agriculture (Sturck *et al.*, 2014).

Water supply in Western Europe, measured in freshwater availability, has been decreasing since the 1980s (FAO, 2016) **(Figure 2.11)**. Decreased freshwater availability was also reported for Spanish riparian areas and rivers (Vidal-Abarca Gutiérrez & Suárez Alonso, 2013). Mixed trends for water availability were found for Germany and Austria (Karabulut *et al.,* 2016). Water demand in Western Europe, taking into account water use and surface water abstraction, has decreased since the early 1990s, although current trends are mixed (EEA, 2015e; Eurostat, 2016b). Water use has remained stable in the southern part but has decreased in the western part of Western Europe (EEA, 2015e). Groundwater extraction in Mediterranean river basins in France, Greece and Spain was reported to have increased (Skoulikidis *et al.*, 2017), while overall groundwater extraction in Spain has decreased (Vidal-Abarca Gutiérrez & Suárez Alonso, 2013). Mixed trends for water use were found for the Danube basins in Germany and Austria (Karabulut *et al.*, 2016) as well as water provision in the Llobregat basin in Spain. Mixed but predominantly increasing stream flow was found for Western Europe, although large differences exist between the north and the south (Stahl *et al.*, 2010). Decreasing stream flow in the last decades was reported for the Mediterranean countries as well as Austria and Germany (Skoulikidis *et al.*, 2017; Stahl *et al.*, 2012). Decreased water flow regulation was reported for Spanish riparian areas (Vidal-Abarca Gutiérrez & Suárez Alonso, 2013). Mixed trends for stream flow were found in Switzerland (Lutz *et al.*, 2016). Increased stream flow was found for the majority of the northern countries of Western Europe (Stahl *et al.*, 2010, 2012), as well as in the Hula Wetland, Israel.

Water supply in Central Europe, measured in freshwater availability, has decreased since the 1990s, although this trend has been mixed in the past decade (FAO, 2016) **(Figure 2.11)**. Mixed trends in water availability were discerned for Central European countries within the Danube basin (Karabulut *et al.*, 2016). Water demand, taking into account water use and surface water abstraction in Central Europe, has declined sharply since the early 2000s, but this trend has been mixed in the past decade (EEA, 2015e; Eurostat, 2016b). Mixed trends for water abstraction have been reported for Central European Mediterranean river basins (Karabulut *et al.*, 2016), whereas water abstraction in Cyprus has increased (Skoulikidis *et al.*, 2017). Mixed but predominantly increasing stream flow was found for Central Europe (Stahl *et al.*, 2010). Decreasing water flow during recent decades was reported for Cyprus, the Czech Republic and Slovakia, as well as the Sava River in Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro and Albania (Lutz *et al.*, 2016; Skoulikidis *et al.*, 2017; Stahl *et al.*, 2010). Stable water flow and ground water levels in the past were found in Slovenia and Poland.

Water supply in Eastern Europe, measured in freshwater availability, has increased since the 1990s and this trend has stabilized in the past decade (FAO, 2016) **(Figure 2.11)**. Information on water demand in Eastern Europe is limited to a few countries, however, freshwater abstraction in the Republic of Belarus and the Republic of Moldova is reported to have decreased steadily over recent decades. A mixed trend for water demand was reported in the Eastern European countries of the Danube basin (Karabulut *et al.*, 2016). Stream flow has decreased in most parts of Eastern Europe (Stahl *et al.*, 2012). Water flow regulation in Russia was found to have increased between 1990 and 2015 (Miura *et al.*, 2015).

Water supply in Central Asia, measured in freshwater availability, shows a mixed, but generally decreasing trend since the 1990s, and has continued to decrease over the past decade (FAO, 2016; SAEPF *et al.*, 2012) **(Figure 2.11)**. Water availability per capita has decreased in Turkmenistan and Uzbekistan, while stable water availability was reported for the Aral Sea basin (Uzbekistan). Total water withdrawal in Central Asia has been stable in the past, while water withdrawal by agriculture, industry and cities has decreased (Alexander & West, 2011; FAO, 2013). There is some evidence of on-going stable water use in Uzbekistan (Aral Sea basin), as well as excess water use for irrigation on a local scale (Conrad *et al.*, 2016). Mixed trends for water use were reported for Uzbekistan, due to strong regulation in response to droughts. Water extraction in the Kyrgyz Republic has decreased, although recent trends are mixed. Water use and availability have decreased in Turkmenistan and Uzbekistan (FAO, 2013). Water flow regulation throughout Central Asia shows a mixed trend, following patterns in precipitation and drought occurrences (FAO, 2013; SAEPF *et al.*, 2012).

Regulation of freshwater quantity and flow mostly contributes to quality of life by supporting water and food security (Section 2.3.1). Water security, which is furthermore underpinned by water quality regulation (Section 2.2.1.7) and other contributions from nature to people, is mostly sufficient and has increased in Europe and Central Asia since the late 1980s. More mixed trends and insufficient water security, notably in rural areas, are reported for Eastern Europe and Central Asia. Europe and Central Asia as a whole is food secure but food security is affected by, among others, decreasing water availability and excessive water withdrawal.

2.2.1.7 Regulation of freshwater and coastal water quality

This contribution from nature to people refers to nature's ability to remove or break down excess nutrients and other pollutants. The combination of physical, chemical and ecological processes in rivers, wetlands and marine ecosystems acts as a natural filter removing substances such as sediments and nutrients linked to nitrogen and phosphorus. Water quality regulation, therefore, depends on both the emission of pollutants into the water, and on the capacity of the natural systems to process or transform these substances and physically block them by sediments. For example, natural, restored and constructed wetlands in the European Union are estimated to remove 75% of the nitrate from agricultural runoff via denitrification (Blackwell & Pilgrim, 2011). Nature-based solutions associated with artificial wetlands and restoration of riparian zones have been demonstrated as cost effective measures for water quality improvement in Estonia, Norway, Sweden, Italy, Belgium and the UK (e.g. Kumar *et al.*, 2017; MWO, 2012; Zedler & Kercher, 2005). The capacity of ecosystems to deliver this contribution to people shows sharp local variations along the rivers inside watersheds. If upland riverbeds are well conserved and pollution is limited, water quality can be well regulated. Downstream, rivers are often impacted by land use intensification, riparian wetlands reduction, overexploitation of water resources and alteration of the river bed morphology. In the latter case, the capacity of rivers to regulate water quality is diminished.

The capacity to provide this contribution in Europe and Central Asia has reduced over recent decades due to the conversion and habitat loss of rivers, wetlands and coastal systems (see Section 3.2.2.2), leading to a 60% decrease in the areal extent of floodplains and wetlands and loss of watersheds' ecological integrity (Geijzendorffer *et al.*, 2017). In 2017 it was estimated that 38% of rivers' surface in the European Union have good or high ecological status, 42% moderate state and 20% poor or bad status (Grizzetti *et al.*, 2017). In 2009, 43% of water bodies still showed a good or high ecological status (EEA[10]), indicating a reduction of rivers with good status over the past eight years.

10. https://www.eea.europa.eu/soer-2015/europe/freshwater

Despite the loss of ecological integrity and areal extent of floodplains and wetlands, the water quality of rivers in the European Union has been improving since the 1990s as a result of the reduction of pollutants (due to the Nitrates Directive (91/676/EEC) and European Union Water Framework Directive (2000/60/EEC)) or as a result of transnational efforts such as the Convention on the Protection of the Rhine. The improvement in water quality is, therefore, the consequence of reductions in pollution, rather than an enhancement of the ecosystems' capacity to provide this contribution from nature to people. The quality of drinking water and bathing water, and the effectiveness of wastewater treatment, continue to improve across the European Union (EEA, 2016e). For example, the percentage of bathing water sites meeting the minimum water quality standards has increased to 96.1% in 2015.

In Western Europe, the capacity to regulate water quality has been diminished since 1990. For example, in Spain and Germany, it is considered the most degraded regulating contribution from nature to people (Spanish NEA, 2013). In the Mediterranean basin, the regulation of water quality by wetlands has been jeopardized by the decreasing ecological integrity and scarce water availability (Geijzendorffer *et al.*, in press; MWO, 2012). However, in other areas, water quality regulation by ecosystems has remained stable (e.g. England) (UK NEA, 2011) or has increased (e.g. Netherlands) (de Knegt, 2014). Despite this general negative trend, water quality in Western Europe has improved due to pollution reduction. After the adoption of the European Union Nitrates Directive and Water Framework Directive, water pollution showed a downward-trend. Still, many water bodies remain affected by dissolved inorganic nutrients and pesticides (EEA, 2015d).

In Central Europe, the overall decreasing trend, due to increased pollution and conversion of floodplains and wetlands, is illustrated in Turkey, Austria, Hungary, Romania and the Danube floodplain (e.g. Hainz-Renetzeder *et al.*, 2015; Karadeniz *et al.*, 2009; Pehlivanov *et al.*, 2014). In addition, the demand for water purification is increasing due to agriculture and urban expansion. In Eastern Europe, water quality currently displays a downward trend due to nitrogen surpluses from intensive agriculture or the conversion of natural ecosystems (e.g. Bouraoui & Grizzetti, 2014). In Russia, the capacity to regulate water quality by forests and tundra of Siberia and eastern Russia has remained stable in the past (Stolbovoi, 2002). However, in the southern regions of Russia, the Southern Urals and Western Siberia, this capacity was found to be lower (Stolbovoi, 2002). For Central Asia, published data is not available.

Regarding the regulation of water quality in coastal and marine waters, the concentrations of dissolved inorganic nitrogen, oxidized nitrogen and orthophosphate have remained stable between 1985 and 2012 in Seas of Europe **(Figure 2.12)** (EEA, 2015c). Monitoring stations in the southern area of the North Sea (historically affected by eutrophication) show a decreasing trend in nitrogen and phosphorus concentrations **(Figure 2.12)**. The Baltic Sea, which is also affected by eutrophication, shows a decreasing trend in nitrogen concentration, but an increase in phosphate concentrations **(Figure 2.12)** (EEA, 2015c). The adoption of national marine strategies fostered by the Marine Strategy Framework Directive (2008/56/EC) has supported the improvement of water quality in coastal and marine waters of the European Union.

The contributions of water quality regulation to quality of life are manifold, with particular interest for water security (Section 2.3.1.3), health (Section 2.3.2), and the enjoyment of recreational experiences in nature (Section 2.2.3.2). The restoration and construction of wetlands, together with the Nitrates, Water Framework the Marine Strategy Framework Directives of the European Union, are driving the decrease in water pollution. However, the loss of areal extent of wetlands and floodplains can jeopardize the future delivery of this contribution from nature to people.

2.2.1.8 Formation and protection of soils

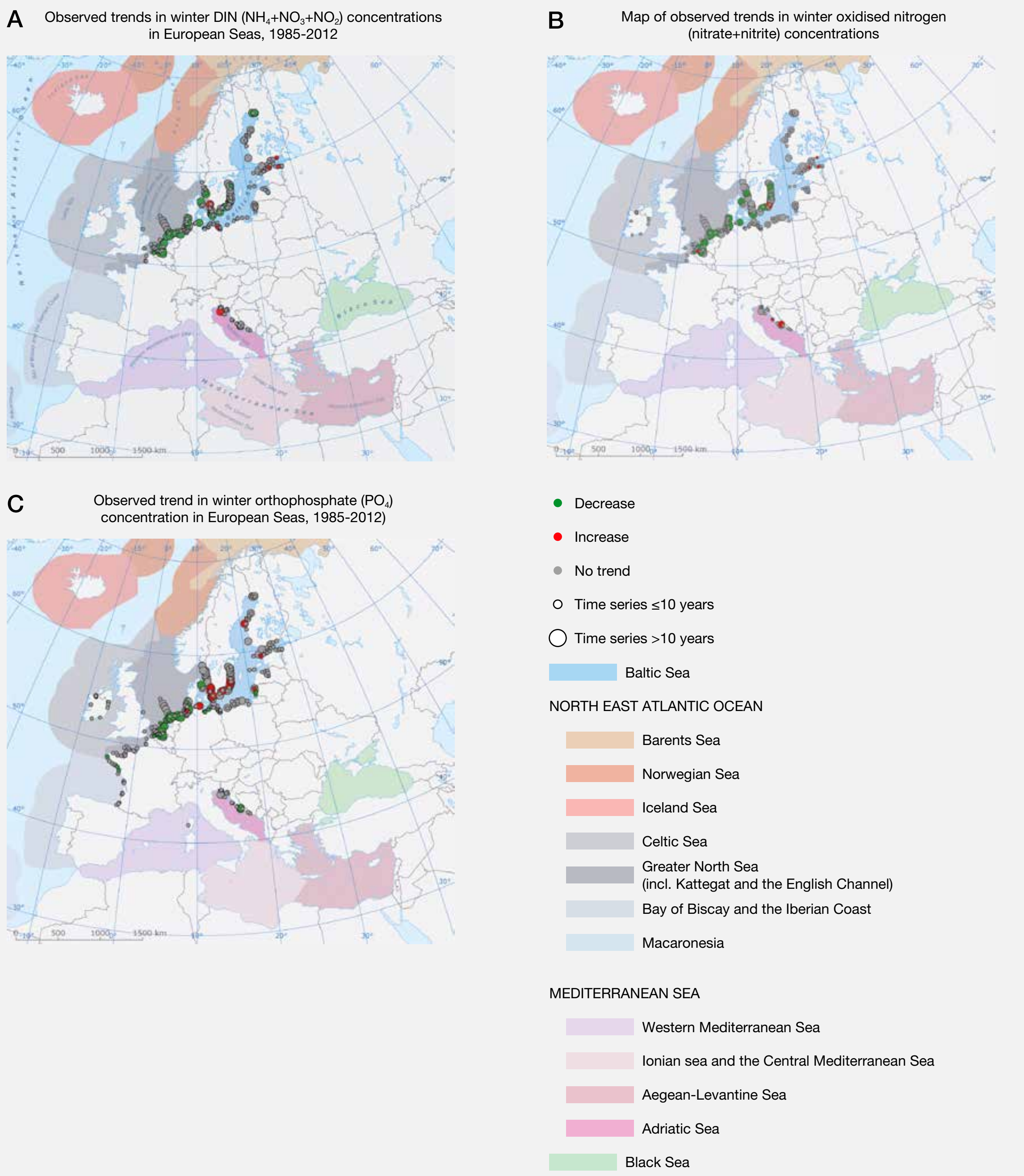
This contribution from nature to people relates to: (i) the central role of soils, which have high levels of biodiversity and which are crucial to several other contributions such as food and feed provision, freshwater quantity and quality regulation, climate regulation, hazards regulation; and (ii) the control of erosion. In addition, threats to soil such as erosion, loss of organic matter and biodiversity contamination, salinization, compaction, acidification and sealing) can severely decrease the ability of soils to deliver this contribution (FAO, 2015b).

2.2.1.8.1 Soil functioning: soil quality

Soil's essential functions are to capture, store and release carbon, nutrients and water; detoxify contaminants and purify water; degrade and recycle wastes; control pests; host a wide diversity of organisms; and create habitat for roots, fungi and invertebrates. The capacity of soil to perform these functions is called soil quality (Karlen *et al.*, 1997). Soil's quality depends on its inherent physical, biological and chemical properties. Soil biota play a major role in this regard (European Commission, 2016b).

Several indicators are used for soil quality (Karlen *et al.*, 1997; European Commission, 2014b), soil fertility (e.g., Burkhard *et al.*, 2014; Mueller *et al.*, 2014; Tóth *et al.*, 2013), and for soil's ability to naturally attenuate contaminants (e.g., Makó *et al.*, 2017; Stone *et al.*, 2016; Van Wijnen *et al.*, 2012). Soil organic carbon content, a widely used and

Figure 2 12 **Stations of European Seas (Iceland Sea, Norwegian Sea, Celtic Sea, North Sea, Baltic Sea, Bay of Biscay and the Iberian Coast, Mediterranean Sea, Adriatic Sea and Black Sea) with available data for the period reported (1985–2012) showing a statistically significant decrease (green), increase (red) or no trend (grey) of A winter dissolved inorganic nitrogen, B oxidized nitrogen and C orthophosphate concentrations. Source: EEA (2015c).**

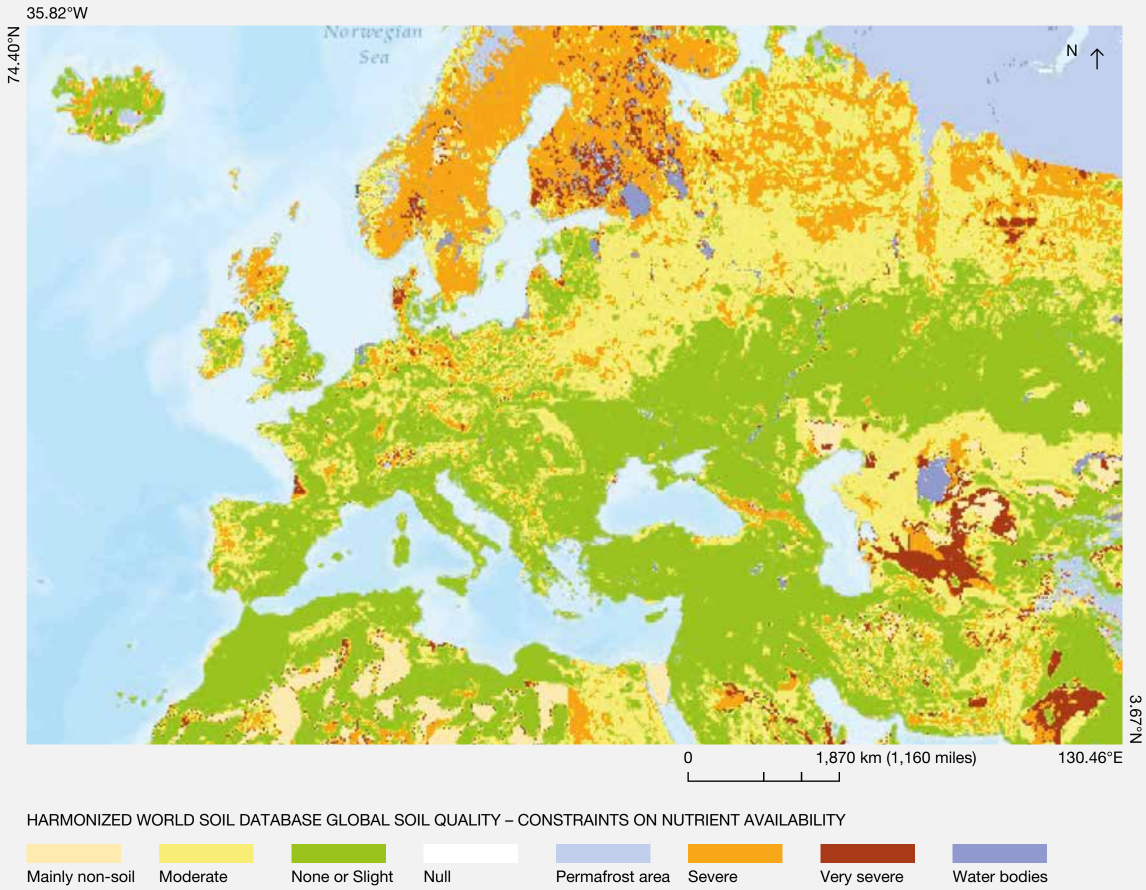


frequently available indicator of soil quality (Lorenz & Lal, 2016) is used here.

Most cultivated soils of Europe and Central Asia are intrinsically fertile except the drylands of Central Asia and salinized soils of Central Asia and Mediterranean Europe (FAO, 2015b; UNEP & UNECE, 2016) **(Figure 2.13)**. The organic carbon content of soils is very variable across land uses and soil types in Europe and Central Asia, generally low in cultivated soil, and high in forest and permanent grassland. Trends also vary with land use. While most grassland soils and forest soils accumulate

Figure 2 13 **Soil quality indicated by constraints on nutrient availability.**

The more fertile the soils, the fewer constraints there are on nutrient availability to plants (none or slight, moderate, severe, very severe) (Fischer *et al.*, 2012). Source: Map extracted from Data Basin at https://databasin.org/datasets/20dcb500682c4ec891e2fc881c2ed65c.



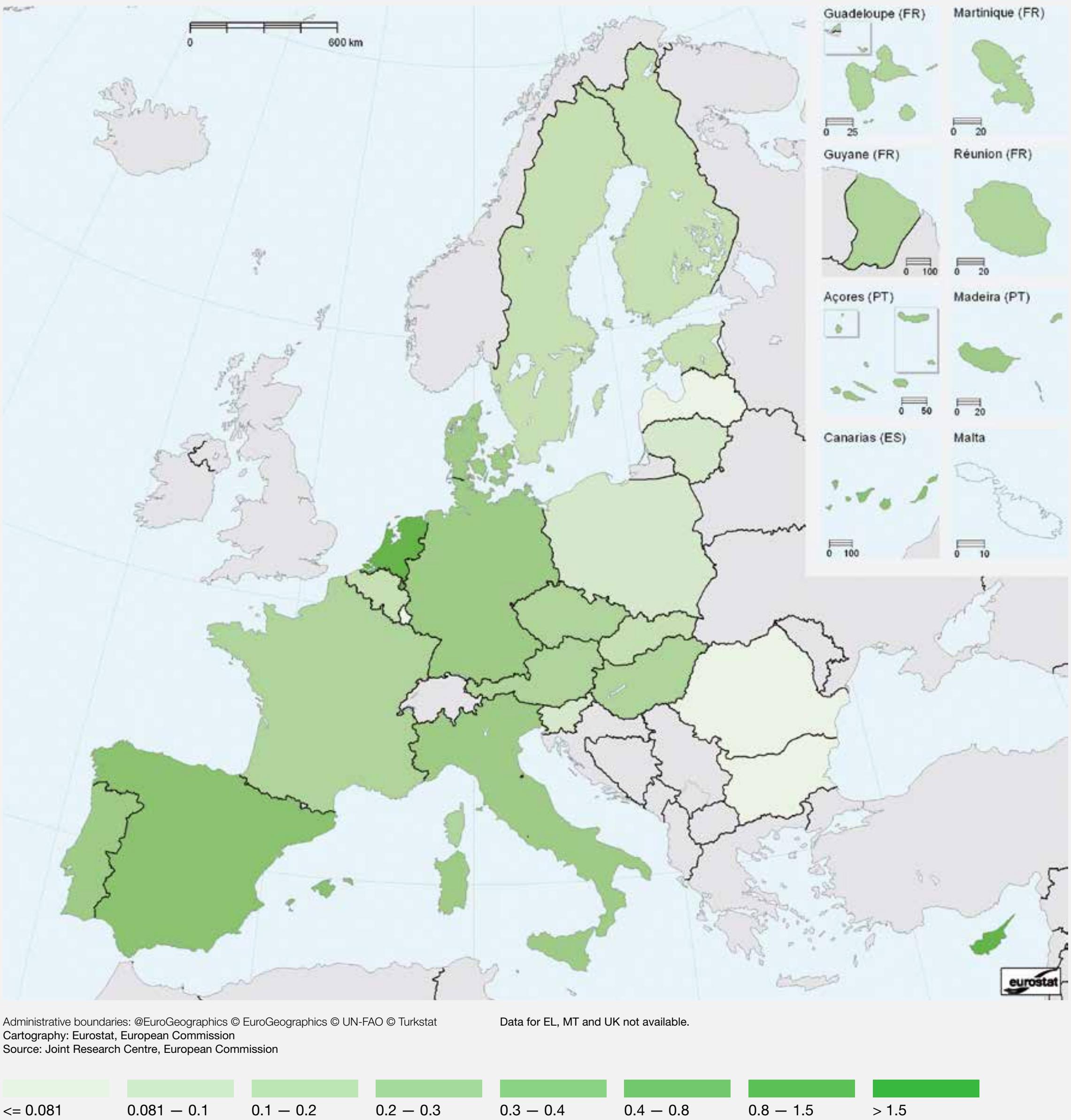
carbon, cultivated soils tend to loose carbon due to previous conversion from grassland or forest to intensive and continuous arable land and to drainage (Jones *et al.*, 2012). This loss has been widely documented in Western Europe (e.g. Capriel, 2013; Goidts & Wesemael, 2007; Heikkinen *et al.*, 2013), in Central Europe where about 70% of Turkish agricultural soils are losing soil organic matter (FAO, 2015b), in Eastern Europe (Sychev *et al.*, 2016) where more than 56 million ha of agricultural mineral soils are losing organic matter (FAO, 2015b), and in Central Asia (Causarano *et al.*, 2011; Sommer & de Pauw, 2011) where the cultivation of virgin lands in Kazakhstan between 1982 and 2000 resulted in the loss of approximately 570 million tonnes of carbon from soils (FAO, 2015b; Sommer & de Pauw, 2011). When alternative cropping practices such as conservation agriculture, organic agriculture or agroforestry are implemented, soil organic carbon loss is reversed, along with soil quality (e.g. Torralba *et al.*, 2016).

Land use changes occurring in Europe and Central Asia since 1990, such as afforestation and large-scale abandonment of cropland in the former USSR, resulted in increases in soil carbon content (Fuchs *et al.*, 2016; Kurganova *et al.*, 2015). A recent trend regarding the maintenance of fertile soils in Europe and Central Asia is the net loss of soil due to urbanization and sealing that occurs predominantly in Western Europe (Montanarella *et al.*, 2015; EEA 2015) and preferentially at the expense of cropland **(Figure 2.14)** (EEA, 2015b).

2.2.1.8.2 Erosion control

Soil erosion is the accelerated removal of soil from the land surface by water, wind or tillage. It threatens the sustainability of agriculture and forestry because of the loss of fertile topsoil, as well as causing damages off-site to settlements and infrastructure and affects the quality of surface waters. The severity of water erosion depends mainly on slope, soil erodibility, and soil cover by plants and litter (Lal, 2001b). Wind erosion depends on soil erodibility and soil cover (Lal, 2001a). Erosion, therefore, takes place mainly on vegetation-free surfaces and, therefore, primarily affects arable land. Soil erodibility depends particularly on soil texture and soil organic matter content (Le Bissonnais & Arrouays, 1997).

Figure 2 14 **Change in agricultural land use expressed as a percentage of total agricultural area (%). 2000–2006, EU-27. On average 50% of land conversion in the European Union is at the expense of agricultural land. Source: Eurostat (2017).**



Administrative boundaries: @EuroGeographics © EuroGeographics © UN-FAO © Turkstat
Cartography: Eurostat, European Commission
Source: Joint Research Centre, European Commission

Data for EL, MT and UK not available.

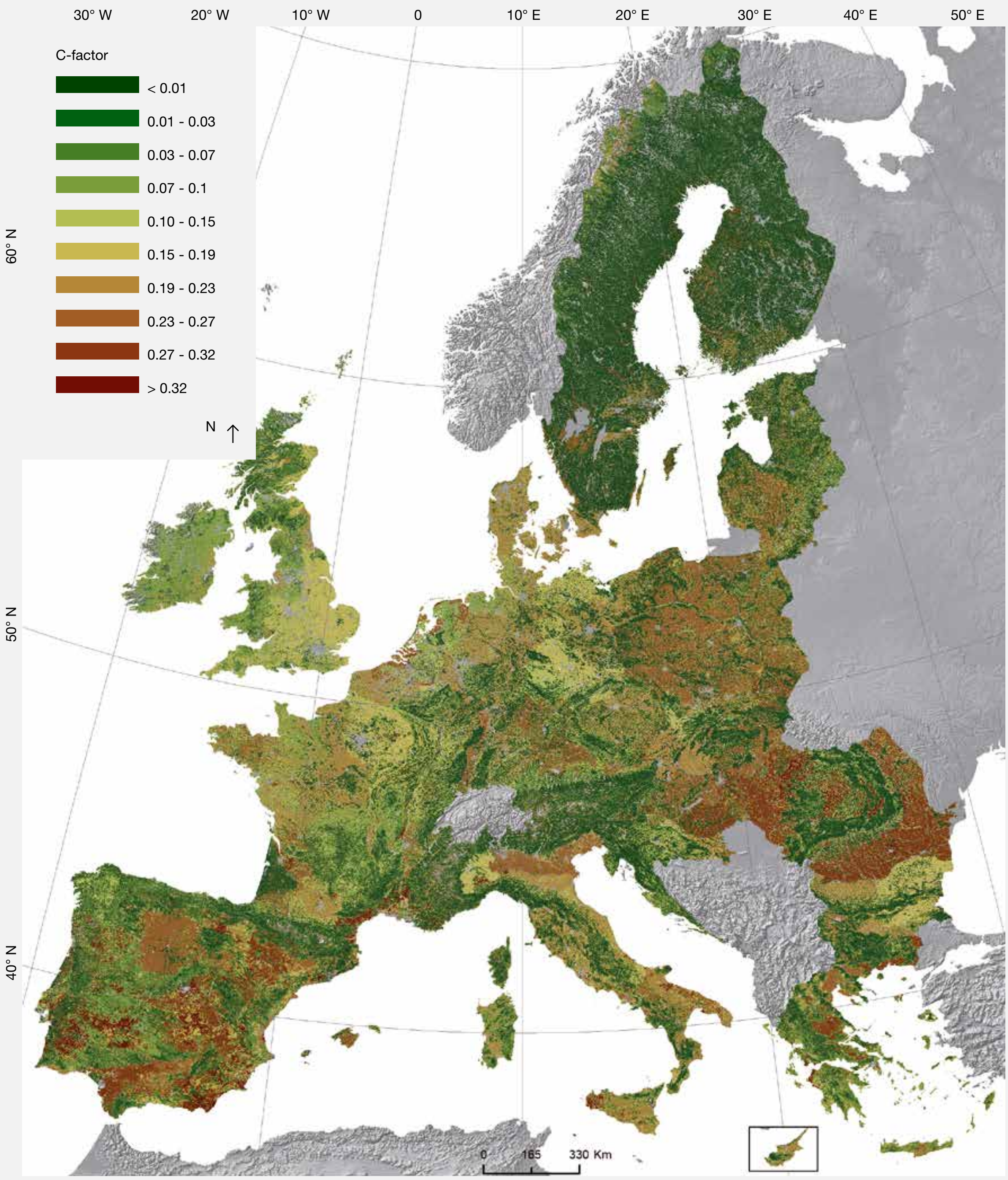
Erosion is the main soil degradation process in Europe and Central Asia (Stolte *et al.*, 2015). Water erosion dominates and affects a quarter of the EU-27 surface area (Jones *et al.*, 2012; Panagos *et al.*, 2015b), 26% of agricultural land in Russia (or 3.5% of total land) (FAO, 2015b) and about 30% of agricultural land in Moldova and Ukraine (FAO, 2015b). Wind erosion is less important in Western and Central Europe, affecting 10% of surface area (Borrelli *et al.*, 2014; Jones *et al.*, 2012), but dominates in Central Asia, where 23% of agricultural land is affected - nearly 80% of that in Uzbekistan (FAO, 2015b).

Erosion control can be defined as the erosion avoided due to the vegetation cover or to a well-aggregated soil (Guerra *et al.*, 2016). The soil cover factor (C) of the "universal soil loss equation" model for water erosion or its revised version, accounting for the effect of vegetation on water erosion, is used as an indicator of the capacity to control erosion (European Commission, 2014b; Panagos *et al.*, 2015a). In the Mapping and Assessment of Ecosystem Services project, erosion control by vegetation was estimated as: (i) the difference of eroded soil with and without vegetation; and (ii) the capacity of ecosystems to avoid erosion (European Commission, 2015b).

Vegetation cover is very heterogeneous in the EU-27 **(Figure 2.15)** (Panagos *et al.*, 2015a) and in Eastern Europe and Central Asia **(Figure 2.16)** in relation to climate. With a lower C factor, the capacity of ecosystems to avoid soil erosion is thus lower in Mediterranean areas of Europe and Central Asia **(Figure 2.17)** (Kulikov *et al.*, 2016). Vegetated soil cover has decreased in many areas of Europe and Central Asia in relation to intensive cultivation, rangeland degradation and desertification (FAO, 2015b; Gupta *et al.*, 2009; Le *et al.*, 2014). Management practices such as conservation agriculture, cover crops and residue return, when implemented locally, increased the C factor (Holland, 2004; Panagos *et al.*, 2016; Panagos *et al.*, 2015a).

Figure 2 15 **Soil erosion cover management factor (C factor) for the European Union. Source: Panagos *et al.* (2015a).**

This factor, which decreases with soil cover (1 to 0) is a multiplicative factor to estimate the amount of eroded soil per unit surface using the revised universal soil loss equation (RUSLE) model.



Erosion control decreased on agricultural land over the last two decades in Europe and Central Asia and is still decreasing in many areas of Central Asia (FAO, 2015b; Gupta *et al.*, 2009) and the East European plain in Eastern Europe (FAO, 2015b; Golosov *et al.*, 2011; Sorokin *et al.*, 2016). By contrast, erosion control has increased in the EU-27 between 2000 and 2010 by an average of 9.5%, and by 20% for arable lands (Panagos, *et al.*, 2015b) and in Mediterranean Europe between 2001 and 2013 (Guerra *et al.*, 2016). Common Agricultural Policy intervention measures, promoting practices such as reduced tillage, residue return, cover crops,

Figure 2 16 **Soil erosion cover management factor (C factor) for Eastern Europe and Central Asia. Source: Nachtergaele *et al.* (2010).**

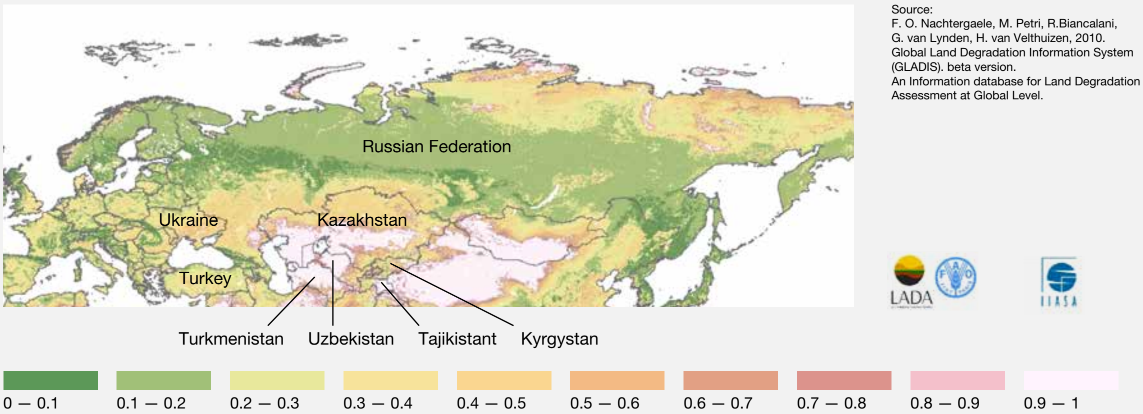
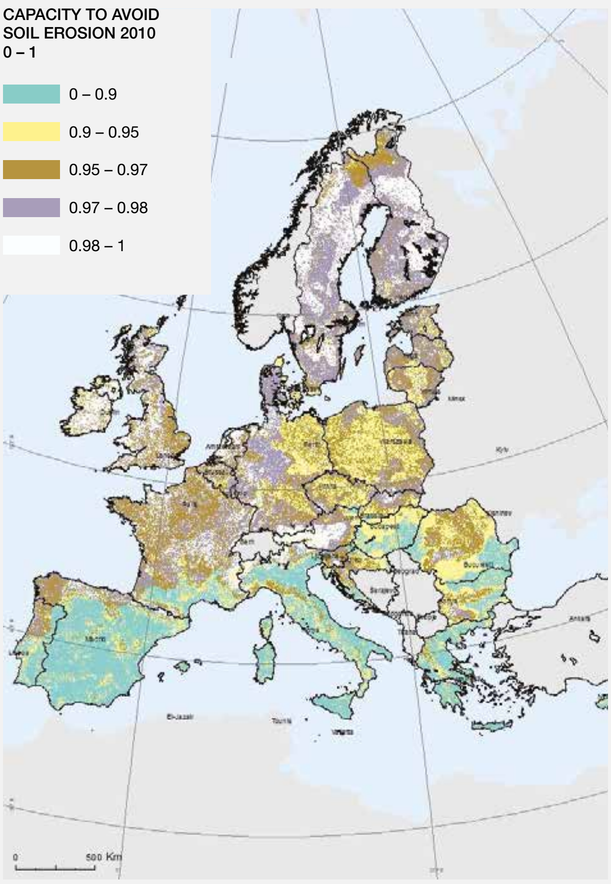


Figure 2 17 **Capacity of ecosystems to avoid erosion (0= lowest capacity; 1=highest capacity). Source: European Commission (2015b).**



conservation agriculture, contour farming and grass strips can explain this trend (Panagos, *et al.*, 2015b). In Central Asia, the surface area of cropland under conservation agriculture, albeit very small, has more than doubled between 2007 and 2011 (Buhlmann *et al.*, 2010; Nurbekov *et al.*, 2016).

2.2.1.9 Regulation of natural hazards and extreme events

The Europe and Central Asia region is exposed to a range of natural hazards, including droughts, floods, landslides and avalanches, storms and wildfires. In the European Union, floods account for 40% of the damages by natural hazards and affect 50% of the population (European Commission, 2015c). With flooding being the most damaging natural hazard, this section focuses on trends of coastal and fluvial flood regulation, while we first briefly report on the general trends in the regulation of other natural hazards. Note that information on nature's capacity to regulate natural hazards is generally lacking for Europe and Central Asia, while information on the occurrence of natural hazards is more abundant.

The severity, frequency and persistence of meteorological and hydrological droughts have increased in Europe and Central Asia since the 1960s, although there are large differences across the region (EEA, 2016d; EM-DAT, 2017). Drought frequency in south-western and central Mediterranean Europe has increased, but has decreased in northern parts of Western Europe and parts of Eastern Europe (EEA, 2016d). The continued degradation and decline of wetland area (Section 2.2.1.7) has contributed to the reduced capacity to regulate droughts (Kumar *et al.*, 2017).

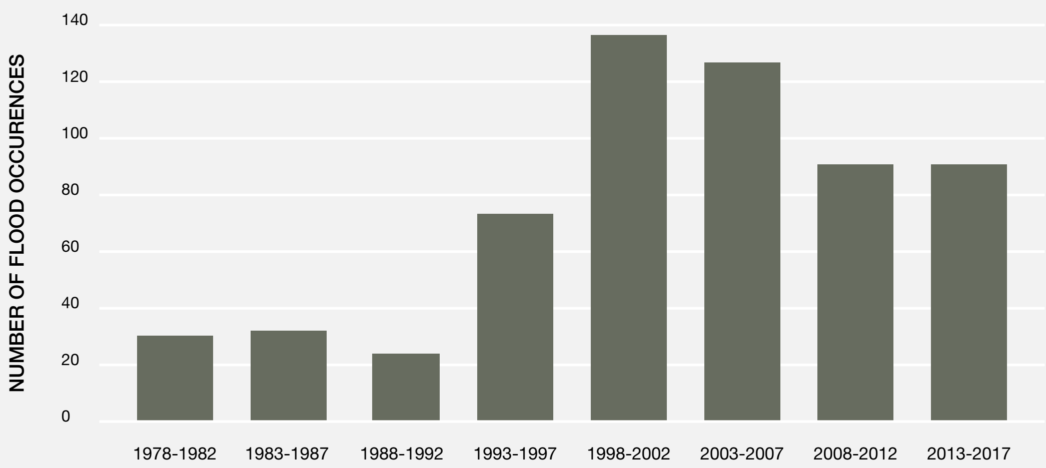
The severity and frequency of landslides and avalanches have mixed trends for the region (EM-DAT, 2017), while an increase in fatal landslides is observed for Western, Central and Eastern Europe (Haque *et al.*, 2016). The regulation of landslides is directly related to the amount of protected forest cover, especially in mountainous areas, and their protection status has changed little in recent decades (Miura *et al.*, 2015).

The frequency and severity of wildfires has generally increased throughout Europe and Central Asia (EM-DAT, 2017) and this trend continues, notably in Eastern Europe (Gauthier *et al.*, 2015) and causing changes in Mediterranean forests (Pausas *et al.*, 2008). The regulation of wildfires depends strongly on the plant composition of forests, protective forest management, and preservation of forest health, the latter being negatively affected by climate change.

In coastal areas, floods are caused by storm surges and sea level rise, whereas fluvial flooding predominantly occurs due to intensive and enduring rainfall within a catchment (Reed, 2002). Nature's capacity to attenuate flooding is reported in terms of the extent to which floods are regulated, whereas the occurrence and severity of floods, as well as the damage caused. The impact of natural hazards depends on the number of people affected, which is increasing as more people live in risk prone areas, such as river floodplains or coastal areas (Dawson *et al.*, 2009).

Information on nature's capacity to regulate floods in Europe and Central Asia is limited and generally shows a mixed trend. Increasing trends are reported for some countries of the European Union and Russia since the 2000s (European Commission, 2015b), but decreasing trends are reported

Figure 2 18 **Trends of flood occurrence for Europe and Central Asia. Source: Own representation based on EM-DAT (2017).**



for densely populated areas with intense rainfall and where most floodplain landscapes and wetlands have been heavily transformed (Heintz *et al.*, 2012; Solín *et al.*, 2011). In addition, the frequency and intensity of floods increased significantly from the 1980s to 2000, after which the number of floods stabilized at a high occurrence and severity (EEA, 2016b; EM-DAT, 2017) (see **Figure 2.18**). Almost 1,500 river floods have been reported for the European Union since 1980, of which more than half have occurred since 2000 (EEA, 2016b), although this increasing trend has a large inter-annual variability (EEA, 2016b; EM-DAT, 2017). The increasing number of severe floods is related to higher frequency of heavy precipitation events and decreased capacity to regulate fluvial floods.

Although there are reported increasing trends for flood regulation for some Western European countries since the 2000s (European Commission, 2015b), general trends are mixed and not well established. However, the number of coastal and river floods in Western Europe has increased since the 1980s, with a strong peak in 2000, and has remained stable but fluctuating in the last decade (EEA, 2016b; EM-DAT, 2017). The strongest increase in number of floods was reported for the southern part of Western Europe, while this number has decreased for most of the northern countries in this subregion (EM-DAT, 2017). The number of severe and very severe floods follows the same trend, with the sharpest increases reported for Spain, Germany and France (EEA, 2016b). Western European countries, such as Germany and France, are ranked among the 20 countries world-wide most affected by weather-related catastrophes in the past 20 years, including floods or landslides after heavy rains (Kreft *et al.*, 2016). The most affected countries in the period 1995-2014 in terms of deaths caused by these climate-change events were Italy, Spain and France (Kreft *et al.*, 2016).

In Central Europe, increasing trends for flood regulation since the 2000s are reported (European Commission, 2015b), but general trends are mixed. Studies in Bulgaria, Hungary and Poland demonstrated decreased flood regulation over time, in addition to increases in precipitation (Acreman *et al.*, 2007; Mrozik, 2016; Pehlivanov *et al.*, 2014). The number of floods in Central Europe has increased significantly since the 1980s, and this trend has continued in the last decade (EEA, 2016b; EM-DAT, 2017). The number of severe river floods follows the same trend, with the sharpest increase reported for Bulgaria, Poland and Slovenia (EEA, 2016b). Periodic overload of drainage systems and local inundations were reported for Poland, as a result of transformation of areas of permeable surfaces (arable land) into impermeable areas (built-up areas) (Mrozik, 2016). Mixed trends of flood frequency were reported for Slovakia, while land cover change negatively affected the capacity to regulate floods (Solín *et al.*, 2011). In addition, the Central European subregion, particularly Romania and Slovenia, has suffered higher damage due to climate-change events than Western Europe (Kreft *et al.*, 2016).

No clear trends in flood regulation have been reported for Eastern Europe. However, the loss of forests and woodlands is assumed to negatively impact the capacity for natural flood mitigation (Bradshaw *et al.*, 2007; Schmalz *et al.*, 2016). In the Danube River Basin, the extent of floodplains has been reduced to 68% of their pre-regulation extent (Hein *et al.*, 2016). Overall, the number and intensity of floods in Eastern Europe has increased greatly since the 1980s, with a peak in 2000, and has remained mixed in the last decade (EM-DAT, 2017). Regular severe floods have been reported throughout the subregion including for Russia (EM-DAT, 2017). Russia has also been among the most affected countries in the period 1995-2014 in terms of deaths caused by extreme climatic events (Kreft *et al.*, 2016).

No clear trends in flood regulation have been reported for Central Asia. The overall number and intensity of floods in the subregion has increased slightly since the 1990s, but has remained stable over the past decade (EM-DAT, 2017). Severe floods have been reported almost annually (EM-DAT, 2017).

Global warming and sea level rise are projected to increase the occurrence and frequency of flood events in large parts of continental Europe (EEA, 2016b; European Commission, 2015c). In addition, coastal flooding is expected to increase especially on the Mediterranean coast (Buyck *et al.*, 2015; European Commission, 2015c). People and their quality of life are increasingly exposed as the capacity to regulate and mitigate floods is likely to continue to decrease with current urbanization trends (Zedler & Kercher, 2005).

2.2.1.10 Regulation of detrimental processes: removal of animal carcasses

Vertebrate scavengers in Europe and Central Asia are represented by old world vultures, which are obligate scavengers that depend totally on carrion, and facultative scavengers, i.e. mostly mammalian carnivores, suids, raptors and corvids, which exploit carrion opportunistically (Moleón *et al.*, 2014). There are five vulture species in Europe and Central Asia: griffon *(Gyps fulvus)*, Himalayan (*G. himalayensis)*, cinereous *(Aegypius monachus)*, Egyptian *(Neophron percnopterus)* and bearded vulture *(Gypaetus barbatus).* Vultures and particularly griffons (the most abundant species in the region) are especially efficient in locating and consuming carcasses (Morales-Reyes *et al.*, 2017c; Sebastián-González *et al.*, 2015) but, within Europe and Central Asia, their range is limited to the southern parts of Western, Central and Eastern Europe and Central Asia. Other raptors, particularly eagles (*Aquila* spp.) and kites (*Milvus* spp.), together with corvids (mainly *Corvus* spp.) are also key scavengers in Europe and Central Asia. Among mammalian facultative scavengers, canids (e.g., wolves *Canis lupus*, jackals *C. aureus*, and foxes *Vulpes* spp. and *Alopex lagopus*), bears *(Ursus arctos)*, wolverines *(Gulo gulo)*, and wild boars *(Sus scrofa)* are important for scavenging (Mateo-Tomás *et al.*, 2015). Empirical evidence suggests that scavenging networks that include obligate scavengers are more efficient in the removal of carrion, including wild animal and livestock carcasses (Moleón *et al.*, 2014; Morales-Reyes *et al.*, 2017c; Sebastián-González *et al.*, 2015). In Europe and Central Asia, vertebrate scavengers remove an important fraction of the carrion biomass available (DeVault *et al.*, 2003; DeVault *et al.*, 2016; Mateo-Tomás *et al.*, 2015), contribute to pest and disease regulation (Ogada *et al.*, 2012) and nutrient cycling (Beasley *et al.*, 2015; Wilson & Wolkovich, 2011). Indigenous and local knowledge holders also describe the role of vertebrate scavengers in providing this contribution from nature to people: *"Even beasts are made by God and have a purpose, even the bad ones like wolves, they have their own role, they eat the corpses of dead animals, and they cleanse the landscape."* (Ivascu & Rakosy, 2017) (See supporting material Appendix 2.2)[11].

Most scientific evidence about the role of scavengers in carcass removal is from Western Europe, coinciding with the largest populations of vultures in this subregion (Margalida *et al.*, 2010). For example, it has been estimated that the Spanish vulture population removes between 134 and 200 tonnes of bones and between 5,551 and 8,326 tonnes of carrion from the landscape every year (Margalida & Colomer, 2012). In addition, the artificial removal of extensive livestock carcasses in Spain imposed by sanitary European Union regulations (Margalida *et al.*, 2010) meant the emission of over 77,000 tonnes of CO_2 eq. to the atmosphere per year and the annual payment of about $50 million to insurance companies by farmers and administrations (Morales-Reyes *et al.*, 2015). In the Massif Central (France) alone, up to 33.1 tonnes of CO_2 per year could be saved if vultures were allowed to access livestock carcasses (Dupont *et al*., 2012). In Central Europe, particularly in Serbia, jackals annually remove more than 3,700 tonnes of animal remains (Ćirović *et al.*, 2016).

The population of obligate and facultative scavengers determines the capacity for carcasses removal. Vultures have suffered sharp declines in Europe and Central Asia due to intended and unintended poisoning (e.g. Mateo-Tomás *et al.*, 2012), electric infrastructures such as wind farms and electric pylons (Carrete *et al.*, 2009; Sánchez-Zapata *et al.*, 2016) and, occasionally, veterinary drugs such as diclofenac (Green *et al.*, 2016; Margalida *et al.*, 2014a; Margalida *et al.*, 2014b). In fact, avian scavengers are the most threatened functional group of birds in Europe and Central Asia (Sekercioglu *et al.*, 2004). However, the trends of vulture populations vary across Europe and Central Asia (see **Table 2.3**, supporting material Appendix 2.4[12]). In Western Europe, where the major strongholds of vultures exist, particularly in Spain (home to >90% of European vultures; Margalida *et al., 2010*), vultures have recovered over recent decades after strong declines since the 1950s (Donázar *et al.*, 2016) due to reintroduction and conservation programmes (e.g. Eliotout *et al.*, 2007; Xirouchakis, 2010). By contrast, the situation of vultures in Central Europe is critical, although different conservation programmes seek to recover their populations (e.g. Demerdzhiev *et al.*, 2014; Grubač *et al.*, 2014; Kirazli & Yamac, 2013). Available information for Eastern Europe and Central Asia is very scarce for obligate scavengers, while facultative scavengers overall exhibit an increasing trend in distribution range and population size across these subregions (Chapron *et al.*, 2014; **Table 2.3**, supporting material Appendix 2.4[12]).

There are several drivers that can threaten the supply of this contribution from nature to people including the conflicting policies that might change the capacity of obligate and facultative scavengers to remove animal carcasses. For example, sanitary policies might restrict the access of scavengers to the carcasses of domestic and wild ungulates (Margalida *et al.*, 2010; Margalida & Moleón, 2016). The implementation of sanitary regulations after the outbreak of bovine spongiform encephalopathy in the European Union (Donázar *et al.*, 2009) had a negative impact on vulture conservation (Margalida & Colomer, 2012) and the functional role of facultative scavengers such as kites and wolves (Blanco, 2014; Lagos & Bárcena, 2015). Nevertheless, recent changes in the European Union sanitary regulation have largely improved this situation (Morales-Reyes *et al.*, 2017b). In addition, the intensification in livestock raising and the decline of traditional farming practices may threaten the removal of carcasses by scavengers (Olea & Mateo-Tomás, 2009). Finally, farmers' perceptions and their conflicting relations with facultative scavengers due to livestock predation can influence their tolerance towards these animals (Morales-Reyes *et al.*, 2017a).

The removal of carcasses by scavengers contributes to different dimensions of people's quality of life. The removal of scavengers may increase the incidence of infectious diseases (Ogada *et al.*, 2012). In addition, supplanting the ecosystem service provided by scavengers in agroecosystems with artificial removal of livestock could raise greenhouse gas emissions, with important environmental and economic costs (see above and Morales-Reyes *et al.*, 2015, 2017b). Vulture declines

11. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

12. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.4_avian_scavengers_trends.pdf

Table 2 3 **Conservation status (according to IUCN Red List categories) and population trend of main scavenger species (species selection based on Mateo-Tomás *et al.*, 2015) per subregion of Europe and Central Asia. Trends are reported as: increasing (+); decreasing (–); stable (0); fluctuating (F); heterogeneous trend within the subregion (mixed; see supporting material Appendix 2.4[12] for additional details of avian scavengers) or unknown (?). NA: data not available (i.e., there are no populations). Conservation status: EN: endangered; VU: vulnerable; NT: near threatened; LC: least concern. Source: Own representation based on Chapron *et al.* (2014); Deinet *et al.* (2013); Wilson *et al.* (2009); IUCN Red List of Threatened Species. Version 2017-1. www.iucnredlist.org; BirdLife International http://datazone.birdlife.org/info/euroredlist.**

Common name	Scientific name	Scavenger group	Functional group	Conservation status	Current population trend	Western Europe	Central Europe	Eastern Europe	Central Asia
Bearded vulture	*Gypaetus barbatus*	Vulture	Obligate scavenger	NT	–	mixed	mixed	mixed	?
Griffon vulture	*Gyps fulvus*	Vulture	Obligate scavenger	LC	+	+	mixed	mixed	?
Himalayan vulture	*Gyps himalayensis*	Vulture	Obligate scavenger	NT	0	NA	NA	NA	?
Egyptian vulture	*Neophron percnopterus*	Vulture	Obligate scavenger	EN	–	mixed	mixed	mixed	?
Cinereous vulture	*Aegypius monachus*	Vulture	Obligate scavenger	NT	–	+	mixed	mixed	?
Golden eagle	*Aquila chrysaetos*	Apex predator	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Spanish imperial eagle	*Aquila adalberti*	Apex predator	Facultative scavenger	VU	+	+	NA	NA	NA
Black kite	*Milvus migrans*	Generalists	Facultative scavenger	LC	?	mixed	mixed	mixed	?
Red kite	*Milvus milvus*	Generalists	Facultative scavenger	NT	–	mixed	mixed	mixed	NA
Common buzzard	*Buteo buteo*	Generalists	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Western marsh harrier	*Circus aeruginosus*	Predator	Facultative scavenger	LC	+	mixed	mixed	mixed	?
Raven	*Corvus corax*	Corvids	Facultative scavenger	LC	+	mixed	mixed	mixed	?
Common magpie	*Pica pica*	Corvids	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Carrion crow	*Corvus corone*	Corvids	Facultative scavenger	LC	+	mixed	mixed	mixed	?
Eurasian jay	*Garrulus glandarius*	Corvids	Facultative scavenger	LC	0	mixed	mixed	mixed	?
Yellow-legged gull	*Larus michahellis*	Seabirds	Facultative scavenger	LC	+	mixed	mixed	?	NA
Grey wolf	*Canis lupus*	Apex predator	Facultative scavenger	LC	0	+	+	–	?
Brown bear	*Ursus arctos*	Apex predator	Facultative scavenger	LC	0	+	+	–	?
Polar bear	*Ursus maritimus*	Apex predator	Facultative scavenger	VU	?	–	NA	–	NA
Wolverine	*Gulo gulo*	Generalists	Facultative scavenger	LC	–	+	NA	–	NA
Golden jackal	*Canis aureus*	Generalists	Facultative scavenger	LC	+	+	+	?	?
Red fox	*Vulpes vulpes*	Generalists	Facultative scavenger	LC	0	0	0	0	?
Arctic fox	*Vulpes lagopus*	Generalists	Facultative scavenger	LC	0	0	NA	0	NA
Stone marten	*Martes foina*	Generalists	Facultative scavenger	LC	0	0	0	0	?

Common name	Scientific name	Scavenger group	Functional group	Conservation status	Current population trend	Western Europe	Central Europe	Eastern Europe	Central Asia
Pine marten	*Martes martes*	Generalists	Facultative scavenger	LC	0	+	+	+	?
Common genet	*Genetta genetta*	Generalists	Facultative scavenger	LC	0	0	NA	NA	NA
Eurasian badger	*Meles meles*	Generalists	Facultative scavenger	LC	0	0	0	0	?
Asian Badger	*Meles leucurus*	Generalists	Facultative scavenger	LC	?	NA	NA	?	?
Egyptian mongoose	*Herpestes ichneumon*	Generalists	Facultative scavenger	LC	0	0	NA	NA	NA
Wild boar	*Sus scrofa*	Omnivore	Facultative scavenger	LC	?	+	+	+	?

also have a negative impact on the cultural identity of farmers and the value they derive from knowing that these species exist (Morales-Reyes *et al.*, 2017a) (see Section 2.2.3.3).

2.2.2 Status and trends of nature's material contributions to people

2.2.2.1 Food and feed

2.2.2.1.1 Food and feed from terrestrial ecosystems

Agroecosystems, including croplands, grasslands and agroforestry systems, cover an important area of Europe and Central Asia, providing crops and animal-derived products that support the region's food security (Section 2.3.1.1) and food culture (see **Box 2.1** and **Box 2.2**). FAOSTAT provides extensive data on the quantity of this contribution delivered by nature to people. However, other terrestrial ecosystems, such as forests and scrublands, also provide food in the form of game, fruits and mushrooms, for which little quantification is available, but see Section 2.2.3.2. Comprehensive data on food quality has not been found, but the relationships between food production and the characteristics of diet and health are explored here and in Sections 2.3.1.1 and 2.3.2.

Overall the agricultural area per capita has been decreasing in Europe and Central Asia since the 1960s, particularly in Western Europe, however, the cultivated area per worker in the agriculture sector has almost tripled in Europe and Central Asia since the 1980s **(Table 2.4)**, a process that goes hand in hand with the mechanization and intensification of agriculture (**Table 2.4**, Section 4.5.2). Particularly, in the Mediterranean basin, quantity and quality of food delivered by agroecosystems is severely influenced by rural abandonment of mountainous and less productive areas and land-use intensification of fertile areas (Caraveli, 2000) (Section 4.5.2).

Food production from agriculture in Europe and Central Asia increased by 56% between the 1960s and the 1990s. It then suffered a decline of 33% until 2014. The three socio-political events that have most influenced these trends are: the dissolution of the USSR in 1989, affecting mostly Central Asia and Eastern Europe (Kraemer *et al.*, 2015); the Yugoslav Wars from 1991 to 1999 disturbing mostly Central Europe; and the Common Agricultural Policy of the European Union and its reforms (particularly since the MacSharry reform in 1992), influencing trends in Western and Central Europe.

The assessment of different agricultural products shows different trends across subregions. Cereals were mostly produced in Eastern Europe, where production has suffered fluctuations in recent decades (see **Figure 2.19**). Among cereals, however, maize is experiencing substantial growth (see **Figure 2.20**) because of its use for biofuel and feed production (see Sections 2.2.2.2 and 2.3.1.4). Fruit has been produced mostly in Western Europe, but Central Asia and Eastern Europe have been increasing their production in the past decade (see **Figure 2.19**). Countries in Eastern Europe are the largest producers of vegetables, which has been experiencing growth (from ca. 4.5 million tonnes in 1991 to more than 7 million tonnes in 2012), as rapidly as in Central Asia (from ca. 1 million tonnes in 1991 to more 3.5 tonnes in 2012) (see **Figure 2.19**). Important crops in Europe are those required for oil production (with increasing trends) and wine (with decreasing trend) (see **Figure 2.19**). Areas for organic agriculture in Western and Central Europe have been increasing since 2005 (in Western Europe from ca. 4% of the total agricultural area to more than 5%; in Central Europe from almost 1% to more than 4%) (see **Figure 2.21**) (FAO, 2017).

Table 2 4 **Historical trends of different indicators used to assess food provision as a contribution from nature to people. Red arrows indicate decreasing, yellow arrows indicate stable, green arrows indicate increasing and black arrows indicate mixed trends. Source: Own elaboration based on different data sources: FAOSTAT (2017); OECD (2017); World Bank (2017).**

CONTRIBUTION	INDICATOR	Western Europe	Central Europe	Eastern Europe	Central Asia	Europe and Central Asia
CROPS	Agricultural area (hectares per capita)	↓	↓	↓	↓	↓
	Cultivated area per agricultural population (hectares per capita)	↑	↑	↑	↕	↑
	Agricultural tractors per 1000 hectares of agricultural area	↕	↕	↓	→	↕
	Permanent crops (% of agricultural area)	↕	↕	↓	→	↕
	Production of cereals per person (kg / person)	↕	↕	↕	↕	↕
	Production of fruit per person - excluding melons (kg / person)	↕	↕	↕	↕	↕
	Fertilizer consumption (kilograms per hectare of arable land)	↕	↕	↓	↕	↕
	Intensity of total pesticides use (tons / hectare of cultivated area)	↕	↕	↕	↕	↕
	Substance use for seed treatment - fungicides and insecticides (tons / hectare of cultivated superficie)	↑	↕	↕	↑	↕
	Total actual renewable water resources withdrawn by agriculture (%)	↕	↓	↕	↓	↕
	Conservation agriculture area (% of cultivated area)	↑			↑	
	Organic agricultural area (% of total agricultural area)	↑	↑	→	→	↑
	Agricultural raw materials exports (% of merchandise exports in dollars)	→	↕	↕	↕	↕
	Agricultural raw materials imports (% of merchandise imports in dollars)	↓	↕	↓	↓	↕
	Cereal production (% of world production)	↕	↕	↕	↕	↕
LIVESTOCK	Domestic mammals per rural inhabitant (except pack animals)	↑	↕	↕	↕	↕
	Poultry animals per rural inhabitant	↕	↕	↕	↕	↕
	Pack animals per square km of agricultural area	↕	↓	↕	↑	↓
	Combine harvesters - threshers per 1000 hectares of agricultural area	↕	↕	↓	→	↕
	Milking machines per head of cattle	↕	↕	↓	↕	↕
	Meadows and permanent pasture (% of agricultural area)	→	↑	↑	→	↑
	Production of meat per person (kg / person)	↕	↕	↕	↕	↕
	Meat production (% of world production)	↓	↕	↕	↕	↕

The production of livestock primary production varies. Meat production increased between 1961 and 1990, when a sharp decline occurred in Eastern and Central Europe due to the dismantling of the Soviet Union (see **Figure 2.22**). However, since the early 2000s the trend changed in Eastern Europe and it is currently producing almost half of the meat in the region. Egg production follows a similar pattern, except in Eastern Europe with an increasing trend since 1996. Milk production has been decreasing since the 1990s (largely due to the introduction by the Common

Figure 2 19 **Historical trends for average country production (tonnes) in each subregion: crop primary production of cereals, fruit (excluding melons) and vegetable crops; and crops processed for olive oil virgin, rapeseed oil, sunflower oil and wine. Note that the vertical axes are on a different scale. Source: Own representation based on data from FAO (2017).**

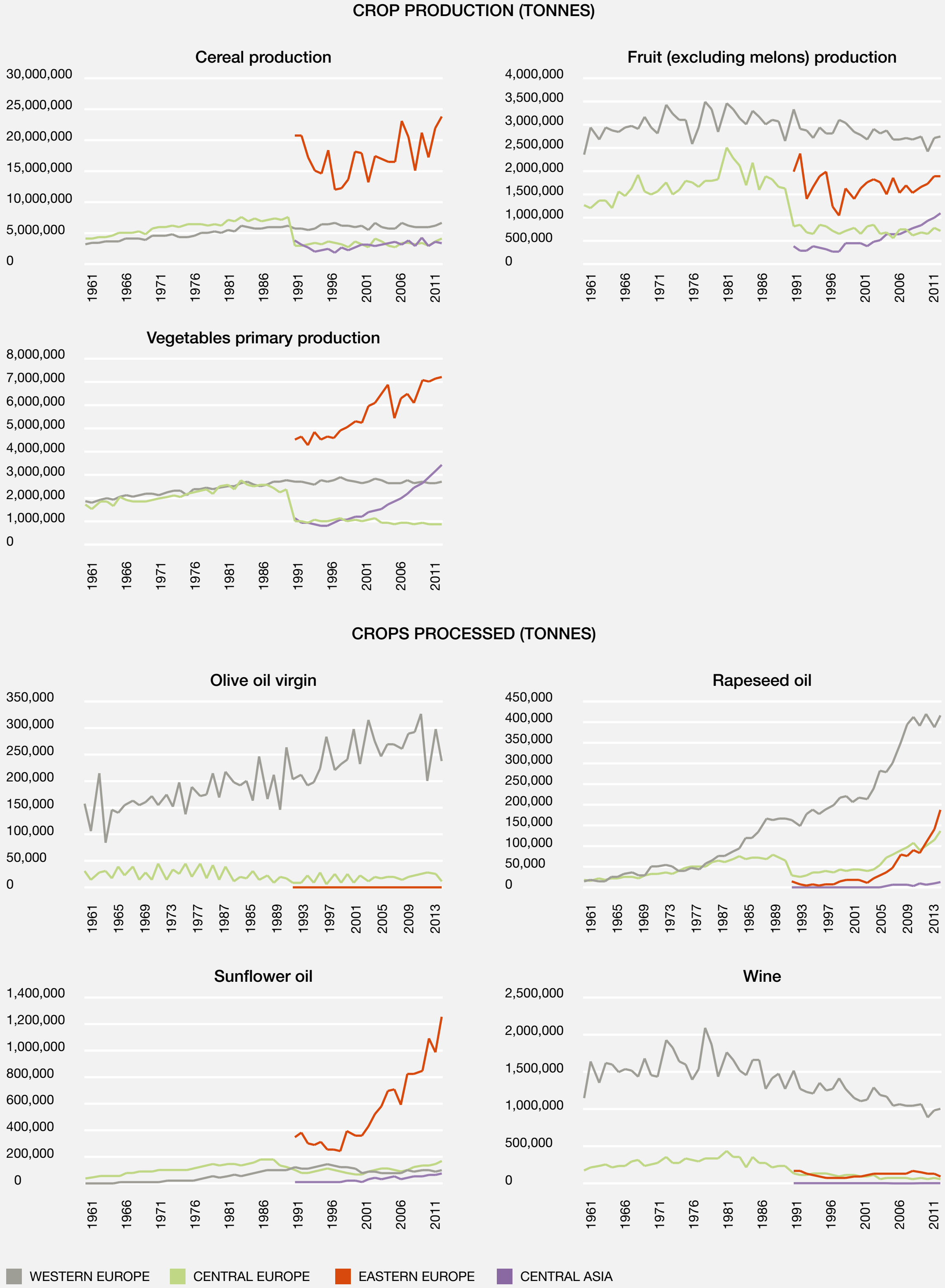


Figure 2 20 **Historical trends for average country production (tonnes) of maize in each subregion. Source: Own representation based on data from FAO (2017).**

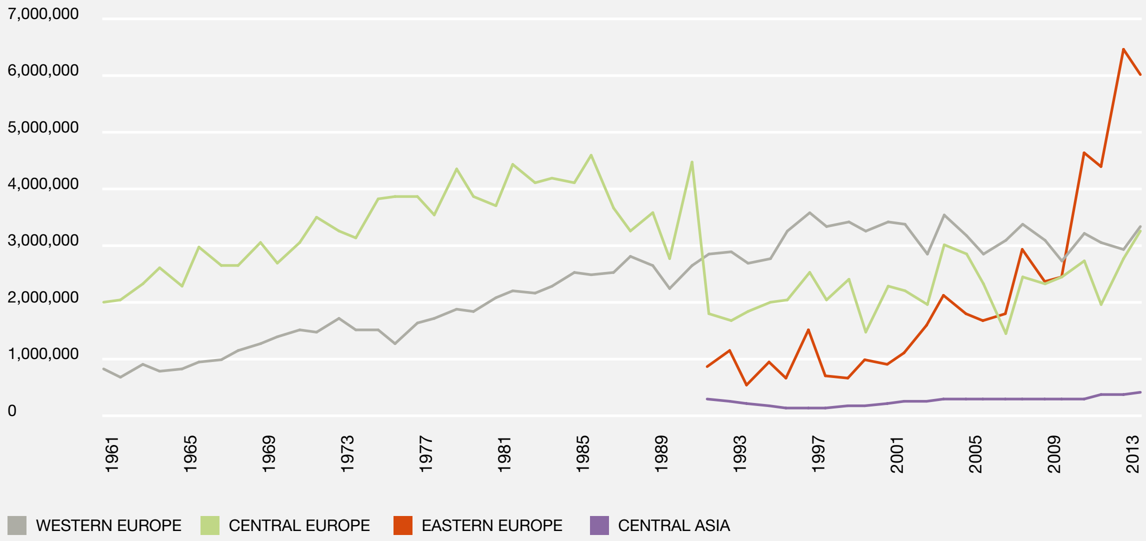
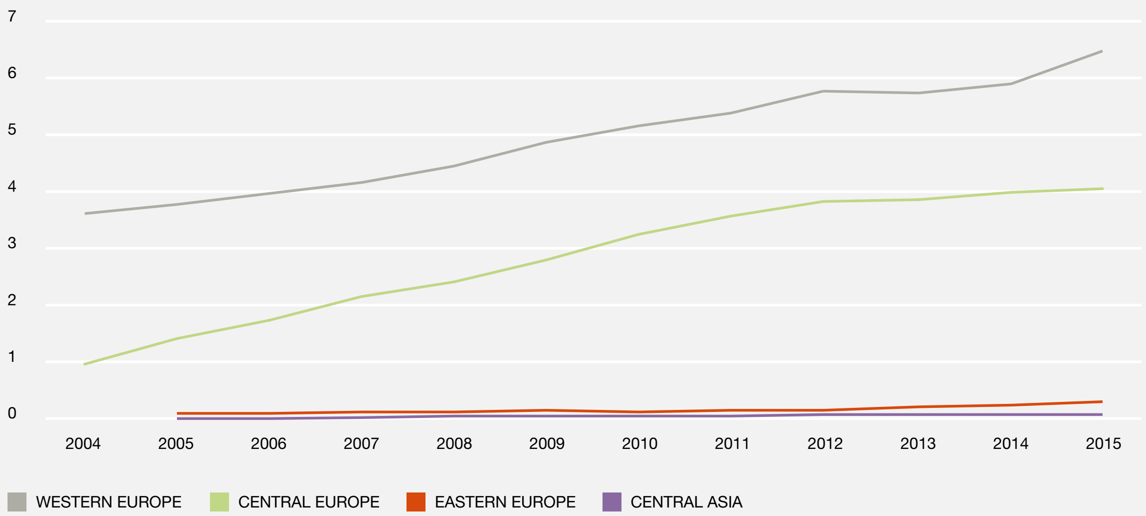


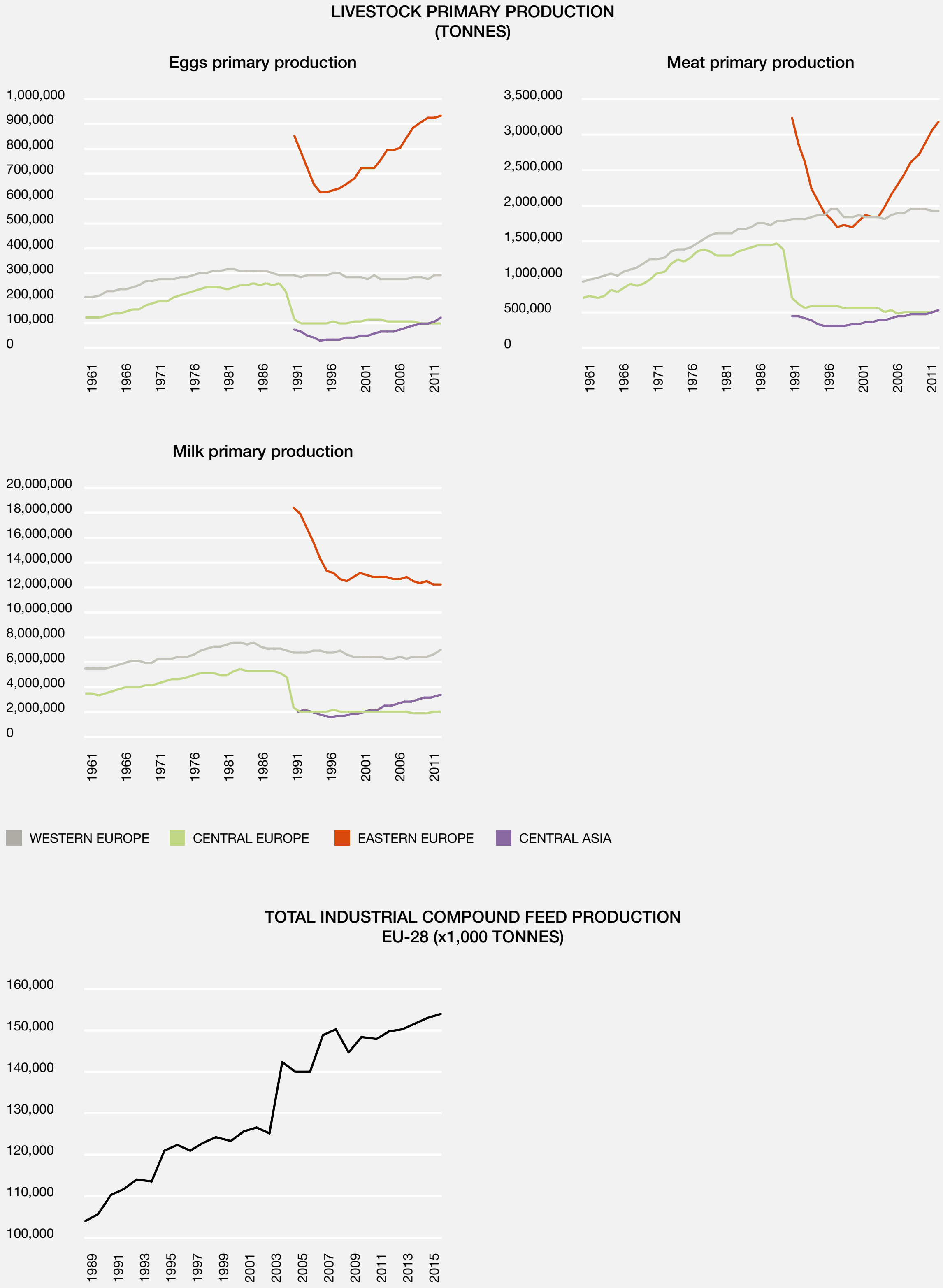
Figure 2 21 **Historical trends of organic agriculture area (% of total agricultural area) in each subregion. Source: Own representation based on data from FAO (2017).**



Agricultural Policy of the European Union of milk quotas), except in Central Asia. The countries with the largest production in the region in 2013 were Russia and Ukraine for eggs, Russia and Germany for meat, and Germany and Russia for milk. The production of livestock feed in EU-28 has experienced a sharp increase of more than 50% over the past three decades, consistent with the intra-regional trade balance of increasing import of ingredients of these feeding compounds such as soybeans, and with the above-mentioned intensification of livestock farming in the European Union.

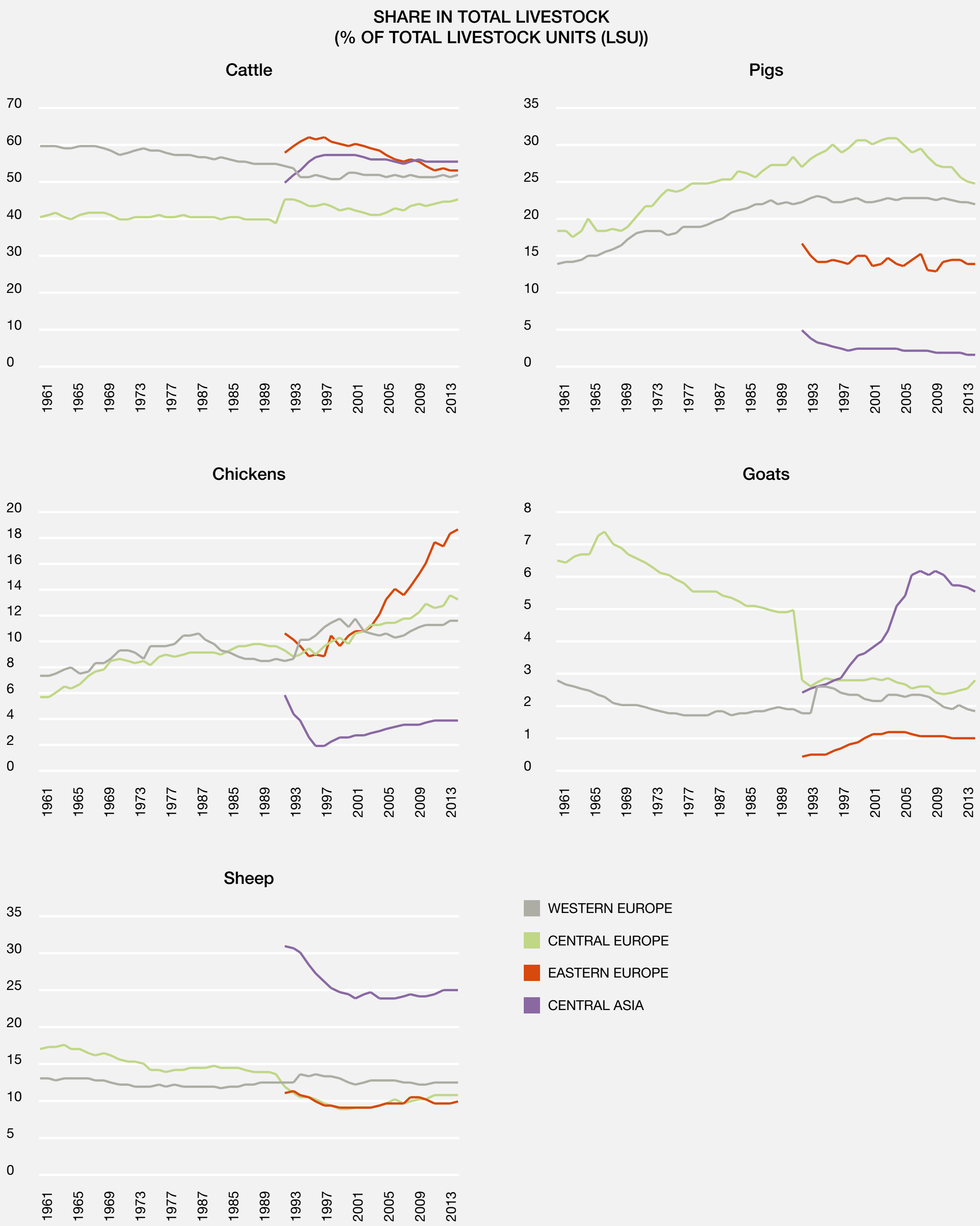
Cattle represent the largest share of livestock animals in Europe and Central Asia (see **Figure 2.23**). In Central Asia, sheep account for about 25% and goats for about 6% of livestock production. In Central Europe, pigs represent the second largest share (25% in 2013), but this has been decreasing since the early 2000s. Chicken account for almost 20% in Eastern Europe, with rapid increases in recent decades. Overall, the trend in the past decade is an increase in chicken production, maintenance of cattle production, and reduction of pigs, goats and sheep **(Figure 2.23)**.

Figure 2 22 **Historical trends for average country production of livestock primary production (tonnes) of eggs, meat and milk in the four subregions and total industrial compound feed in the EU-28. Source: Own representation based on data from FAO (2017) and FEFAC (2017).**



Forests provide nuts, mushrooms, herbs, spices, aromatic plants and game that have been used not only as food, but also for health and cultural purposes for millennia. Yet a recent report by the Food and Agriculture Organization of the United Nations acknowledges that there is a tendency to underestimate their role because they are poorly represented in international statistics, as in most cases their use and trade are confined to the informal sector (Sorrenti,

Figure 2 23 **Historical trends in the share of total livestock represented by cattle, pigs, chicken, goats and sheep in the subregions. Source: Own representation based on data from FAO (2017).**



2017). However, recent studies show that non-timber forest products still form the basis of livelihoods and play a significant role in food, nutrition and as a source of income, particularly in times of deep economic crisis (e.g. Elbakidze *et al.*, 2007).

2.2.2.1.2 Wild capture and cultured aquatic food production

Fishing has a long, rich tradition in Europe and Central Asia (Ståhlberg & Svanberg, 2011), and is still an important source of protein for indigenous people (Demeter, 2017). Across Europe and Central Asia, aquatic ecosystems make an important contribution to people's diets, directly as food and as feed for livestock. The largest contribution of aquatic ecosystems is wild-captured seafood, especially from the highly productive North East Atlantic. Seafood production from this area is 8.9 million tonnes per year (production data from 2014, if not otherwise stated). Wild capture of seafood from the Mediterranean and Black Sea area (restricted to Europe and Central Asian fleets) is much smaller (0.5 million tonnes per year), even when taking the smaller size of this area into account. This is largely due to lower nutrient concentrations in the Mediterranean. In relation to primary production, fisheries are similarly productive in the Mediterranean and Black Sea as, e.g., in the North Sea (Libralato *et al.*, 2008). A decline in production since the turn of the millennium (see **Figure 2.24**) is due to a transition to more sustainable management practices, after a phase of overexploitation where catch limits larger than those scientifically advised were regularly set (Carpenter *et al*., 2016; Hilborn & Ovando, 2014).

Reported production of wild capture food from inland waters in Europe and Central Asia is dominated by freshwater (67%) and diadromous (31%) fisheries. Compared with marine production, wild capture food from inland waters is relatively small at 0.4 million tonnes per year, but it plays an important role especially in Eastern Europe and Central Asia, which are dominated by commercial fisheries (Aps *et al.*, 2004). Data prior to 1988 are insufficient for a regional assessment, but, as **Figure 2.25** shows, production of wild capture food from inland waters in Europe and Central Asia fell from 1988 to 2005, but since then has grown slightly. The decline in production in Eastern Europe since 1988 until the turn of the millennium **(Figure 2.25)** has been attributed to the serious depletion of many open access freshwater fishery resources caused by overfishing and "insufficient control and enforcement (illegal and unreported catches do not appear in statistics)" (Aps *et al.*, 2004).

Contrasting the situation for wild-capture fisheries, production from aquaculture has continuously increased since 1950, with the exception of a brief phase of contraction in Eastern Europe after the socioeconomic transformations around 1990 (see **Figure 2.26**). According

Figure 2 24 **Marine wild-capture seafood production in seas surrounding Europe and Central Asia. Colouring indicates contributions from the North East Atlantic Ocean (FAO Area 27, violet) and Mediterranean and Black Sea (FAO Area 37, grey). Source: Own representation based on data from FAO (2017).**

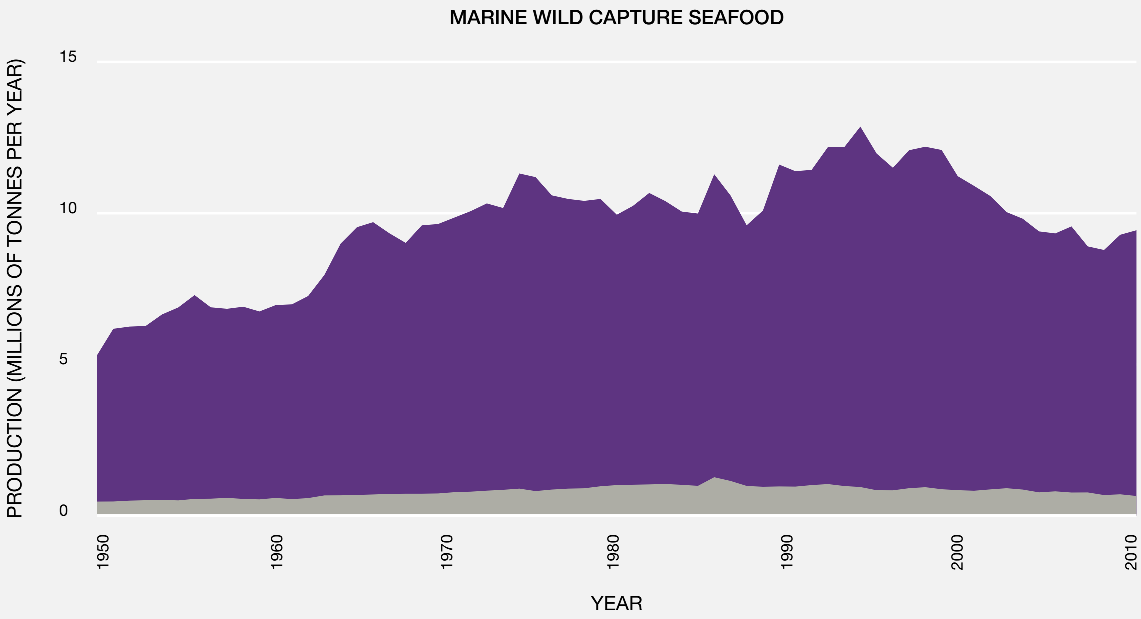


Figure 2 25 **Inland wild capture production of aquatic food in Europe and Central Asia. Colouring indicates contributions from Central Asia (violet), Eastern Europe (orange), northern parts of Central Europe (green), southern parts of Central Europe (white), and Western Europe (grey). Source: Own representation based on data from FAO (2017).**

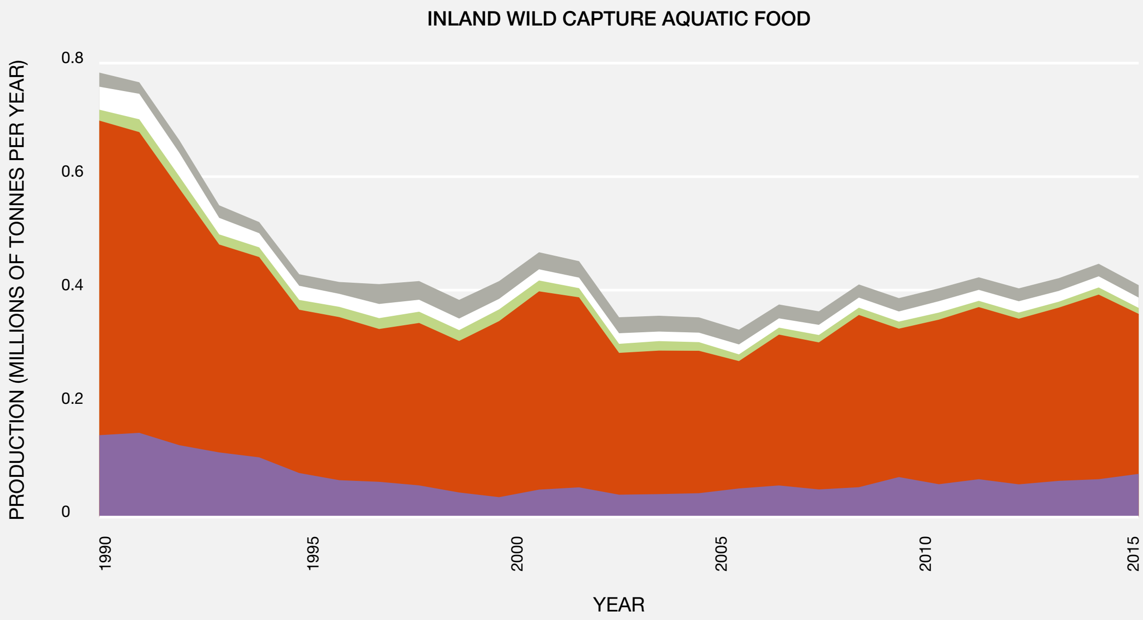
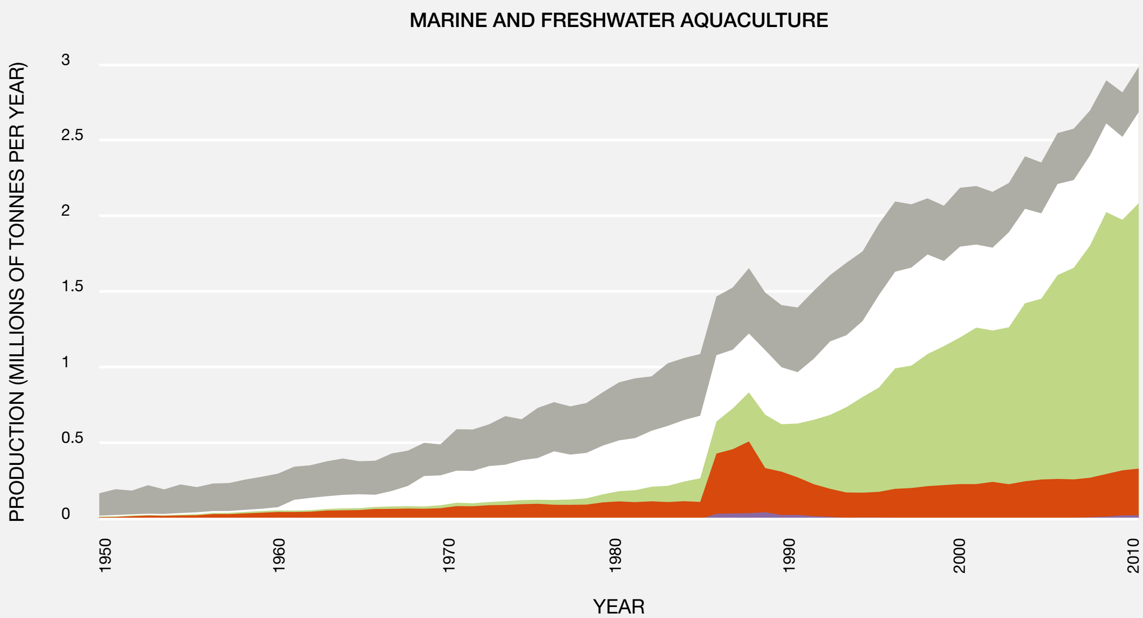


Figure 2 26 **Aquaculture production in Europe and Central Asia. Colouring indicates contributions from Central Asia (violet), Eastern Europe (orange), northern parts of Central Europe (green) and southern parts of Central Europe (white), and Western Europe (grey). Source: Own representation based on data from FAO (2017).**



to these data, production has grown at an average rate of 2.7% per year since 2000 and by 2014 reached 3.0 million tonnes per year. Salmon farming in northern parts of Western and Central Europe made an important contribution to this expansion. Overall, diadromous fish now contribute around 63% to total aquaculture production, followed by molluscs (21%), freshwater fish (10%) and marine (6%) fish. Despite this continuous rise in aquaculture production, Europe and Central Asia lags behind the global rate, where the proportion of aquaculture fish production now contributes 40% of production (FAO, 2014a). This indicates the potential for significant further expansion in Europe and Central Asia. However, as with wild-capture fisheries, aquaculture can have adverse environmental effects that might offset its benefits (Read & Fernandes, 2003).

2.2.2.2 Energy

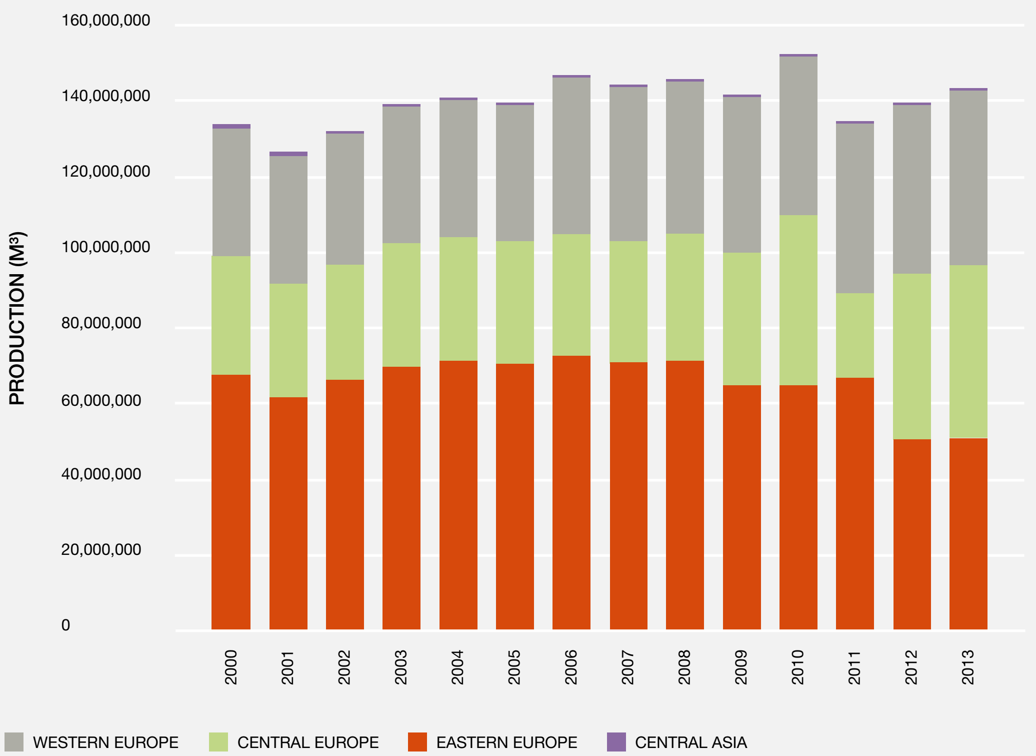
Various forms of biomass can serve as fuel including plants, animal dung, and agricultural residues. Plant matter is used directly or in processed forms such as charcoal and oil. Two forms of biomass-based energy are particularly relevant in Europe and Central Asia and therefore the focus of the following sections: woodfuel and biofuels.

2.2.2.2.1 Woodfuel

Woodfuel (including logs, charcoal, chips, bark, and sawdust) has a high energy density (comparative average values in MJ/kg - woodfuel: 16; charcoal: 28; coal: 30; natural gas: 37 and fuel oil: 4) (IEA, 2004). Its availability, accessibility and renewability make it attractive, especially in rural areas. According to statistics from the Food and Agriculture Organization of the United Nations, overall woodfuel production and consumption has been largely stable since 2000 (see **Figure 2.27**). Within Western Europe, woodfuel use is significant especially in Scandinavia. It is unclear whether the comparatively low woodfuel production in Central Asia according to statistics from the Food and Agriculture Organization of the United Nations (see **Figure 2.27**) (between 2000-2013 it varied between 190,000 and 1,000,000 m^3 p.a.) is due only to biogeographic and climatic differences, or also due to underreporting.

Driven by the European Union's legally binding targets in the Renewable Energy Directive (RED - 2009/28/EC), production of renewable energy within the EU-28 almost doubled between 2004 and 2013. Based on Eurostat, in 2013, total biomass (woodfuel and other biomass including municipal waste) accounted for 65% of the gross inland energy consumption of renewables in the

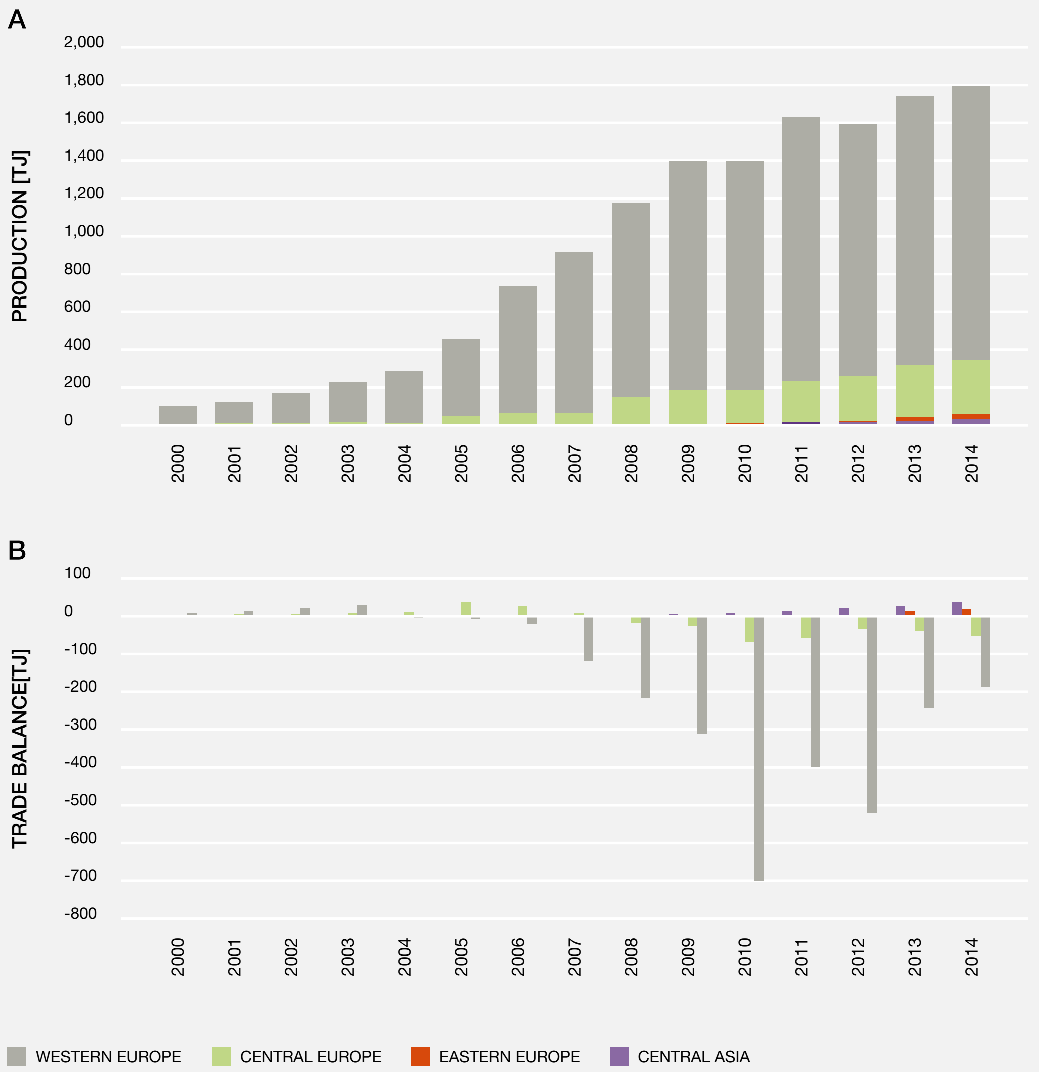
Figure 2 27 **Woodfuel production in Europe and Central Asia between 2000 and 2013. Source: Own representation based on data from FAO (2017).**



EU-28, of which wood and wood wastes contributed the highest share with 45%. Around 23% of the EU-28's total roundwood production of 425 million m³ in 2014 was used as woodfuel (Eurostat, 2017). Among the European Union member States, Sweden produced the most roundwood (70 million m³) in 2014, followed by Finland, Germany and France (each producing between 52 and 57 million m³). More than half of roundwood produced is used as fuel in Denmark, France and Cyprus (2013 and 2014), while Bulgaria, Croatia, Hungary and Lithuania reported proportions between 32 and 46%. However, direct woodfuel use by households is not included in these numbers, which is why they are likely to be underestimates.

In the European Union, woody biomass accounts for almost 50% of renewable energy consumption (Pelkonen *et al.*, 2014). In some widely forested countries, large proportions of total energy consumption originate from forest biomass, for example 30% in Sweden (Hansen & Malmaeus, 2016) and 25% in Finland (Jäppinen & Heliölä, 2015). Due to a long-standing tradition of forestry and forest management in Western and Central Europe, deforestation driven by woodfuel and other wood product extraction is not currently a threat for the region (UNEP & UNECE, 2016). On the other hand, dependence on woody biomass as a source of domestic energy continues to be prominent especially in rural and economically disadvantaged communities in Europe and Central Asia. In Central Asian countries such as Tajikistan,

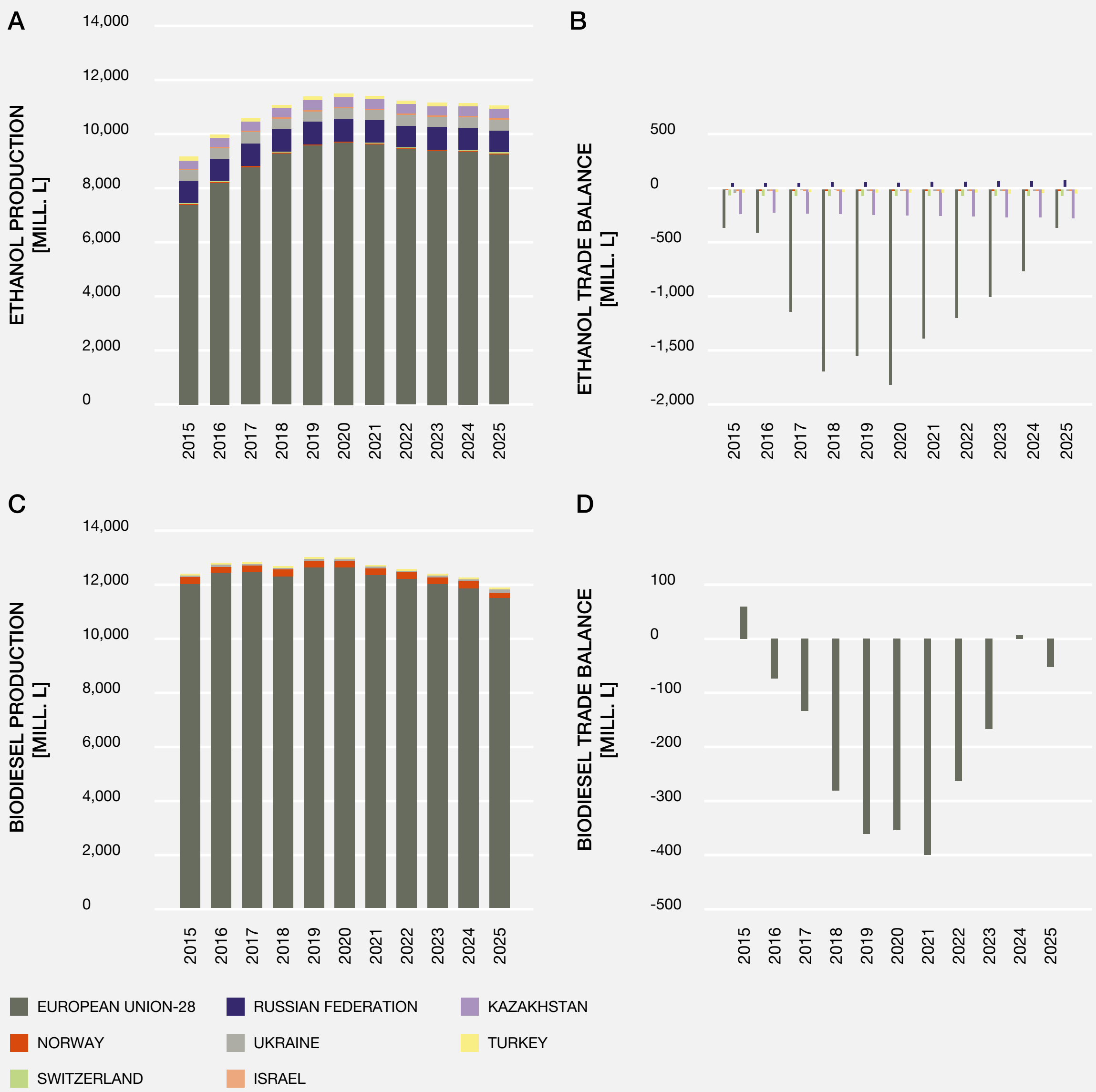
Figure 2 28 **A Biofuel production by regions in Europe and Central Asia from 2000 to 2014. B Trade balance of biofuels by regions in Europe and Central Asia from 2000 to 2014. Source: Own representation based on U.S. Energy Information Administration (2017).**



deforestation continues and overuse of forests for fuel is one of the main reasons for land degradation (Mustaeva *et al.*, 2015). In the Balkans and the South Caucasus, wood remains an important affordable energy source (Adeishvili, 2015). In Albania, for instance, firewood meets one-third or more of the total energy demand for heating and accounts for almost 90% of wood use (Markus-Johansson *et al.*, 2010). In certain areas of Europe and Central Asia, restraining economic conditions lead to considerable illegal woodfuel harvesting. In Turkey, for example, off-the-record logging for woodfuel (estimated 4,300,000 m^3) reached more than half the permissible woodfuel harvests (7,000,000 m^3) in 2010 (Pak *et al.*, 2010). In the Ukraine, the economic recession and the gas crisis caused by the Russian-Ukrainian conflict is reported to have significantly increased firewood thefts (Roué & Molnar, 2017).

Woody biomass demand from countries with ample forest resources such as Sweden and Finland is foreseen to increase (Jonsson, 2013) and generally in Western, Central and Eastern Europe the shift towards a carbon neutral society is expected to further boost the demand for woodfuel (Bostedt *et al.*, 2016). This intensification of biomass removals from forests may have trade-offs in forest productivity, biodiversity and soil quality (Bouget *et al.*, 2012; Verkerk *et al.*, 2014).

Figure 2 29 **A and C Biodiesel and ethanol production in selected countries in Europe and Central Asia from 2015 to 2025. B and D Trade balances of biodiesel and ethanol in selected countries in Europe and Central Asia from 2015 to 2025. Source: Own representation based on OECD-FAO (2016).**



Historically, woodfuel collection is among the earliest uses of forests by humans (Pelkonen *et al.*, 2014). Local ecological knowledge related to forest management is just as rooted in Europe and Central Asia as woodfuel utilization. An example from the communities inhabiting the lowland landscapes of Transcarpathian region *Zakarpats'ka oblast'* in western Ukraine points to a tradition of accessing firewood as dry wood and during forest logging (Roué & Molnar, 2017). The locals state the need for young forest stands in addition to old, diverse structured forests: "*For firewood we went only here, on the Lapos. That was the closest, and there was thin, dry wood, which could be broken by hand.*" (ibid) (See supporting material Appendix 2.2[13]).

2.2.2.2.2 Provision of biofuels

The term "biofuel" generally refers to liquid transportation fuels made from biomass materials, such as ethanol and biodiesel. Biofuel production rose by a factor of ten between 2000 and 2014 in Western Europe **(Figure 2.28)**. Simultaneously, imports increased both in Central and Western Europe, but the import dependence was much higher in Central Europe. Central Asia and Eastern Europe had only a negligible share **(Figure 2.28)**. In terms of energy content, current annual production of biofuel **(Figure 2.28)** remains small compared to that of woodfuel (140,000,000 m^3 correspond to 1,000,000 – 2,400,000 tJ energy).

13. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

An outlook for Europe and Central Asia shows a slight increase in ethanol production until 2020, which is expected to become stable by 2025 **(Figure 2.29)**. For biodiesel, production is expected to peak by 2019 and to decline until 2025. The EU-28 as major producer is equally a major consumer with a strongly negative trade balance for both ethanol and biodiesel production. It is expected to roughly equalize until 2025. Only for Kazakhstan, a continuously negative trade balance for ethanol is expected. However, impacts of the production of energy crops on the environment and on other contributions from nature to people limit their use (Meyer & Leckert, 2017). Major concerns exist concerning the potential of GHG emission offset, regulation of soil quality, water quality and quantity, biodiversity, and indirect land-use change that displaces ecological impacts outside of the biofuel production region (Efroymson *et al.*, 2013; McBride *et al.*, 2011). These trade-offs could be considered in policy by implementing, for instance, stricter rules for biofuel certification that consider the environmental and social impacts within and beyond the feedstock production region (Meyer *et al.*, 2016).

In the future, agricultural residues, as one example of second-generation biofuel feedstocks, can also contribute substantially to energy production. Studies for the European Union consider that around 25 to 60% of agricultural residues could be available for this purpose (Bentsen & Felby, 2012).

Figure 2 30 **Annual production of roundwood in Europe and Central Asia, 1961–2014 in cubic metres. Source: FAO (2017).**

Figure 2 31 **Annual roundwood removal in Western, Central and Eastern Europe (for Eastern Europe only data for the Russian Federation is available) in 1,000 m³. Source: Own representation based on Eurostat (2017).**

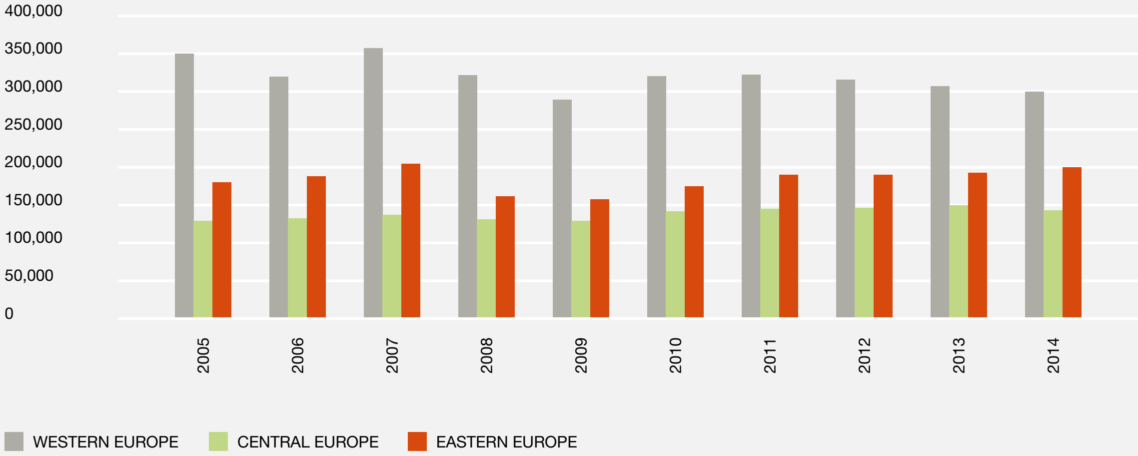
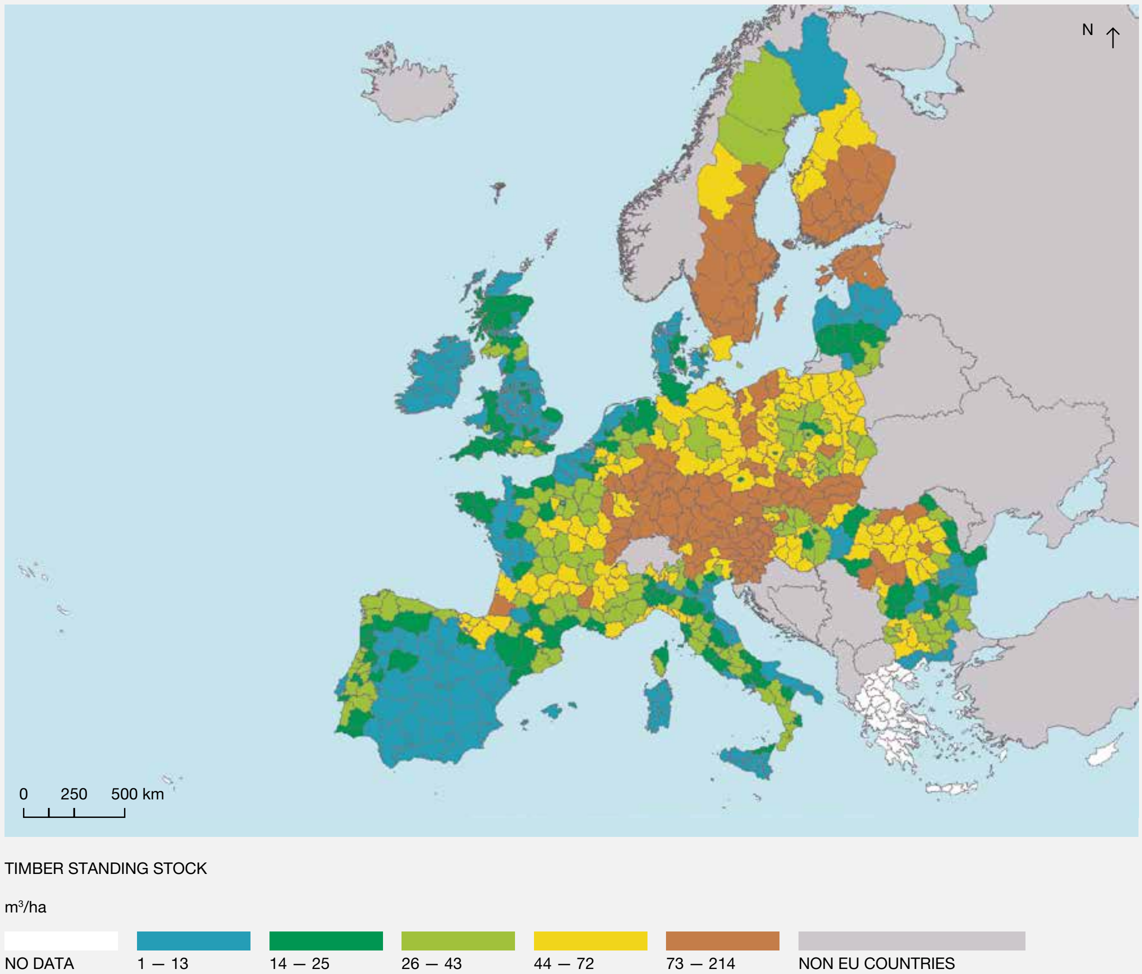


Figure 2 32 **Density of timber stock (all uses) in European Union (EU) countries. Source: European Commission (2011).**



2.2.2.3 Materials and assistance

Nature contributes to people's quality of life by providing materials for construction, clothing, ornamental purposes, or assistance for herding, guidance and guarding (IPBES, 2017a). For most of these materials, comprehensive national or sub-national level data do not exist, with the exception of wood. Here, we present the status and trends of this contribution from nature to people in Europe and Central Asia associated with the provision of wood, cotton, and other vegetal materials, materials from marine systems and the assistance of dogs in guarding and protecting livestock.

2.2.2.3.1 Provision of wood

Roundwood is defined as all wood removed with or without bark, including wood removed in its round form or in other forms (FAO, 2015a). Roundwood can be subdivided into industrial roundwood, used mainly for construction and in processed timber products, and woodfuel (see Section 2.2.2.2.1). Total production of roundwood has remained stable in Europe and Central Asia (FAO, 2015a), with a major impact by the fall of the iron curtain **(Figure 2.30)** and a slight decline for the period 2005-2014 in Western Europe **(Figure 2.31)**. Timber standing stock, regardless of use or degree of management, are largest in some regions of Western and Central Europe: forests of Central Europe, Scandinavia and the Alps **(Figure 2.32)**.

2.2.2.3.2 Cotton and other vegetal materials

During the period 1961-2014 cotton lint was mostly produced in Central Asia and Turkey. Production in Central Asia has fluctuated without a clear trend **(Figure 2.33)**, masking marked technological, economic and political transformations of the cotton industry (Kandiyoti, 2007).

Reed has traditionally been used in many regions for thatching, but it can be also be utilized in a number of other ways, including in construction and gardening, in paper, textile and plastic production, and as fodder and fertilizer (Köbbing *et al.*, 2013). Reed is grown and harvested throughout the subregions (Köbbing *et al.*, 2013). Mediterranean countries of Europe play an important role in the provision of cork, as they produce 87% of cork globally, especially the Iberian Peninsula, which is home to the majority of cork oak (*Quercus suber*) forests in the world (Acácio & Holmgren, 2014; APCOR, 2011) and, therefore, also cork extraction **(Figure 2.34)**. About 70% of harvested cork is used for the production of bottle stoppers. Other products include flooring, insulation material, clothes and accessories, and decorative objects (Bugalho *et al.*, 2011).

Rosins are solid forms of resins obtained from pine trees and some other conifers. They are extracted by tapping the tree (Mitchell *et al.*, 2016). Historically used to waterproof ships, they are now used in the production of chemicals, paints, inks, varnishes, floor coverings and soaps. Sources of rosins in Europe and Central Asia are *Pinus pinaster* (Portugal), *P. sylvestris* (former Soviet Union), *P. halepensis* (Greece) and *P. brutia* (Turkey) (FAO, 1995).

Only a few countries in Europe and Central Asia produce turpentine and resin, with decreasing trends due to the high costs of labour. Portugal accounts for the majority of world trade in gum turpentine, but production fell from an average of 110,000 tonnes per year during 1978-1987 to 30,000 tonnes by 1992 (FAO, 1995). Minor production is

Figure 2 33 **Annual production of cotton lint in Central Asia, 1992–2014, in tonnes. Source: FAO (2017).**

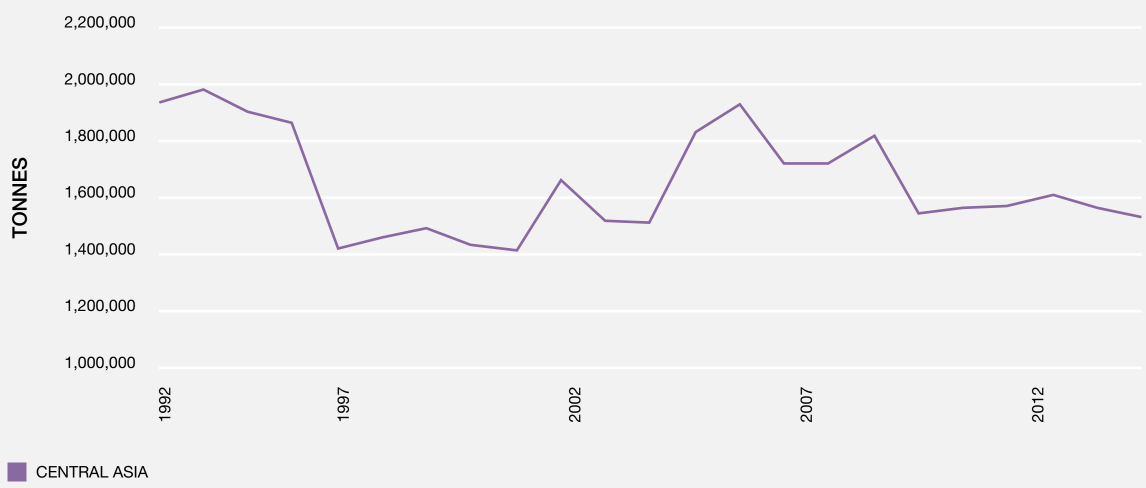
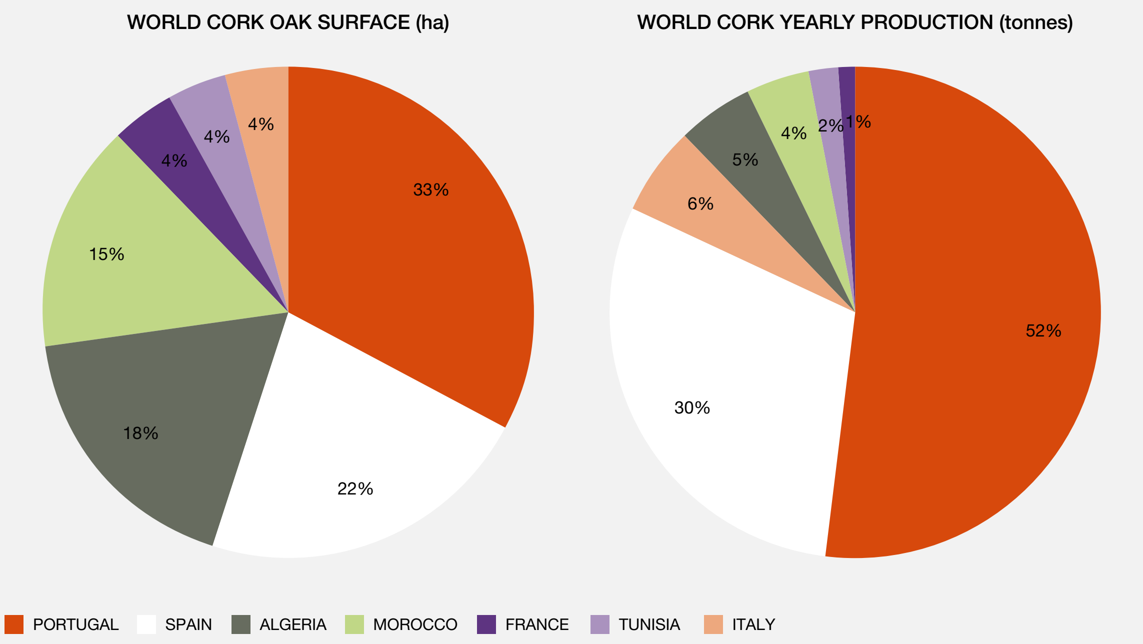


Figure 2 34 **Cork oak distribution and production in the western Mediterranean. Source: APCOR (2009).**



also reported in Central and Eastern Europe (FAO, 1995). Recently, new uses of pine resin in polymers have emerged (Wilbon *et al.*, 2013).

2.2.2.3.3 Materials from marine ecosystems

Marine ecosystems provide a wide range of materials for different uses, including algae maerl, seaweed fishmeal, fish oil (used in textile production, metallurgy, production of detergents, paints and resins), shellfish and molluscs for ornamental purposes (Murillas-Maza *et al.*, 2011). Seaweed and kelp species are used in various ways in Western Europe **(Figure 2.35)**. Kelp is now particularly used for extraction of alginates, which are used in the food processing industry, as well as in the production of textiles and pharmaceuticals (Netalgae, 2012; Smale *et al.*, 2013). France and Norway are the main producers of kelp in Western Europe with annual production of about 50,000 tonnes of *Laminaria digitata* in France and about 200,000 tonnes of *L. hyperborea* in Norway (Smale *et al.*, 2013). In Western Europe, production of macroalgae has decreased in the last 10 years (Bioforsk, 2012).

Maerl is a collective term for various species of non-jointed coralline red algae (family Corallinophycidae) that live unattached to the seabed. Maerl has been dredged in the European Union for use as an agricultural soil conditioner and for use in animal and human food additives, water filtration systems, and pharmaceutical and cosmetic products. By the 1970s extraction peaked with about 600,000 tonnes per year in France[14]; however, due to their very slow growth, maerl beds have declined throughout the North East Atlantic and are classified as vulnerable on the European Union Red List (Gubbay *et al.*, 2016a).

2.2.2.3.4 Assistance of livestock protection and guard dogs

For centuries guard dogs have helped shepherds protect their livestock from predators, specifically brown bears (*Ursus arctos*) and wolves (*Canis lupus*), in Central Europe and Central Asia (Gehring *et al.*, 2010; Linnell & Lescureux, 2015). With the decimation of these predators in Western Europe and the collectivization of agricultural policy under communist regimes, much of the indigenous and local knowledge about the use of guard dogs was lost (Gehring *et al.*, 2010; Linnell & Lescureux, 2015). However, with the recent recovery of large carnivores in continental Europe (Chapron *et al.*, 2014), guard dog use is being suggested as a means of facilitating human-carnivore coexistence (Linnell & Lescureux, 2015). Indeed, more than 1,000 dogs are now used in the Alps for this purpose (Gehring *et al.*, 2010). Indigenous peoples and local communities value them, as a herder explains: "*No, the beasts are no real problem for us, we have our dogs and sticks, we are not afraid of wolves and bears*" (herder; Ivascu & Rakosy, 2017) (see supporting material Appendix 2.2[15]). Guard dogs in Europe and Central Asia hold substantial

14. http://forum.eionet.europa.eu/european-red-list-habitats/

15. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

Figure 2 35 **Main uses of macroalgae in Europe. Source: Netalagae (2012).**

identity value among shepherds and breeds are closely linked to specific areas **(Figure 2.36)** (Linnell & Lescureux, 2015).

2.2.2.4 Provision of medicinal resources

The value of biodiversity as a resource for the production of medicines is one of the clearest examples of the relationships between nature and human health. Numerous species of plants, animals and fungi have been used to produce traditional therapies since ancient times, and wild flora and fauna continue to support the development of modern pharmaceutical products. This section considers medicinal plants in Europe and Central Asia, which form part of traditional and local medicinal practices, as well as medicinal plant products, which are sold commercially, and their use in modern pharmaceutical development. It covers plants, which are harvested directly from the wild, as well as those that are grown in home gardens or cultivated commercially. For the assessment of this contribution from nature to people, in addition to the literature review undertaken in this chapter (supporting material Appendix 2.1[16]), we also conducted an expert[17] elicitation on the basis of several key messages. The original key messages and the results of the expert elicitation are provided in supporting material Appendix 2.5[18].

Nature's capacity to provide medicinal plant resources depends on the species richness of medicinal plants. Several areas in Europe and Central Asia are characterized by high medicinal plant species richness, including the

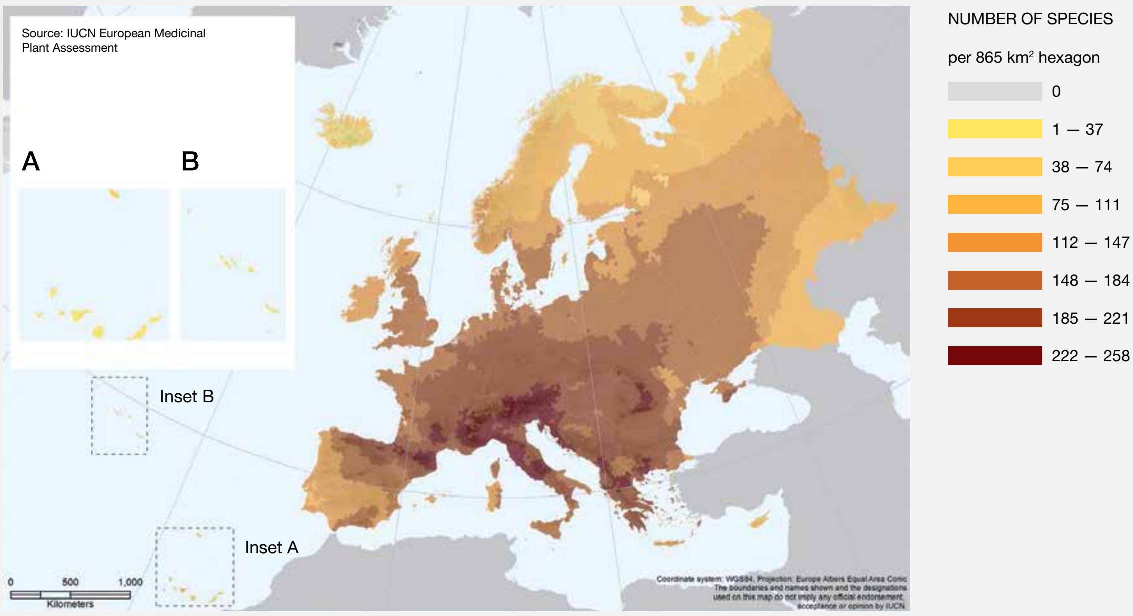
16. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.1_protocol_of_the_systematic_review_used_for_chapter_2_of_the_eca_assessment.pdf

17. Eighteen experts from the different biodiversity and health networks (such as the Belgian Community of Practice Biodiversity & Health (COPBH) and its international connections, Co-operation on Health and Biodiversity (COHAB), ESP thematic working group on health, Network for Evaluation of One Health (NEOH) and contact authors of publications found in the literature review conducted for this contribution from nature to people).

18. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.5_medicinal_plants.pdf

Figure 2 36 **Breeds of guard dogs identified in Europe and Central Asia. Source: Linnell & Lescureux (2015).**

Figure 2 37 **Species richness of selected medicinal plants in the European Union. Source: Allen *et al.* (2014).**



Mediterranean region, the Alps and the Pyrenees, the Massif Central in France, the Balkan Peninsula, the Crimean Peninsula and the Carpathian Mountains **(Figure 2.37)** (Allen *et al.*, 2014). However, some of these medicinal plants are threatened due to unsustainable patterns of exploitation (Allen *et al.*, 2014). Land development and land use change are the next greatest threats, with residential and commercial development and agricultural practices also having important impacts. In Central Asia, intensified agricultural practices, loss of indigenous knowledge, and climate change have also been identified as significant threats to medicinal plant diversity (e.g. Bocharnikov *et al.*, 2012; Breckle & Wucherer, 2006; Haslinger *et al.*, 2007) (see supporting material Appendix 2.5[19]). Consequently, collection of plants from the wild and loss of habitat due to

19. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.5_medicinal_plants.pdf

physical development and land use change are the most significant threats affecting medicinal plants in the region.

Indigenous and local knowledge plays an essential role in creating greater understanding of the potential contributions of many plant species to human health. The importance of biodiversity-derived medicines has been widely noted, with a significant number of commercially available pharmaceutical products being derived from compounds identified in biodiversity (e.g. Bernstein, 2015). The World Health Organization estimates that 70-80% of the global population depend on some form of indigenous and local medicinal knowledge for their primary health care (Ekor, 2014). In addition, indigenous and local knowledge has been a source of interest and inspiration for modern drug development for several decades (see also Section 2.2.3.4); at the same time, various ethical issues associated with bioprospecting and biopiracy have been raised. These issues appear to be less significant in Europe (Efferth *et al.*, 2016) (supporting material Appendix 2.5[19]).

Despite the importance of indigenous and local knowledge, there is a rapid rate of decline of traditional medical knowledge in Europe and Central Asia. In our fast-changing environment, especially related to increasing urbanization and changing agricultural practices, many traditions are disappearing from rural areas, with a profound loss of indigenous and local knowledge, particularly among the younger generations (see Section 2.2.3.1). This decline has been highlighted by several scientific studies (e.g. Quave *et al.*, 2012; Sánchez-Mata *et al.*, 2016). In some regions of Western and Central Europe, direct links have been identified between disappearing traditional farming systems and the decline in biodiversity of medicinal plants. On the other hand, there has been renewed interest in preserving traditional forms of knowledge about medicinal plants in the face of societal change and globalization as a form of cultural heritage (Pardo-de-Santayana *et al.*, 2010).

Recent decades have also seen an increase in the use of medicinal plants as complementary, non-conventional or alternative forms of medicine (Barata *et al.*, 2016; Roberti di Sarsina, 2007). Reasons cited for this increased attention have included public desire for affordable health remedies, and a perception that "natural" products are somehow safer and more effective than mainstream medicines. These factors have stimulated a rapid expansion of commercial markets for these remedies (FAO, 2005; Leonti & Verpoorte, 2017). The commercialization of traditional medicines and medicinal indigenous and local knowledge has seen many of these remedies moving from traditional practices to health and other markets.

Migrant populations moving into Europe and Central Asia from other regions have also brought their own traditional knowledge and related medicinal practices with them. Evidence suggests that these communities rely largely on plants and plant products imported from their home countries rather than alternatives that occur naturally in their new home regions (Pieroni *et al.*, 2013; Quave *et al.*, 2012) (supporting material Appendix 2.5[19]). This raises a number of further issues for conservation and public health, including those related to the collection, importation, sale and use of plants across borders outside of normal regulatory frameworks. While it appears that migrants prefer medicinal plants and related products imported from their home regions to local native alternatives, increasing demand may see alternative plant species being sought in migrants' new home environments, presenting a further challenge for the sustainable exploitation of living resources. Therefore, because of increasing migration into Europe and Central Asia from other regions, there is an urgent need to increase the understanding of traditional medicinal practices within national public health care systems.

In addition to their potential role in supporting public health, traditional medicines may provide other social and economic benefits. Research in Tajikistan and Afghanistan has indicated that the use of medicinal plant species contributed significantly to local health sovereignty and security (see Section 2.3.2), which was particularly important during a period of social and political instability (Kassam *et al.*, 2010). From a public health perspective, it appears important to ensure that traditional medicinal practices, which do not use marketed products but instead rely directly on harvested plants, are recorded and assessed, and to engage with practitioners to explore and communicate on issues of safety and efficacy.

2.2.3 Status and trends of nature's non-material contributions to people

2.2.3.1 Learning and knowledge generation

2.2.3.1.1 Formal learning and knowledge generation

Nature benefits people by contributing to learning processes that inspire people and allow them to acquire knowledge and to develop skills. These benefits can occur through formal institutions, informal learning and at all levels of education (Angelstam *et al.*, 2013; Anić *et al.*, 2012; Mocior & Kruse, 2016). There are contrasting trends across these benefits. Formal learning linked to nature has increased recently, partly as a result of new learning and knowledge development processes linked to sustainable environmental management. Informal learning that draws on nature has also expanded due to the increases in recreation and tourism (see Section 2.2.3.2), especially in protected areas promoting education and learning (Angelstam *et al.*, 2013; Smrekar *et al.*, 2016; Zedler, 2017). Some informal forms of learning and knowledge generation based on nature are in decline, particularly linguistic diversity which has traditionally been shaped by biodiversity and features of the natural environment (Section 2.1.1.1.2 Gorenflo *et al*., 2012; Maffi, 2005). The interactions between language and nature mean that a decline in linguistic diversity will be accompanied by a reduction in the variety of ways people communicate about aspects of nature and biodiversity (Harmon & Loh, 2010).

Formal learning in outdoor spaces has grown as national education systems have expanded. Formal learning provides additional benefits for learners and teachers in terms of cognitive outcomes, critical thinking, inspiration, observation skills and engagement with nature (Bizikova *et al.*, 2012; Mocior & Kruse, 2016; Schlegel *et al.*, 2015). Adults who have learned about sustainable development at school, or informally through activities such as gardening, may perceive their living space in a manner that is conducive to more sustainable lifestyles (Bendt *et al.*, 2013; Breuste & Artmann, 2015; Fridl *et al.*, 2009).

People using natural environments for recreational experiences also learn from each other. For example, a survey of 1,300 marine divers and recreational anglers in the UK showed that the sharing of knowledge and experience with others was a valued cultural ecosystem service (Jobstvogt *et al.*, 2014). Learning benefits linked to inspiration from nature were also found in a survey of 291 people in Turkey (Fletcher *et al.*, 2014). In Spain a survey of 1,400 people revealed that environmental education was a preferred ecosystem service for a large proportion of respondents and environmental education was viewed as a more important cultural ecosystem service than aesthetic values and recreational hunting (Martin-Lopez *et al.*, 2012). Also in Spain, a survey of 198 beneficiaries of the largest park in Barcelona found that environmental learning was a perceived benefit of the park of low monetary value, but of high non-monetary value (Langemeyer *et al.*, 2015).

2.2.3.1.2 Indigenous and local knowledge

Local ecological knowledge has been increasingly documented in Western, Central and Eastern Europe, particularly around its role in sustainable management of nature's contributions to people, its contribution to ecosystem restoration and its role in building social-ecological resilience (Carvalho & Frazão-Moreira, 2011; Hernández-Morcillo *et al.*, 2014; Molnár *et al.*, 2016). Overall, local ecological knowledge in Western, Central and Eastern Europe has eroded in recent decades, something acknowledged in the scientific literature as well as by the indigenous and local knowledge holders (see supporting material Appendix 2.2[20]). Significant losses of indigenous and local knowledge were found in Western Europe in agrobiodiversity management (Iniesta-Arandia *et al.*, 2014; Kizos *et al.*, 2013; Reyes-García *et al.*, 2015), in forest management (Johann, 2007; Rotherham, 2007), and in pastoralist systems (Fernández-Giménez & Fillat Estaque, 2012; Oteros-Rozas *et al.*, 2013b). Evidence of erosion of indigenous and local knowledge was also found in Central Europe, associated with agrobiodiversity management (Šmid Hribar & Urbanc, 2016), pastoralism (Lozej, 2013; Otčenášek, 2013) and medicinal plants and wild food plants (Łuczaj *et al.*, 2012; Pardo-de-Santayana *et al.*, 2010; Pieroni *et al.*, 2013). However, some research has found stable patterns in indigenous and local knowledge associated with wild food plants and mushrooms in Central Europe (Łuczaj *et al.*, 2015; Pieroni *et al.*, 2013). In Eastern Europe, a decline in indigenous and local knowledge has been found in wood-pastures (Varga & Molnár, 2014), pastoralist systems (Kikvidze & Tevzadze, 2015; Lavrillier *et al.*, 2016), and the indigenous and local knowledge associated with wild food (Łuczaj *et al.*, 2013).

The erosion of indigenous and local knowledge also involves the loss of linguistic diversity as indigenous and local languages represent the reservoirs of considerable knowledge about non-human species and their relationships with the environment (Nabhan, 2001). The endangerment level of indigenous and local languages in Europe and Central Asia is critical (see **Figure 2.38**). While a large number of these languages are extinct[21] (12% of total languages) or critically endangered[22] (11%), 14% still remain alive as most children speak the language (vulnerable category). The level of endangerment varies across subregions (see **Figure 2.38**). While Central Asia has no languages under the categories of extinct and critically endangered, 31% and 24% of languages in Eastern Europe and Central Europe, respectively, are classified as extinct or critically endangered. Despite this level of threat, it is noticeable that the trends of the Index of Linguistic Diversity for indigenous languages in Eurasia between 1970 and 2005 is rather stable (with a slight decline from 1990) (see **Figure 2.39**) because Western and Central Europe might have lost the majority of its linguistic diversity prior to 1970 (Harmon & Loh, 2010).

The general loss of indigenous and local knowledge is mainly attributed to the transition from an agriculturally-based and subsistence-oriented economy to a market-oriented economy (Carvalho & Morales, 2010; Hernández-Morcillo *et al.*, 2014; Pardo-de-Santayana *et al.*, 2010). Changes in culture that affect shared beliefs, meanings

20. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

21. Extinct: There are not speakers

22. Critically endangered: The youngest speakers are grandparents and older, and they speak the language partially and infrequently

and practices regarding plants and animals or other contributions from nature to people, are also responsible for the lack of value associated with indigenous and local knowledge among younger generations, which consider these traditional practices and knowledge as symbols of poverty or backwardness (Christanell *et al.*, 2010; Hernández-Morcillo *et al.*, 2014; Pardo-de-Santayana *et al.*, 2010). Gender relations are of special interest in Western Europe, where women and men have had differentiated roles in preserving indigenous and local knowledge (Pardo-de-Santayana *et al.*, 2010; Reyes-García *et al.*, 2010). Demographic changes, such as ageing of indigenous and local knowledge holders, rural abandonment and outmigration of women and younger generations from rural areas, have also led to a marked decline in generational transmission of indigenous and local knowledge (Fernández-Giménez & Fillat Estaque, 2012; Molnár, 2014; Oteros-Rozas *et al.*, 2013b). These factors are also acknowledged by indigenous and local knowledge holders as powerful drivers of erosion of their knowledge (see also supporting material Appendix 2.2[20]).

Some governmental policies can also support the maintenance of indigenous and local knowledge. For example, the Common Agricultural Policy reform legislation offers support for "high nature value" farming, which is characterized by long-established, low-intensity and holistic farming systems highly adapted to local environmental conditions (Keenleyside *et al.*, 2014). In this sense, high natural value farming is not only essential if the European Union is to meet its 2020 biodiversity targets, but also to counteract the decline in indigenous and local knowledge.

There is a proven gap in documentation of indigenous and local knowledge in Central Asia and therefore more studies are needed on how traditional practices and indigenous and local knowledge associated with nature could bring important insights into biocultural diversity conservation in

Figure 2 38 **Level of endangerment of languages in Europe and Central Asia A and level of endangerment by subregion B Source: Own representation based on Moseley (2010); UNESCO (n.d.). Overseas territories in other regions are not included.**

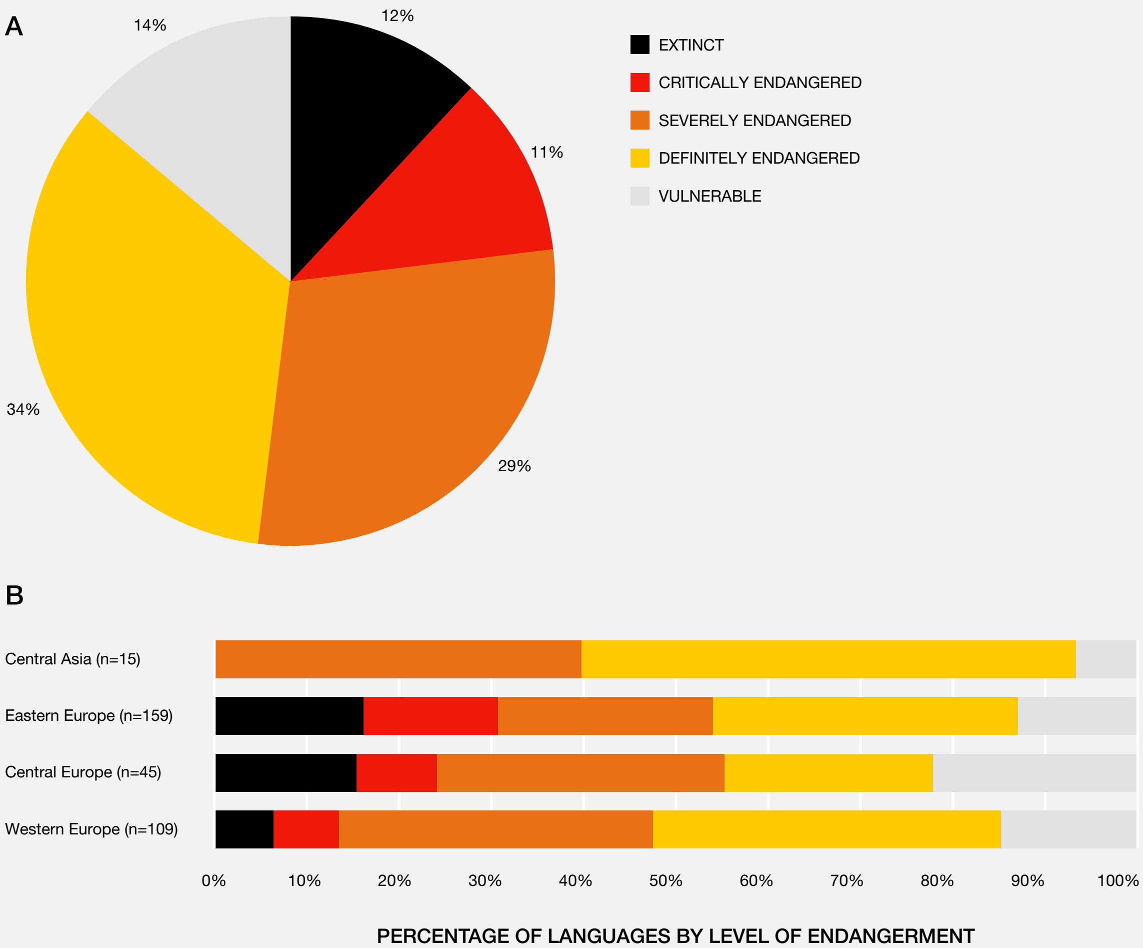
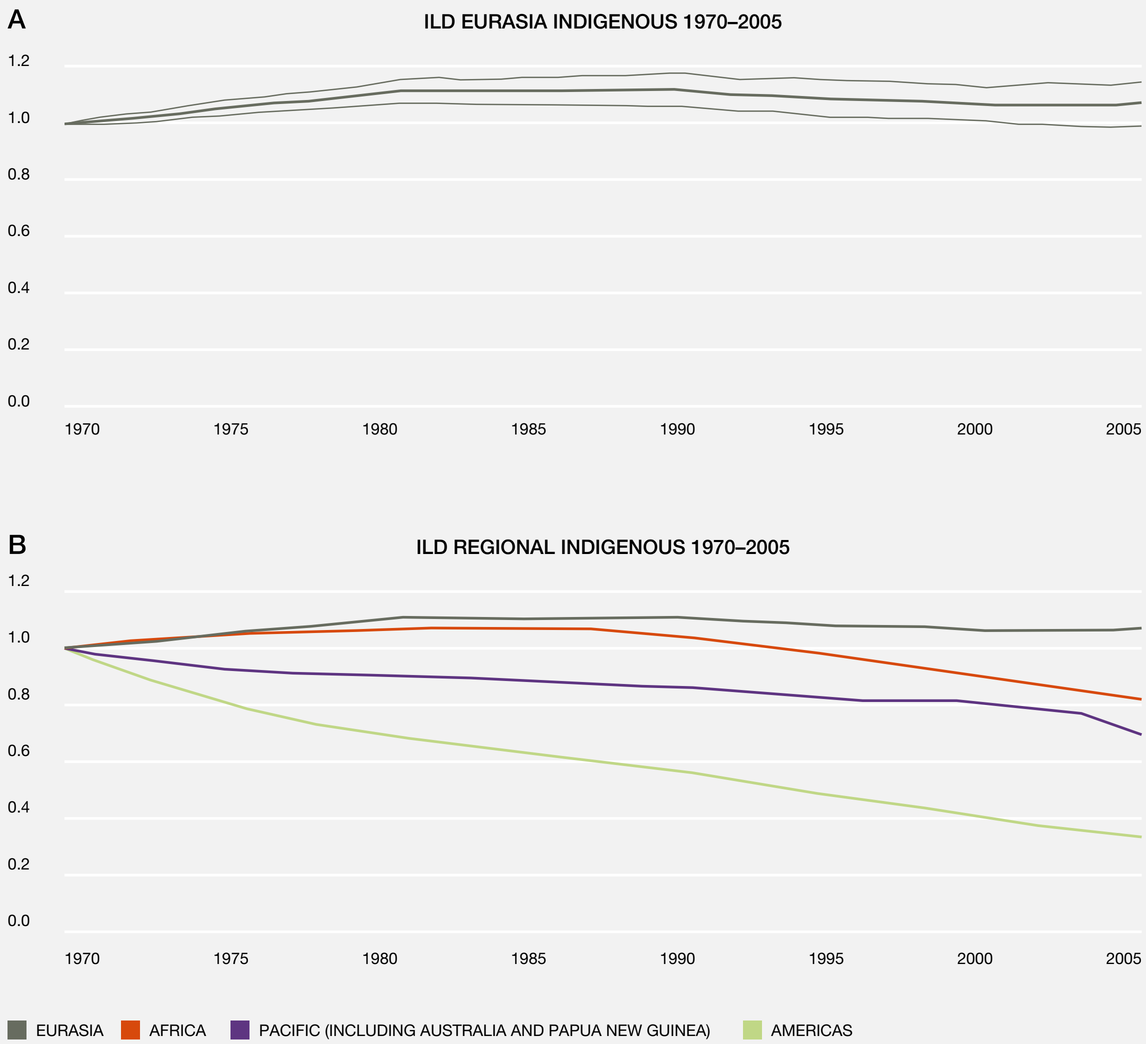


Figure 2 39 **Trends of the Index of Linguistic Diversity (ILD) in Eurasia A and in the different regions of the world B Source: Harmon & Loh (2010).**



the subregion (Pawera *et al.*, 2016). In addition, although there is some evidence about the role of indigenous and local knowledge in marine systems (Maynou *et al.*, 2011; Moore, 2003), more research is needed to report on the status and trends of this knowledge in that context.

2.2.3.2 Physical and psychological experiences

2.2.3.2.1 Recreational experiences

Nature in Europe and Central Asia provides opportunities for recreation such as hiking, trekking, climbing, running, mountain biking, horseback riding, camping, picnicking, sailing, boating, swimming, snorkeling or diving, skiing and green care, as well as activities related to species, such as wildlife-watching, particularly birdwatching. Nature also provides opportunities to perform extractive recreational activities, such as hunting, fishing and angling, mushroom gathering, berry and fruit picking (Bell *et al.*, 2007; Schulp *et al.*, 2014a; Seeland & Staniszewski, 2007). Thirty-eight per cent of the European Union is characterized by high outdoor recreation potential (Paracchini *et al.*, 2014), particularly coastal and freshwater systems and broadleaved woodlands (Hornigold *et al.*, 2016). Recreation is a well-recognized contribution from nature to people in broadleaved forests of Western and Central Europe (e.g. Grilli *et al.*, 2015; Mavsar *et al.*, 2013; Sténs *et al.*, 2016). In freshwater ecosystems, recreation is more common in rivers with clear water and high flows than rivers with mud, algae and litter (Eder & Arnberger, 2016; Vesterinen *et al.*, 2010). Marine and coastal systems also provide the basis for recreational activities, such as recreational fishing, birdwatching, whale-watching, swimming, diving and snorkeling or other water sports (Ahtiainen *et al.*, 2013; Beaumont *et al.*, 2007). In the last decades, the capacity for nature-based recreation in the aforementioned ecosystems has decreased because of land-use change (e.g. Liquete *et al.*, 2016b; Pietilä & Fagerholm, 2016; Roberge *et al.*, 2016).

Green spaces in urban areas provide multiple physical and psychological experiences (Bolund & Hunhammar, 1999; Kabisch *et al.*, 2016), such as sense of peacefulness and tranquility (Chiesura, 2004) or hiking and walking (Baró *et al.*, 2016; Smrekar *et al.*, 2016). While an overall increase in urban green spaces was identified in Western Europe from 2000 to 2006, most of the cities of Central and Eastern Europe experienced a decline in the same period (Kabisch & Haase, 2013). The recreational experience in urban green spaces depends on different elements, such as the presence of forests

Figure 2 40 **Demand for nature-based recreation in the European Union.**

Trends of percentage of people in the European Union with nature (i.e. ecosystems or landscapes) and other related-nature (beach and sport-related activities, e.g. scuba-diving, cycling, etc.) motivations as the main reasons for going on holiday. Source: Own representation based on European Commission (2016b).

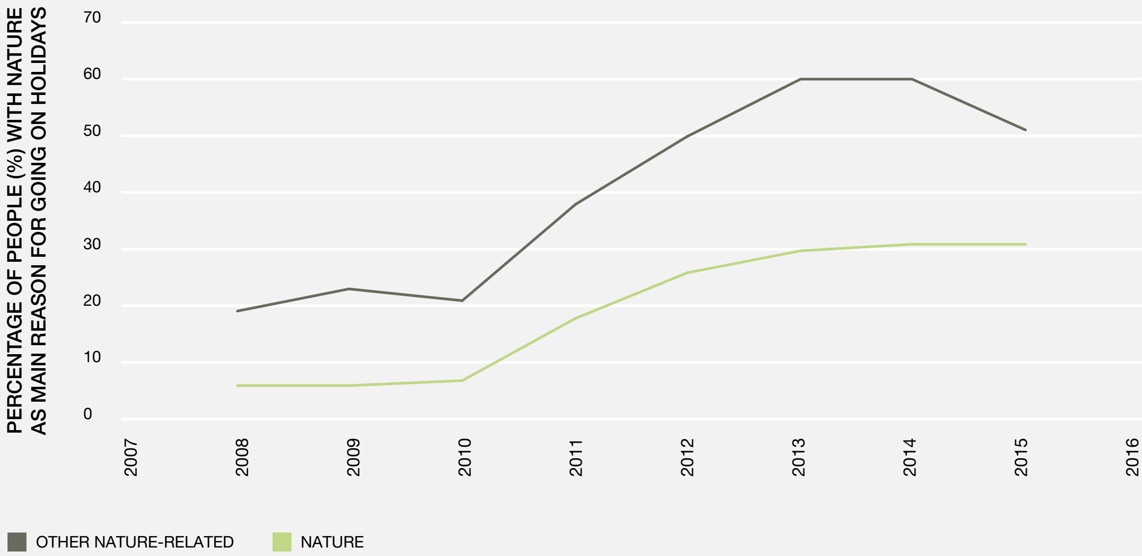
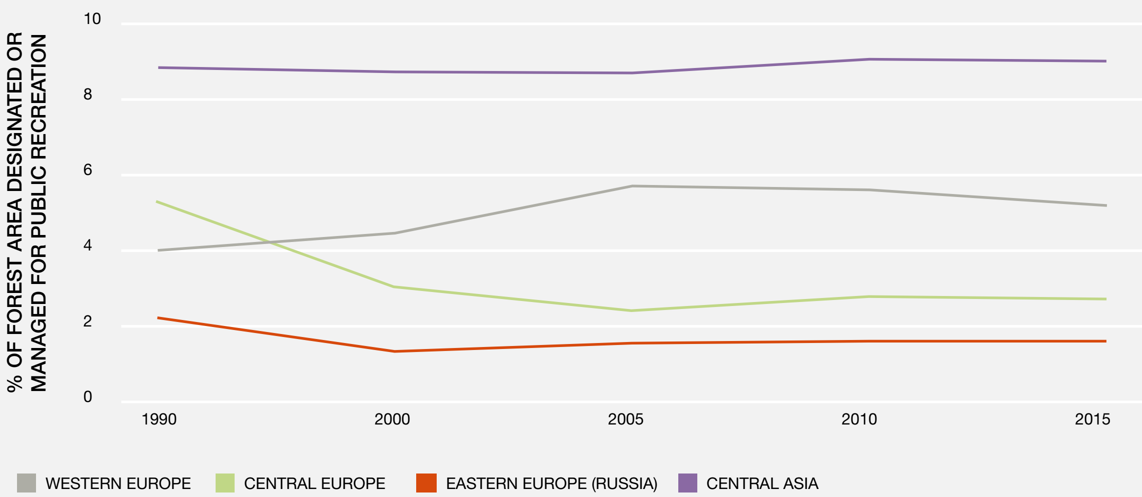


Figure 2 41 **Distribution of recreational options in Europe and Central Asia: Temporal trends of the forest surface managed or designated for recreational purposes in the four subregions. Source: Own representation based on http://www.fao.org/forest-resources-assessment/en/.**



and wetlands or riparian systems (Baró *et al.*, 2016) or high species richness (Fuller *et al.*, 2007). Urban gardens are increasingly recognized among these elements in Western and Central Europe (Bell, 2016; Breuste & Artmann, 2015; Camps-Calvet *et al.*, 2015).

Nature-based recreation is in high demand in Europe and Central Asia (e.g. Agbenyega *et al.*, 2009; García-Llorente *et al.*, 2012; Sténs *et al.*, 2016). For example, 31% of people surveyed in the European Union gave nature as their main reason for going on holiday. Other reasons were nature related, such as beach and sport-related activities (e.g. cycling, boating or diving), which were mentioned by 51% of people surveyed in the European Union (European Commission, 2016a). In the last decade, nature as the main reason for holidays has increased in the European Union **(Figure 2.40**). Participation in nature-based recreation is not equally distributed between countries due to differences in the number of protected areas **(Table 2.5)**, forest areas designated for recreational purposes **(Figure 2.41)**, or accessibility to natural areas (Bell *et al*., 2007).

Nature's capacity to provide extractive outdoor experiences relies on a variety of species. In the European Union, 97 species are hunted, while 152 species and 12 genera of mushrooms and 592 edible plant species are reported as being collected (Schulp *et al.*, 2014b). However, this estimation is incomplete because studies in Turkey showed that at least 2,000 species of mushrooms are edible (Çağlarirmak, 2011; Kizmaz, 2003). The highest richness of game species is reported in Central Europe, southern Scandinavia and the Baltic countries, while for edible mushroom and plant species it is the forested and mountainous areas of Western Europe **(Figure 2.42)** (Schulp *et al.*, 2014a).

Hunters as a percentage of the European Union population in 2010 varied between 0.17% (Netherlands) and 12.4% (Italy) (Schulp *et al.*, 2014a). In Central Asia, the flourishing of sport hunting (Kronenberg, 2014) and the presence of body parts of particular animals (e.g. snow leopard (*Uncia uncia*), Asiatic Bear (*Ursus arctos isabellinus*)) in markets suggest both legal and illegal hunting (Cunha, 1997; Haslinger *et al.,* 2007). Recreational fishing is a growing phenomenon in Western Europe (Toivonen *et al.*, 2004). Collection of mushrooms, truffles, berries, fruits and edible nuts is more prevalent in Western Europe than Central Europe and Eastern Europe **(Figure 2.43)** (MCPFE *et al.*, 2007). However, the diversity of wild plants collected has suffered a decline in recent decades in Western and Central Europe (Łuczaj *et al.*, 2012; Reyes-García *et al.*, 2015; Rzadkowski & Kalinowski, 2013). This decline coincides with urbanization and loss of natural habitats, rural abandonment, cultural change, the erosion of indigenous and local knowledge, and industrialization of food production (Łuczaj *et al.*, 2012; Reyes-García *et al.*, 2015). By contrast, some uses of wild edible plants are preserved due to a revival of traditions linked with "traditional" cuisine (Reyes-García *et al.*, 2015; Schulp, *et al.*, 2014b).

Figure 2 42 **Species richness of the 38 common game species in the European Union A, 27 common edible mushroom species in the European Union B, and 81 common wild food vascular plant species in the European Union C.**
Source: Schulp *et al.* (2014b).

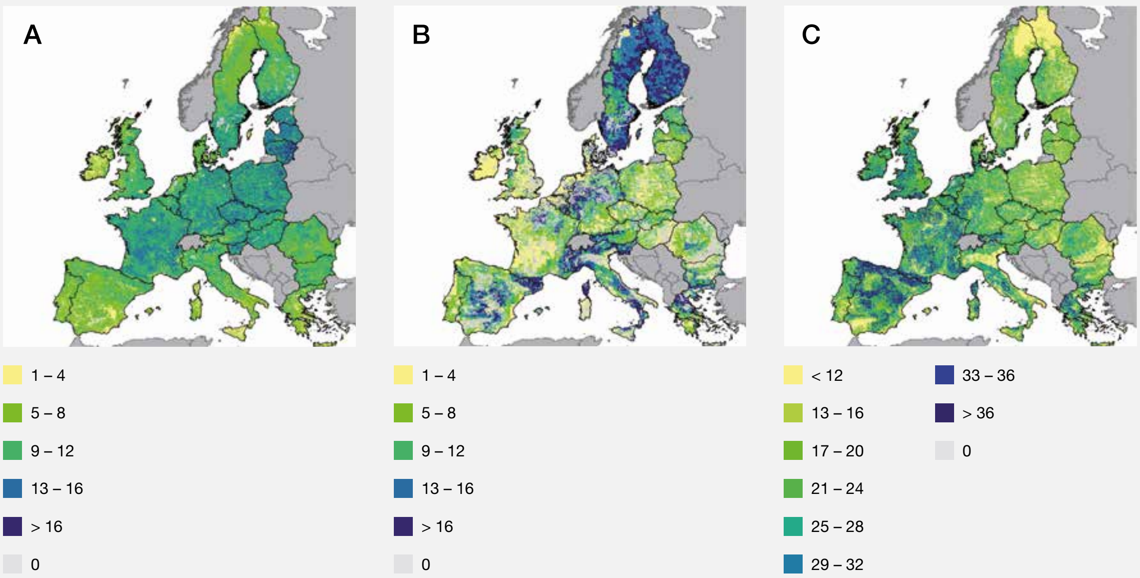
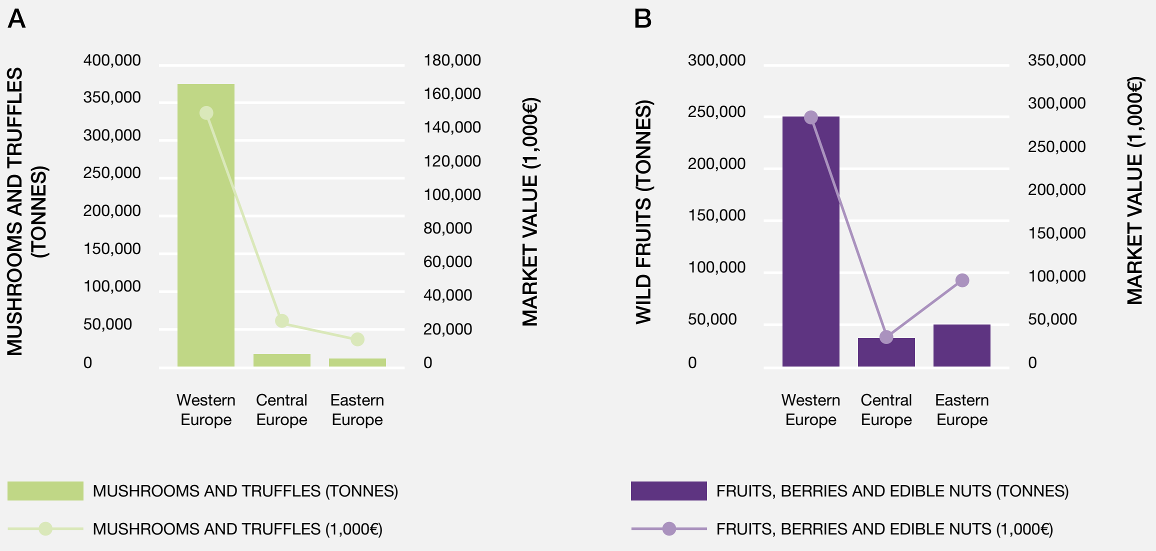


Figure 2 43 **Distribution of the amount and market value of A mushrooms and B berries, fruits and edible nuts picked in forests in Western, Central and Eastern Europe. Source: Own representation based on MCPFE *et al.* (2007).**



2.2.3.2.2 Aesthetic experiences

Nature is a source of aesthetic experiences for people in Europe and Central Asia (e.g. Daniel, 2001; Kaplan & Kaplan, 1989; Ode *et al.*, 2009; Schirpke *et al.*, 2013). Aesthetic enjoyment is dependent on perceived naturalness (e.g. Arriaza, 2004; Van den Berg & Koole, 2006), landscape heterogeneity (e.g. Dramstad *et al.*, 2006; Frank *et al.*, 2013; Schirpke *et al.*, 2013; Sevenant & Antrop, 2009), and high levels of biodiversity (e.g. Casalegno *et al.*, 2013; Lindemann-Matthies *et al.*, 2010; Tribot *et al.*, 2016).

People in Western and Central Europe prefer natural areas with verdant vegetation over arid landscapes and urban landscapes (García-Llorente *et al.*, 2012; Sevenant & Antrop, 2009). Landscape configurations like open forests (Gundersen & Frivold, 2008; Hansen & Malmaeus, 2016) or wood-pastures are most preferred among verdant natural areas (e.g. Plieninger *et al.*, 2015; Surová *et al.*, 2013; Van Zanten *et al.*, 2014). However, mosaic landscapes were considered to have higher aesthetic value than landscapes dominated by forest in Western and Central Europe (e.g. García-Llorente *et al.*, 2012; Howley, 2011; Howley *et al.*, 2012; Schirpke *et al.*, 2013). Mountains and coastal systems also provide aesthetic enjoyment, expressed by high numbers of related geotagged photographs (Oteros-Rozas *et al.*, in press; Van Zanten *et al.*, 2016). Water features also contribute to aesthetic pleasure (e.g. Kaltenborn & Bjerke, 2002; Tveit *et al.*, 2006; Van Zanten *et al.*, 2016).

The capacity of landscapes to provide aesthetic experience has declined because of urbanization, land-use intensification, rural abandonment, disappearance of common lands and water pollution (see Chapter 4) (Šmid Hribar *et al.*, 2015; Hunziker *et al.*, 2008; Ruskule *et al.*, 2013).

2.2.3.3 Supporting identities

Individuals derive a good quality of life from knowing of the mere existence of particular species, ecosystems or a landscapes, independent of their actual use (Krutilla, 1967; Reyers *et al.*, 2012), but also from their sense of place, cultural heritage, and from spiritual experiences. In contrast to physical and experiential values (see Section 2.2.3.2), this contribution from nature to people relates to virtues and principles (Chan *et al.*, 2012).

2.2.3.3.1 Protected areas

Protected areas indicate where societies have expressed their will to protect species and ecosystems. Protected areas can take many forms, as distinguished by (IUCN, 2017). Some categories of protected areas contain core zones, where natural dynamics can take place and which are largely inaccessible to the public. These categories are: "Ia Strict Nature Reserve", "Ib Wilderness Area", "II National Park" and "IV Habitat/species management area". The status of these protected areas in Europe and Central Asia, as reported in the World Database on Protected Areas (UNEP-WCMC & IUCN, 2016), was used as an indicator for "supporting identities" (see **Figure 2.44** and **Table 2.5**). Globally, there has been an increase in protected areas

Figure 2 44 **Terrestrial and marine protected areas in Europe and Central Asia. The map displays strong protection categories (Ia, Ib, II and IV). Source: World Database on Protected Areas (UNEP-WCMC & IUCN, 2016).**

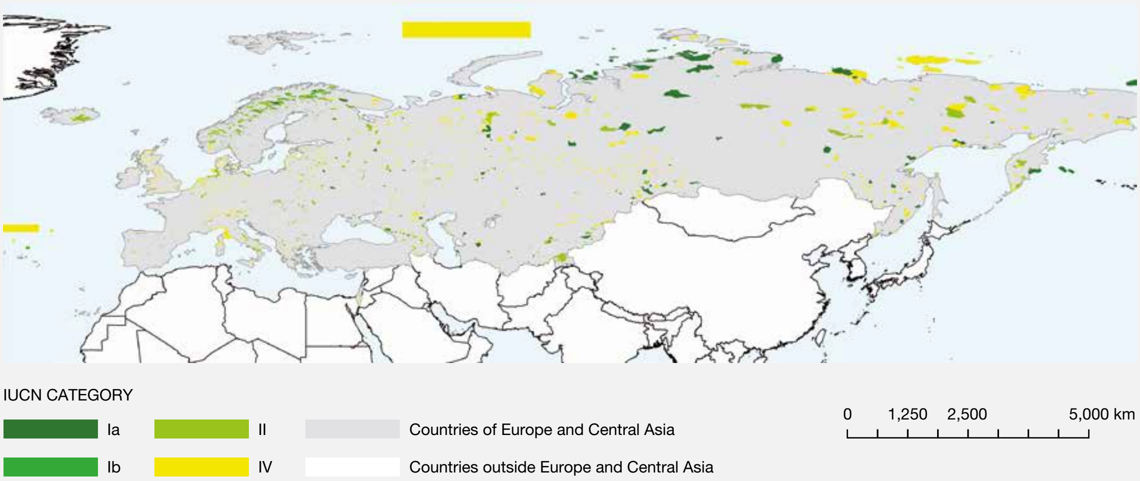


Table 2 5 **Proportion of protected areas in Europe and Central Asia. The table displays strong protection categories (Ia, Ib, II and IV) in the four subregions. Source: World Database on Protected Areas (UNEP-WCMC & IUCN, 2016).**

Region	Ia Strict nature reserve [% of land area]	Ib Wilderness area [% of land area]	II National Park [% of land area]	IV Habitat/species management area [% of land area]	Total area (in km²) of categories Ia, Ib, II and IV
Central Europe	0.00	0.27	0.87	0.93	92,284
Western Europe	0.48	2.70	3.16	1.60	1,077,634
Eastern Europe	1.91	0.00	1.02	5.20	6,930,197
Central Asia	0.68	0.00	0.65	1.04	196,475

(all IUCN categories) from about 8% in 1990 to 14.7% in 2016 (UNEP-WCMC & IUCN, 2016). It should be noted that motivations to establish a protected area differ, so the chosen indicator does not necessarily reflect particularly important species and ecosystems (Joppa & Pfaff, 2009).

2.2.3.3.2 Emblematic, symbolic or iconic species or ecosystems

An existence value can be attributed to emblematic, symbolic or iconic species or ecosystems that are particularly appreciated for their existence, independent of their actual use for recreation (e.g., bird watching, game viewing). Certain so-called "flagship species" have drawn wide public interest (Barua, 2011). Many of these species' habitats occur outside Europe and Central Asia, for example the tiger (*Panthera tigris*), gorilla (*Gorilla gorilla*), giant panda (*Ailuropoda melanoleuca*), orangutan (*Pongo abelii*), as well as elephants and seahorses (Barua, 2011). The contribution from nature to people in these cases is not provided by ecosystems in Europe and Central Asia, but is valued by people within the region. There is currently a knowledge gap on how iconic and emblematic species that *are* native to Europe and Central Asia are perceived across the region. The wolf (*Canis lupus*), brown bear (*Ursus arctos*), wolverine (*Gulo gulo*), lynx (*Lynx lynx*) and wisent (*Bison bonasus*) have been framed as "Europe's big five" in collaboration with conservation experts (IUCN, 2014). A global meta-analysis found that species in forest and marine inland waters are particularly highly valued. Of these species, the moose (*Alces alces*) and the humpback whale (*Megaptera novaeangliae*) (Martín-López *et al.*, 2008) occur in Europe and Central Asia. Furthermore, there is country-specific evidence of people assigning particular existence values to species. For instance, people in Sweden value large carnivores, irrespective of having the possibility to view them (Karlsson & Sjöström, 2008). In Spain, the imperial eagle (*Aquila adalberti*) and the Iberian lynx (*Lynx pardinus*) were among the species for which people showed the highest preference and willingness-to-pay for their conservation (Martín-López *et al.*, 2007). In the UK, White *et al.* (2001) found high conservation interest for the otter (*Lutra lutra*), measured through high willingness-to-pay for their conservation. Preferences for the existence of species, such as willingness-to-pay for marine biodiversity, can differ across the region (Ressurreição *et al.*, 2012). Willingness-to-pay for conservation has also been shown to be more strongly influenced by certain marine iconic species that are actively experienced (seals, octopus, birds) than by species that do not directly have a use value (i.e. are only protected for their existence) (Jobstvogt, 2014).

2.2.3.3.3 Attitudes towards nature

Another indication of this contribution from nature to people is attitudes towards nature conservation. In the EU-28, 76% of the people totally agree with the statement "We have a responsibility to look after nature". This percentage differs regionally, ranging from 65% in Italy to 94% in Cyprus and Sweden (European Commission, 2015a). See also supporting material Appendix 2.2[23] with quotes recognizing a decreasing trend of appreciation of nature by young holders of indigenous and local knowledge.

23. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

2.2.3.3.4 Spiritual experiences

Ecosystems have traditionally served as areas for spiritual or religious rituals and experiences derived from nature (Groot *et al.*, 2005). Natural areas of special spiritual significance include areas recognized as sacred by indigenous and traditional peoples as well as by institutionalized religions or faiths as places for worship and remembrance (Verschuuren *et al.*, 2010). Sacred or holy natural places occur at a variety of scales in Europe and Central Asia, varying from rock formations or forest patches to mountains and islands. Supporting material Appendix 2.6[24] shows a selected list of natural areas considered as "sacred natural sites" based on IUCN's Task Force on Cultural and Spiritual Values of Protected Areas (Wild & McLeod, 2008) and the Delos Initiative (Mallarch & Papayannis, 2012). Five sites on this list are located in Central Europe, three in Eastern Europe, 17 in Western Europe and one in Central Asia. The importance of these sites and other natural areas of spiritual and cultural significance to the quality of life in Europe and Central Asia is elaborated on in Section 2.3.3**.**

2.2.3.4 Maintenance of options

The desire to maintain potential options or benefits provided by nature for future generations is an expression of how people value inter-generational justice (see Section 2.3.4). The capacity of supply of this contribution from nature to people is indicated by overall patterns in species-level biodiversity (see **Table 2.6**, Section 3.2.3). One measure of the unique contribution to this contribution is given by total number of endemic species, which is low for Europe and

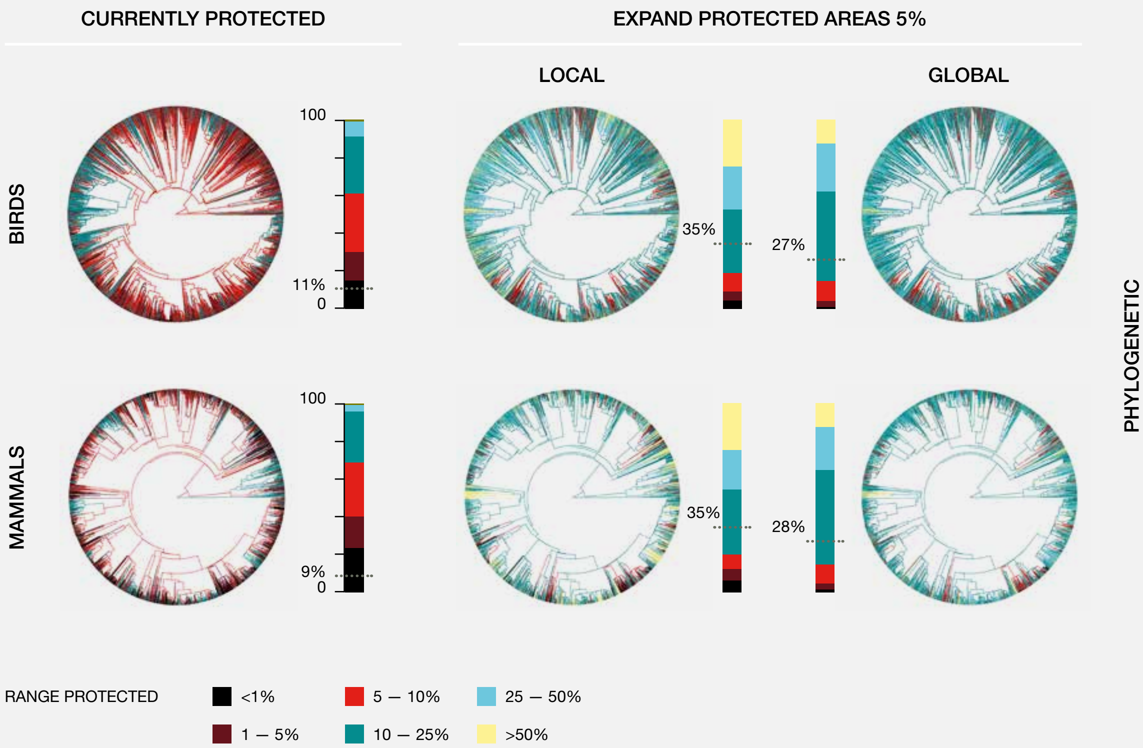
24. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.6_list_of_sacred_natural_sites.pdf

Table 2 6 **Numbers of classified, endemic and threatened species as proxy for the status of the maintenance of options of nature's contributions to people in Europe and Central Asia relative to the other three IPBES regions (the Americas, Asia and the Pacific, and Africa). Source: Brooks *et al.* (2016), data for taxonomic groups that have been comprehensively assessed using IUCN red list criteria. Total global number of assessed species, over all these assessed groups, = 32,790. Total number of these assessed species that are threatened = 6,539.**

	Europe and Central Asia	Average value over the other 3 IPBES regions
Number of assessed species, over all assessed groups, that are found in nominated IPBES region	2,487	11,840
Number of those species endemic to the region	332	9,681
Number of assessed species that are threatened and are found in nominated region	302	2,251
Number of those threatened species that are endemic to the region	83	2,036

Figure 2 45 **Status of protection of phylogenetic diversity shown on the phylogenetic trees for birds and mammals.**

Tree diagrams on the left show current protection levels, and tree diagrams on the right use colours to show potential conservation gains for a 5 per cent increase in protected areas. For each branch of each tree, degree of protection is defined as the percentage of the total branch occurrences that is protected (percentage of "range protected"). Source: Pollock *et al.* (2017). Reprinted by permission from Macmillan Publishers Ltd.



Central Asia relatively to Africa, Asia and Pacific and America regions (see **Table 2.6**). Phylogenetic diversity (Faith, 1992) over multiple taxonomic groups is also an informative metric of the capacity of biodiversity to deliver maintenance of options (Faith, 2016) (also see Chapter 3). An assessment of the phylogenetic diversity of birds and mammals (see **Figure 2.45**) (Pollock *et al.*, 2017) identified many high priority areas, such as in southern Croatia, the Odessa region of Ukraine, and north-western Kazakhstan, for their better conservation.

The maintenance of options from biodiversity in Europe and Central Asia (and from outside the region) can be assessed through the valuation of genetic diversity by pharmaceutical companies (see Section 2.2.2.4). After a period of reduced interest there is a shift back towards natural products, supported by improved methods to explore species' DNA to search for useful compounds (Piper, 2017). The appreciation for this contribution from nature to people is also found in the greater awareness of recent unanticipated benefits from biodiversity. The State of the World's Plants (Willis, 2017) provides examples of benefits from genetic variation. For example, the ash tree (*Fraxinus excelsior*) is suffering dieback across northern parts of Western Europe from a fungus; however, whole genome sequencing has helped characterize the genetic diversity, so that resistant individuals can be identified.

Medicines derived from medicinal plants (see Section 2.2.2.4) and from marine organisms also raise awareness of biodiversity option values. However, benefits of this contribution from nature to people also may include other products. For example, it has been found that honeycomb moth caterpillars can eat through plastic (Bombelli *et al.*, 2017). The caterpillars are beewax-eating pests, but enzymes from the caterpillars provide an un-expected global benefit. Another example is the recent published role of golden jackals (*C. aureus*), long regarded as a pest, as a remover of domestic animal carcasses, which is saving about two million euros in those countries west of Black Sea with estimated jackal population size >100 individuals –i.e. Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Hungary, Romania and Serbia- (Ćirović *et al.*, 2016). The appreciation and value of this contribution from nature to people can also be estimated through the ongoing reporting of surprising discoveries in the popular press. For example, the golden jackals' example was widely communicated through a New Scientist article[25]. Such examples can reinforce people's relational value, linking biodiversity to future generations' quality of life (Faith, 2016). The Millennium Ecosystem Assessment (2005) concluded that "*the value individuals place on keeping biodiversity for future generations— the option value— can be significant*". Recently, a consortium of IUCN and global conservation NGOs argued for the value of biodiversity in maintaining options, providing many examples of past surprising benefits from biodiversity (Gascon *et al.*, 2015).

2.2.4 Interregional flows of nature's contributions to people: dependency of Europe and Central Asia on ecosystems of other regions

2.2.4.1 Introduction: interregional flows of nature's contributions to people

Nature's contributions to people being used in Europe and Central Asia are provided by ecosystems both within and outside the region. Through interregional flows of nature's contributions to people, i.e. the active or passive transport of energy, matter or information, differences between the provision and actual consumption of ecosystem services can be balanced (Liu *et al.*, 2016). Flows of nature's contributions to people happen both between subregions of Europe and Central Asia, and between the region and other parts of the world. Interregional flows of nature's contributions to people involve telecoupling, i.e. socioeconomic and environmental interactions over distances (Liu *et al.*, 2016), and have several consequences. Ecosystem service use in one location can have impacts on ecosystems in other locations, such as degradation and connected loss of biodiversity (Mayer *et al.*, 2005). For example, deforestation embodied in final consumption of the EU-27 equated to 732,000 ha (2004). In other words, 10% of the world's annual deforestation (7,290,000 ha per year) was the result of consumption by the EU-27 (see **Figure 2.46**) (European Commission, 2013).

Furthermore, interregional flows can have effects on quality of life, such as distributional equity, as discussed in the context of land grabbing (see Section 2.3.1.1) (Rulli *et al.*, 2013). On the other hand, interregional flows of nature's material contributions to people can lead to overall lower costs of food (Schmitz *et al.*, 2012). Additionally, access to goods from outside the region through trade contributes to food security (see Section 2.3.1.1) as well as supporting livelihoods in the producing country.

25. https://www.newscientist.com/article/2090451-invasive-trash-eating-jackals-save-europe-e2-million-a-year/

Figure 2 46 **Consumption of nature's contributions to people associated with global deforestation allocated by sector for the EU-27 (2004).**

Brazil, Argentina, Paraguay, Indonesia and Malaysia, among others, have been identified as important sources of embodied deforestation. Source: European Commission (2013b).

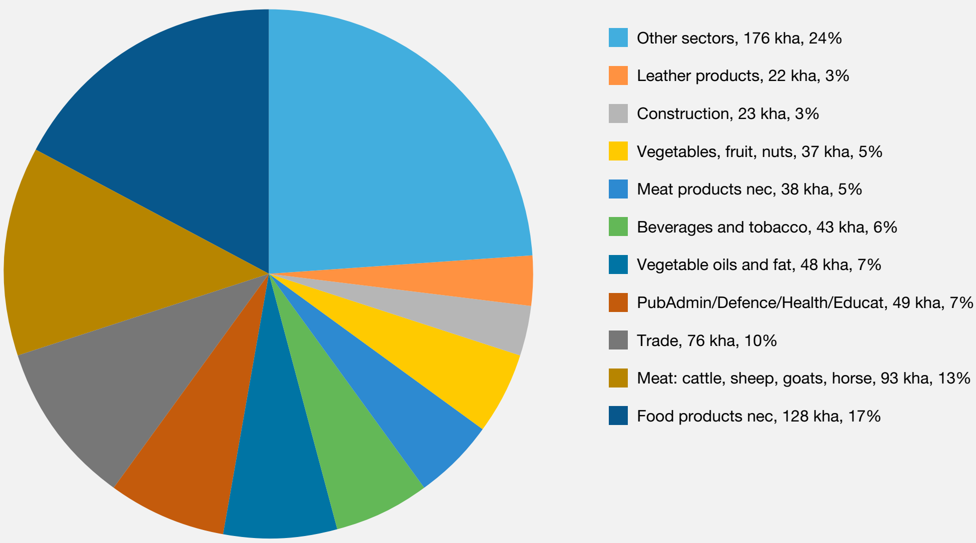
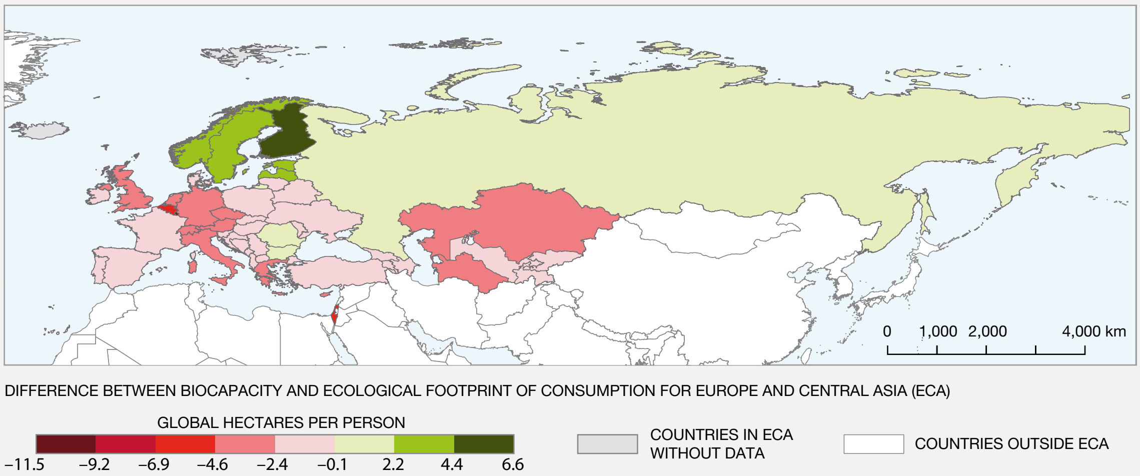


Figure 2 47 **Difference between biocapacity and ecological footprint (consumption) in global hectares per person for Europe and Central Asia (ECA).**

A positive value (green) indicates a biocapacity reserve; a negative value (red) indicates a deficit. A deficit derives from the overuse of local renewable resources or the net import of renewable resources for consumption. Countries shaded in green have high biocapacity, so they have a reserve despite having a higher ecological footprint than many other countries. Source: Own representation based on Global Footprint Network (2017).



2.2.4.2 Ecological footprint

Ecological footprint is a composite indicator for use of nature's contributions to people (Borucke *et al.*, 2013; Kitzes & Wackernagel, 2009) that quantifies the area needed to provide certain material or regulating contributions and expresses consumption in an area in terms of the area needed to renewably provide those contributions (Kitzes & Wackernagel, 2009). Ecological footprint includes proxies for nature's contributions to people such as crops, grazing land, fish, timber, and carbon sequestration (Borucke *et al.*, 2013). Biocapacity is another proxy for ecosystem productivity. Specifically, biocapacity refers to the capacity of a certain area to generate an ongoing supply of renewable resources and thus is a proxy for ecosystem productivity. Data on the ecological footprint of consumption and on biocapacity (in global hectares per person) are available for most of the countries within Europe and Central Asia (missing: Andorra, Iceland, Liechtenstein, Monaco, San Marino). For Europe and Central Asia in 2013, the ecological footprint (consumption) was 4.6 ha and biocapacity only 2.9 ha (based on 49 countries) (Global Footprint Network, 2017). This indicates that the region either overuses or net imports renewable natural resources. Both ecological footprint and biocapacity differ regionally, and so does the difference between the two measures **(Figure 2.47)**. For Western Europe (data for 19 of 24 countries), the footprint was 5.1 ha, vs. 2.2 ha biocapacity; for Central Europe (all 18 countries) the footprint was 3.6 ha, vs. 2.1 ha biocapacity, for Eastern Europe (all seven countries) the footprint was 4.8 ha, vs. 5.3 ha biocapacity; and for Central Asia (all five countries) the footprint was 3.4 ha, vs. 1.7 ha biocapacity. This means that Western and Central Europe and Central Asia have a deficit, while Eastern Europe has a reserve, in terms of biocapacity. A deficit can be ascribed to overuse of local renewable resources or net import (interregional flows) of renewable resources for consumption. In **Figure 2.47** countries shaded green have high biocapacity, so they have a reserve despite some also having large ecological footprints.

2.2.4.3 Status and trends of interregional flows for selected nature's contributions to people

Human appropriation of net primary productivity (HANPP) is a measure that includes biomass extraction from ecosystems for food, fodder, fibres and bioenergy. For large parts of Western Europe, HANPP appropriated is lower than HANPP embodied in consumption. For Central and Eastern Europe and Central Asia, HANPP of the region is about the same as or slightly higher than HANPP embodied in consumption (Erb *et al.*, 2009a, 2009b). European Union imports embodied HANPP to an increasing extent, in particular from South America (Kastner *et al.*, 2015) (see **Figure 2.48**).

Central and Western Europe depend on land elsewhere for crop production to a large degree; Eastern Europe and Central Asia to a lesser degree. Main sources are Brazil, Argentina, China and the USA (Yu *et al.*, 2013). In 2008 Western Europe showed relatively low levels of self-sufficiency in terms of crop production and consumption,

Figure 2 48 **Human appropriation of net primary productivity (HANPP) (Mt dm/yr) embodied in trade between the European Union and ten world regions. Arrows indicate the largest flows (red=import, black=export). Source: Kastner *et al.* (2015).**

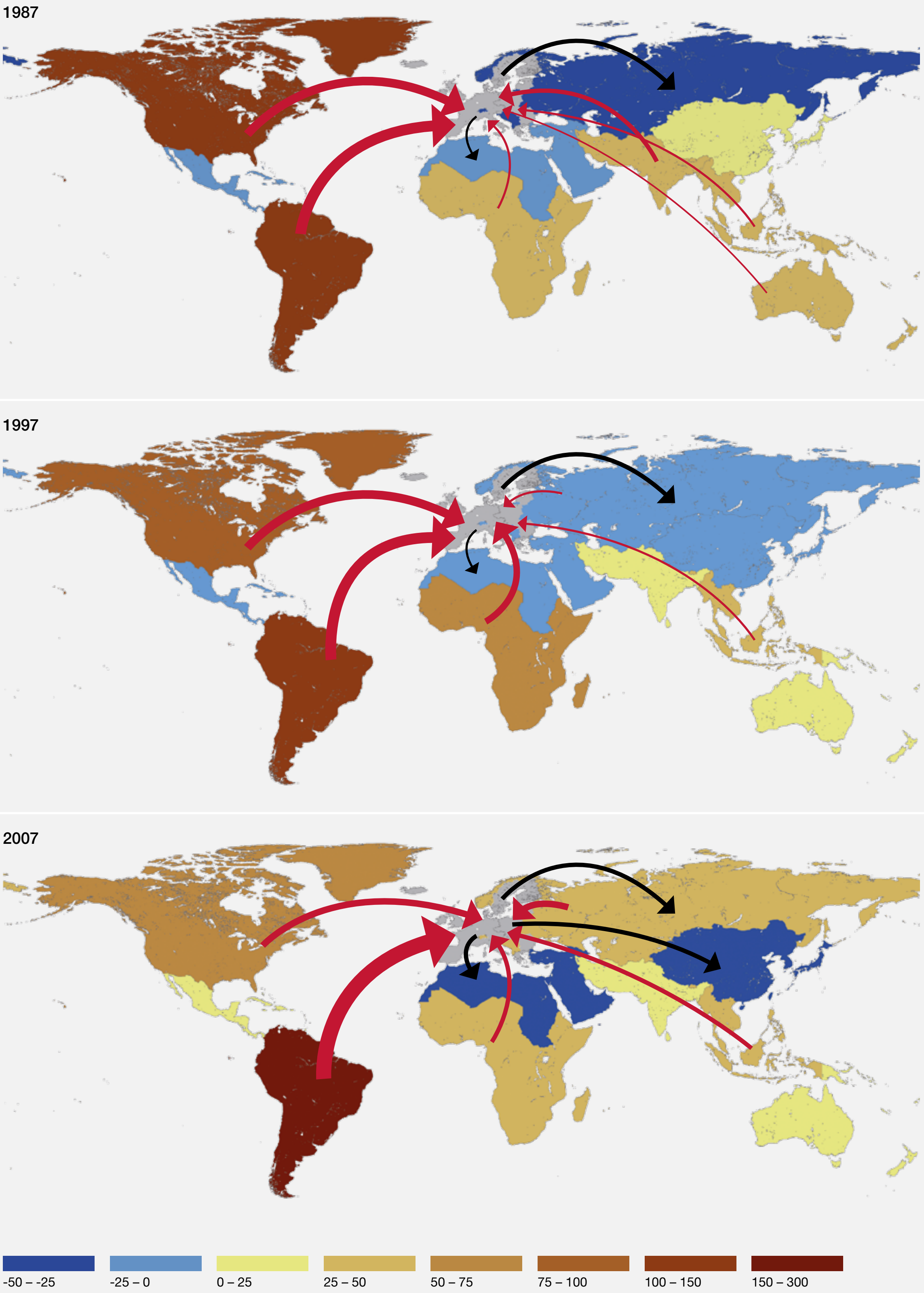


Figure 2 49 **Croplands (million ha harvested per year) related to import and export of crops. Source: Kastner *et al.* (2014).**

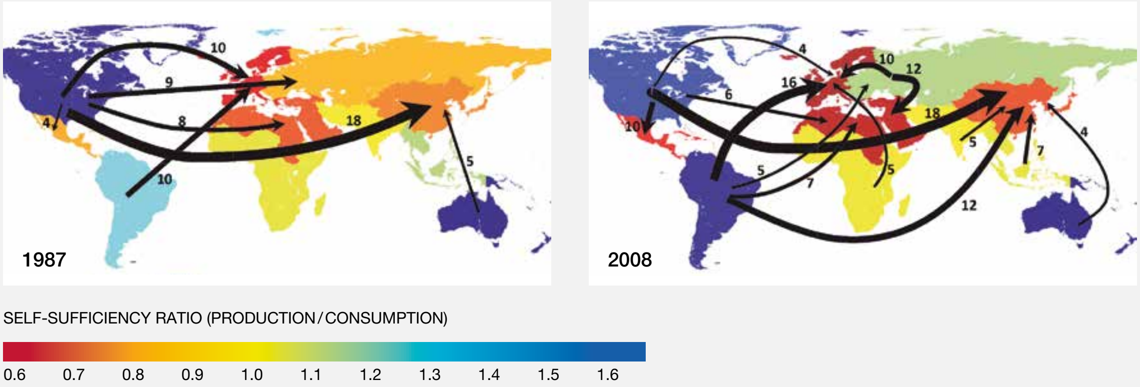
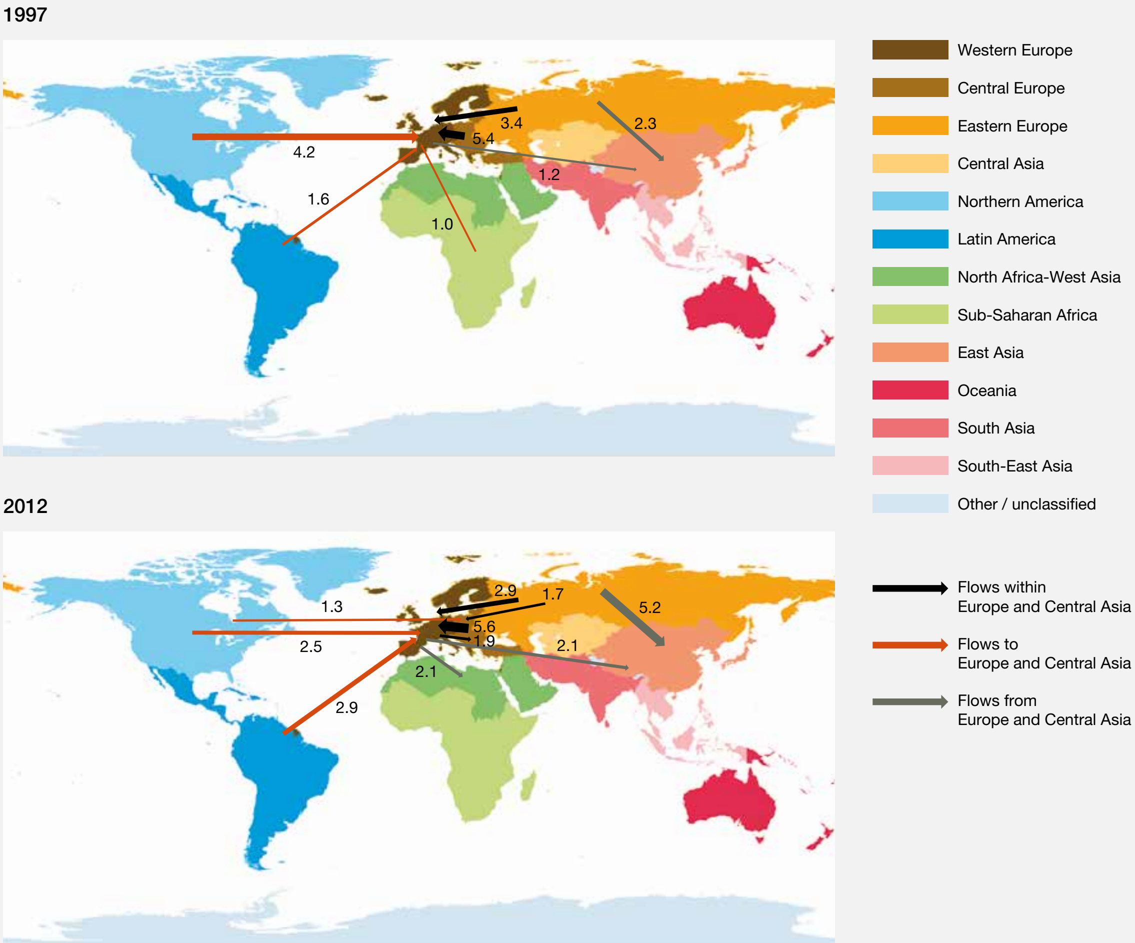


Figure 2 50 **Flows of traded wood and wood products (million tonnes of C), within, to and from Europe and Central Asia for 1997 and 2012.**

Only flows above 1 million t C are indicated with arrows. Source: Based on data from Henders *et al.* (2015); Kastner *et al.* (2011).



while Central and Eastern Europe as well as Central Asia showed higher production than consumption levels (i.e. self-sufficiency ratio larger than 1) (see **Figure 2.49**) (Kastner *et al.*, 2014). **Figure 2.49** indicates Central and Western Europe depended in 2008 on food and feed imports equivalent to the annual harvest of 35 million hectares of cropland, a land area the size of Germany. See Section 2.3.1.1 on food security.

Worldwide median minimum distance from fishing source to place of consumption has increased from about 500 km in 1950 to about 2,500 km in 2011 (Watson *et al.*, 2015b). Seafood exports from Europe and Central Asia increased over the period 1976-2009, with Russia, Norway and Spain being the main exporters. Per capita consumption also increased, with Norway, Iceland, Spain, Portugal and Lithuania being the countries with the highest per capita consumption (Watson *et al.*, 2015a) (See Section 2.2.2.1).

Interregional flows of roundwood and wood products (t C per year) have changed patterns between 1997 and 2012 **(Figure 2.50)**. The largest flows within Europe and Central Asia are exports from Central and Eastern Europe to Western Europe (stable between 1997 and 2012). Eastern Europe increased exports to South Asia. Flows from North America to Western Europe decreased, flows from Latin America to Western Europe increased.

Interregional flows take place also for carbon sequestration. There is evidence that terrestrial ecosystems only sequester a small fraction of anthropogenic carbon emissions in Europe (defined here as the landmass between the Atlantic Ocean and the Urals, excluding Turkey and the Mediterranean isles) (Janssens *et al.*, 2003). The rest is sequestered by terrestrial ecosystems in other parts of the world, by oceans, or adds to the atmospheric carbon stock.

2.2.5 Summary of trends of nature's contributions to people

The contributions to people from ecosystems in Europe and Central Asia have changed markedly since the 1950s, promoting changes in the quality of life of its societies (see Section 2.3). Although the ecosystems of the region are currently delivering multiple contributions to people, there has been evidence of negative trends in the provision of regulating and some non-material contributions since the 1960s (see **Figure 2.51**). Overall, 58% of publications provide evidence of negative trends of nature's contributions to people provided between 1960 and 2016, while 28% reported positive trends (see supporting material Appendix 2.7[26] for the whole list of references reporting increasing, constant, decreasing and mixed trends per contribution). This pattern, however, is not consistent across contributions: while 59% and 66% of the scientific publications reviewed provide evidence of declining trends in regulating and non-material contributions, respectively, only 39% of the studies show negative trends in the delivery of material contributions **(Figure 2.51)**. In fact, of the range of nature's contributions to people delivered in Europe and Central Asia, about 44% have been assessed as declining, particularly regulating and some non-material contributions, such as learning derived from indigenous and local knowledge. The decreasing trends of learning derived from indigenous and local knowledge also have consequences for other contributions from nature to people, such as the use of medicinal plants (Section 2.2.2.4), wild food gathering (Section 2.2.3.2.1), the use of guard dogs for protecting livestock (Section 2.2.2.3.4) and the cultural identity of peasants, herders and shepherds (Section 2.3.3, supporting material Appendix 2.2[27]), which have also declined over the assessed period.

Intensification of management practices, technology, manufactured capital and market forces have promoted increasing trends in the provision of particular material contributions from nature to people, including food, biomass-based energy and materials **(Figure 2.51)**. The increasing trends in the delivery of specific material contributions have come at the expense of the long-term deterioration of regulating contributions. Some key regulating contributions, such as habitat maintenance, pollination, regulation of freshwater quantity and quality, formation and protection of soils, and regulation of floods, have been negatively affected since the 1960s by intensified management practices that seek to increase production of crops, livestock, aquaculture, woodfuels and cotton. In addition, the increasing demand in Western and Central Europe for nature's material contributions to people, such as food and biofuels, is straining the capacity of ecosystems and nature's contributions to people in other regions of the world (Sections 2.2.2.3 and 2.2.4).

The improvement found for some of nature's regulating contributions to people in the last decade in Western and Central Europe (see **Figure 2.51**), such as regulation of water quality, protection of soils and removal of animal carcasses by scavengers, can be explained by the successful implementation of European Union policies, such as the Nitrates and Water Framework Directives (see Section 2.2.1.7) and the Common Agricultural Policy (see Section 2.2.1.8), the implementation of different nature-based solutions for water quality (see Section 2.2.1.7), as well as different conservation programmes for vertebrates (see Section 2.2.1.10). In addition, it is worth noting that water-based regulating contributions from

26. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.7_assessment_references_synthetic_table.pdf

27. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

Figure 2 51 **Assessment of each of nature's contributions to people (NCP) based on published literature for each subregion and for Europe and Central Asia as a whole.**

The bottom row of the panel shows the trends of all contributions. The bar indicates the proportion of papers that provide evidence of decreasing, constant, increasing or mixed trends for each contribution, representing the level of agreement. The intensity of the colour represents the total number of publications identified and used in this assessment (i.e., solid colours indicate many papers, whereas faded colours indicate few, and blank space indicates zero studies), thus, representing the quantity of evidence. The degree of confidence is also represented by indicating the level of agreement (i.e. the strongest agreement is presented when only one colour is shown) and the quantity of evidence (i.e. the most robust evidence is presented when the assessment is validated by more than 31 multiple independent papers, which is represented by dark solid colours). Colours can also vary for the same contribution when trends of contribution subtypes differ. See supporting material Appendix 2.7* for the list of references reporting trends in contributions across subregions of Europe and Central Asia. Source: Own representation.

* Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.7_assessment_references_synthetic_table.pdf

nature to people have improved in Western Europe since the 1990s due to changing patterns in societal behaviour driven by European Union policies, but not because of an enhancement in ecosystems' capacity to provide them. For example, although water quality is improving due to the aforementioned Union policies and pollution reduction, ecosystems' capacity to regulate water quality has been jeopardized by a reduction in the areal extent of wetlands and floodplains (see Section 2.2.1.7). The abstraction and use of freshwater have decreased since the 1990s; however, water availability per capita has also decreased by 15% since 1990 (see Sections 2.2.1.6, 2.3.1.3). Similarly, the increasing trends of physical and psychological experiences (see **Figure 2.51**) can be explained by the fact that people in the European Union have increasingly demanded nature for recreational activities, although land-use change has threatened the ecosystems highly valued by people for these experiences (see Section 2.2.3.2.1).

The pattern of trends in nature's contributions to people is consistent across the subregions of Europe and Central Asia **(Figure 2.51)**. Declining trends of these contributions are reported in Central Europe (61% of the scientific evidence), Western Europe (55%), Eastern Europe (54%) and Central Asia (48%); while increasing trends are mostly reported for Western Europe (35% of scientific evidence). Nevertheless, it should be noted that more scientific research (in English language-journals) on nature's contributions to people has been conducted in Western and Central Europe than in Eastern Europe and Central Asia (Boerema *et al.*, 2017), with implications for the levels of confidence about status and trends of nature's contributions to people across subregions **(Figure 2.51)**.

2.2.6 Future trends in nature's contributions to people

This section examines the potential impacts of individual drivers on future trends in nature's contributions to people, with trends in direct and indirect drivers covered in Chapter 4 and the impacts of combined drivers and trade-offs between contributions discussed in Chapter 5, Sections 5.2 and 5.3. A semi-structured literature review (see Section 2.2) was undertaken, with information extracted into a template to enable comparison across nature's contributions to people and to facilitate integration with Chapter 5's analysis of the impacts of multiple drivers on the status and trends of contributions (see Section 5.3.3 and 5.3.4). In the allotted time, this search process could only be fully applied to food and feed, air and climate regulation, and learning and inspiration. Even the targeted semi-structured literature review yielded comparatively few articles, except for Western Europe. Thus, it was not possible to estimate robustly future trends in nature's contributions to people in Europe and Central Asia. As in Chapter 4, the most frequently identified driver of trends in contributions was climate change, followed by land use, land-use change and forestry (LULCC).

2.2.6.1 Regulating contributions

Nature's regulating contributions to people are likely to show mixed responses to climate change across Europe and Central Asia (Kovats *et al.*, 2014). Few studies have examined future trends in *pollination or pollinators*, but both qualitative and quantitative modelling studies suggest that climate change is likely to lead to pollinator decline. Modelling shifts in bumblebee distribution showed that, by 2100, up to 36% are projected to be at high risk from climate change (losing >80% of their current range), with 41% at risk (losing 50-80% of their current range), depending on the scenario (Kerr *et al.*, 2015).

Little literature was found for the *air regulation* as a contribution from nature to people. Tallis *et al.* (2011) estimated that the planned increase in tree cover, from 20% to 30% in the Greater London Authority area, could increase particulate matter (PM_{10}) removal by 18% by 2050, assuming no change in tree cover types. Papers on past and present trends in urban air quality comment on the importance of trees and green space in the future (e.g., Baró *et al.*, 2014).

Climate regulation may become more important as countries seek to meet their greenhouse gas commitments under the Paris Agreement. For example, the Tajikistan government has a national programme on carbon sequestration (2014-2024), which includes plans for afforestation and reforestation (Mustaeva *et al.*, 2015). For future carbon budgets, climate and land use, land-use change and forestry (LULCC) were the most frequently analyzed drivers, with the net balance of their effects depending on their impact on vegetation, soil storage and decomposition. In the Arctic, global mean temperature increases could decrease carbon storage in permafrost soils by 2100, despite increased uptake of carbon by vegetation. In northern parts of Western and Eastern Europe, warming could increase tree carbon storage (Olchev *et al.*, 2009; Shanin *et al.*, 2011), although it would decrease if precipitation declines (Olchev *et al.*, 2009), especially in southern areas of the European Union (Lavalle *et al.*, 2009). Also, forest disturbance from wind, bark beetles and wildfires are projected to decrease the carbon storage potential of forests in Western and Central Europe by 503.4 TgC between 2021–2030 (Seidl, 2014).

Land use change and fire could have mixed effects on future *carbon budgets* (Kuemmerle *et al.*, 2011; Verkerk *et al.*, 2014). Unmanaged woodlands in Western Europe should continue to be a carbon sink (Allen *et al.*, 2016), while in central Russian forests, fire and management could have a greater influence than climate on future vegetation and soil carbon stocks, with forests becoming a carbon source rather than a sink (Shanin *et al.*, 2011). There are similar mixed responses to land use change and management on formerly abandoned lands in Eastern Europe and Central Asia (Causarano *et al.*, 2011), with afforestation increasing carbon storage, while for biofuel production, using low intensity/high density grass-legume pastures, it depends on the timing of cultivation, tillage and climate change, and soil carbon sequestration would increase unless climate change were to decrease vegetation net primary productivity (Vuichard *et al.*, 2008).

Artificialization and soil sealing are rapidly increasing in the European Union (FAO, 2015b; Jones *et al.*, 2012) and might affect the *formation and protection of soils* as a contribution from nature to people in the near future, while this is not yet a problem in Central Asia due to the vast extent of land (UNEP & UNECE, 2016). Hence, the supply of erosion control in the coming decades will mainly depend on the farming practices and land-use policies implemented.

Changes in climate will affect the demand for, and supply of, *hazard regulation*. Greater demand could result from increased glacier melt (Hagg *et al.*, 2006; Sorg *et al.*, 2012; Stoffel & Huggel, 2012); flooding due to heavy precipitation events in parts of Western and Central Europe (Kovats *et al.*, 2014); and fire frequency and severity, especially in parts of

Russia (Gauthier *et al.*, 2015) and southern Western Europe, where the annual burned area could increase by a factor of three to five by 2100 under the IPCC A2 emission scenario (Dury *et al.*, 2011).

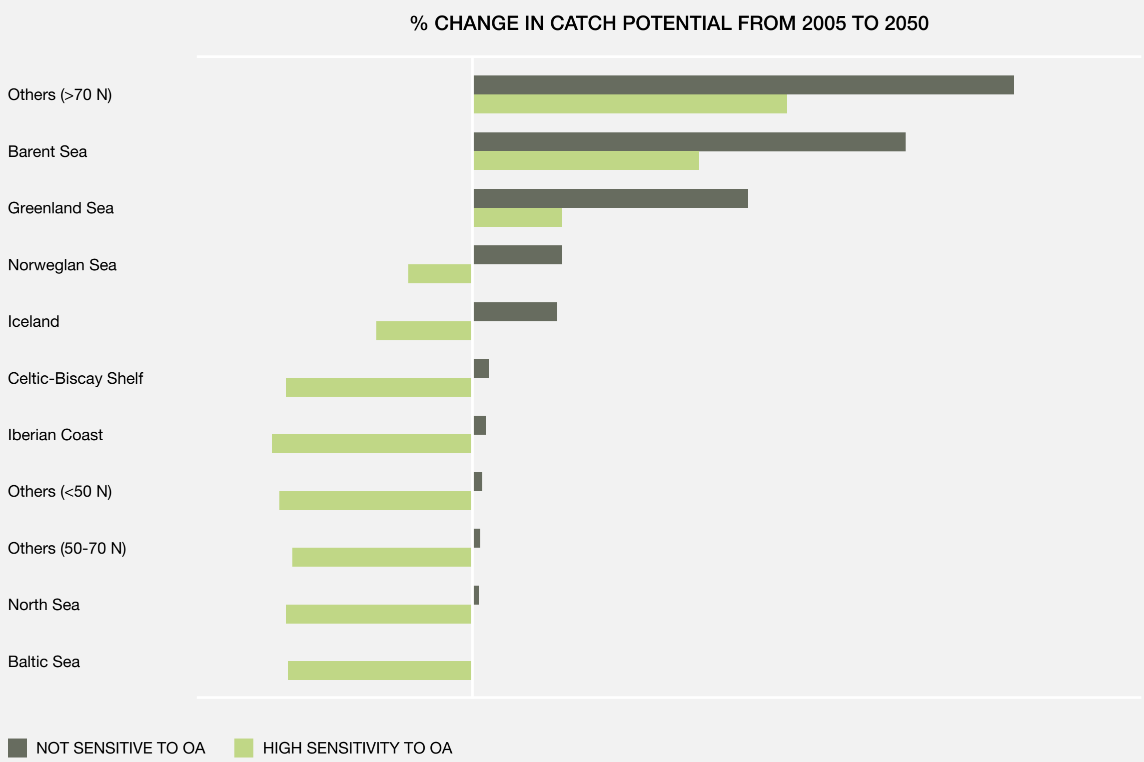
2.2.6.2 Material contributions from nature to people

Changes in seasonal, and extremes of, temperature and precipitation, as well as CO_2, can affect *food and feed* provision, which show mixed trends in yield, depending on the scenario, region and crop. Global modelling of cereal production in 2050 shows increases in countries in the Organization for Economic Co-operation and Development and in countries emerging from the former Soviet Union, partly as a result of an enhanced CO_2 fertilization effect, with cereal consumption possibly increasing in the former, and increasing in the latter depending on scenario (Alcamo *et al.*, 2005). Zabel *et al.* (2014) also suggest that climate change will increase the extent of agriculturally suitable land and food production in Russia. Food, livestock and fibre production, however, are projected to decrease in parts of Western and Central Europe, but to increase in the northern parts of these regions (Kovats *et al.*, 2014). Climate change is projected to cause increased yields of rainfed maize, while rainfed wheat shows a mixed response across Europe and Central Asia, depending on the climate scenario (Nelson *et al.*, 2010). It could lead to an overall decrease in daily per capita calories available (Nelson *et al.*, 2009) and in fodder quality (Quetier *et al.*, 2007). In Eastern Europe and Central Asia, by 2050, yields of many irrigated crops show a mixed response, but water shortages mean that irrigation is unlikely to be able to continue at current levels, so yields could decrease by 50% or more (Sutton *et al.*, 2013). Other studies project decreases in agricultural production from combined effects of climate change and deteriorating land use practices in the Czech Republic (Lorencova *et al.*, 2013) and across Western Europe (Haines-Young *et al.*, 2012).

Timber production may decrease in many parts of Central Europe, but with increases predicted in northern parts of Western Europe. In Finland, forest stand models, in which tree growth is converted into site and then regional forest growth, calculate that, under an Intergovernmental Platform on Climate Change SRES B2 scenario (based on

Figure 2 52 **Projected changes in maximum catch potential by 2050 relative to 2005 under the SRES A1B scenario, with assumptions about sensitivity to ocean acidification (OA).**

Projections are made using a dynamic bioclimatic envelope model with physical and biogeochemical outputs from the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory Earth System model (TOPAZ). Source: Cheung *et al.* (2012).

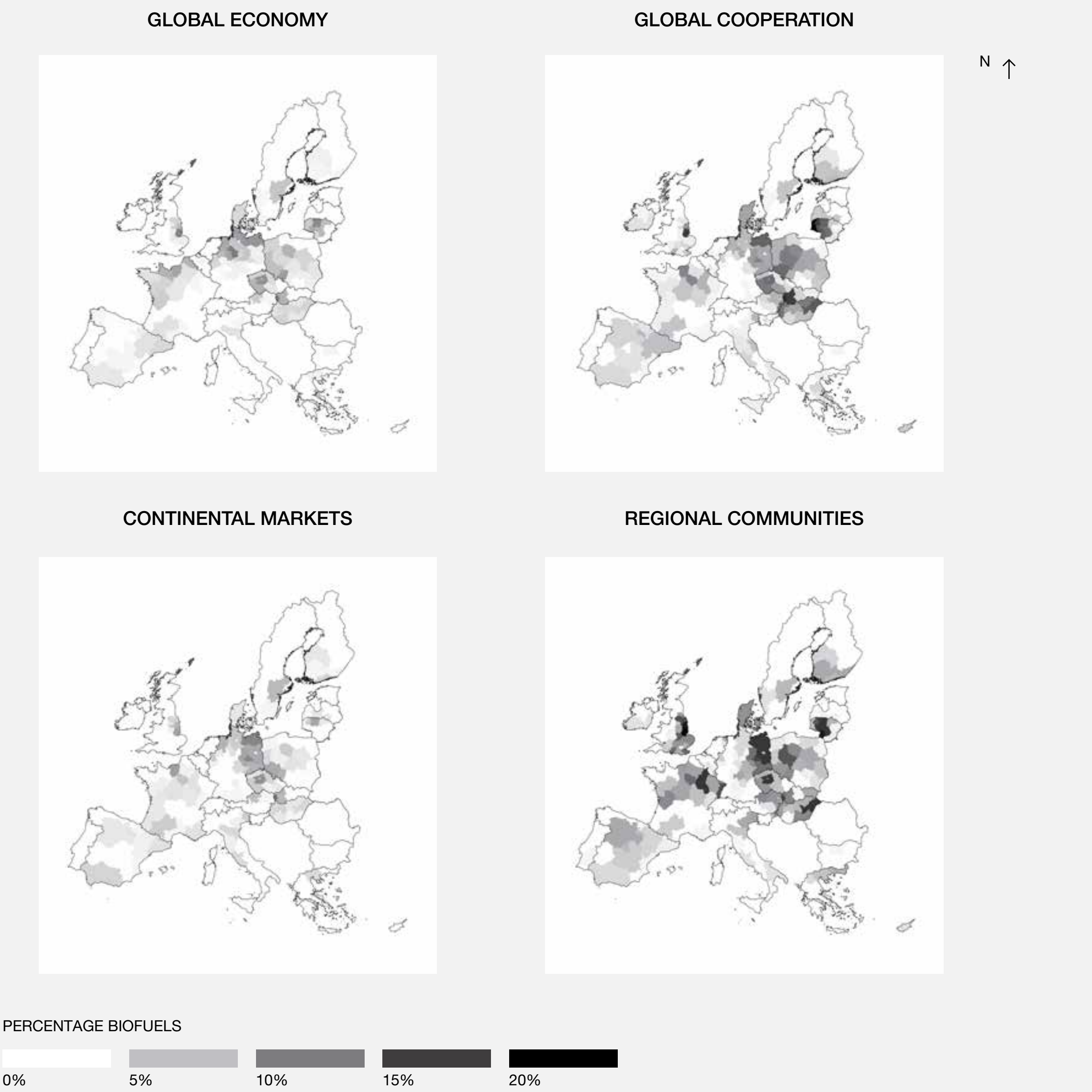


the Special Report on Emissions Scenarios (SRES)), pine growth in southern Finland could increase by 16% and in Lapland by 31%, while under a higher (SRES A2) emissions scenario these figures are 40% and 80% respectively (Forsius *et al.*, 2013).

In the EU-27, demand for *biomass-based wood for energy*, and wood products are both projected to increase from 2010 to 2030 under a *global markets* scenario (Verkerk *et al.*, 2014), but the production and consumption of wood products is lower and could slow under the *regional sustainability* scenario (Jonsson, 2013), with Eastern Europe accounting for a greater proportion of production and consumption of solid wood, pulp and paper products. The increasing demand, especially for wood-based energy, means that EU-27 supply may not meet the future demand for raw wood materials.

For fish production, the maximum catch potential could increase in Western Europe, especially in high latitude seas (>50ºN), with an average yield increase of 30-70% **(Figure 2.52)**, depending on assumptions about the effects of ocean acidification on fish ecophysiology (Cheung *et al.*, 2012).

Figure 2 53 **Biodiesel and ethanol production in the European Union (EU-27) by 2030 under different scenarios combining drivers such as globalization and regionalization, import levels, processing facilities and infrastructural arrangements, subsidy levels, and nature conservation policies. Source: Hellmann & Verburg (2011).**



Within Europe and Central Asia, the main biodiesel and bioethanol producers and consumers are within the European Union. Based on the Special Report on Emission Scenarios (Nakicenovic & Swart, 2000), the scenarios for the spatial allocation of *biofuel crops* within the EU-27 region showed that by 2030, for different storylines with various political and economic circumstances, some regions are projected to have a higher share of biofuel crops (Hellmann & Verburg, 2010) **(Figure 2.53)**.

For 2050 under a *business-as-usual* scenario, biofuel potential amounts annually to 3.6 EJ (Western Europe), 6.3 EJ (Central Europe), and 7.9 EJ (Central Asia and Russian Federation) (Haberl *et al.*, 2011). **Figure 2.53** shows that current biofuel production in the subregions is strongly below the future potential. Western Europe has the lowest potential, but the significantly highest biofuel production. However, these biofuel potentials do not take changes in population, diets, and climate into account. The highest unused potentials for biofuels are in Central Asia and Russia.

2.2.6.3 Nature's non-material contributions to people

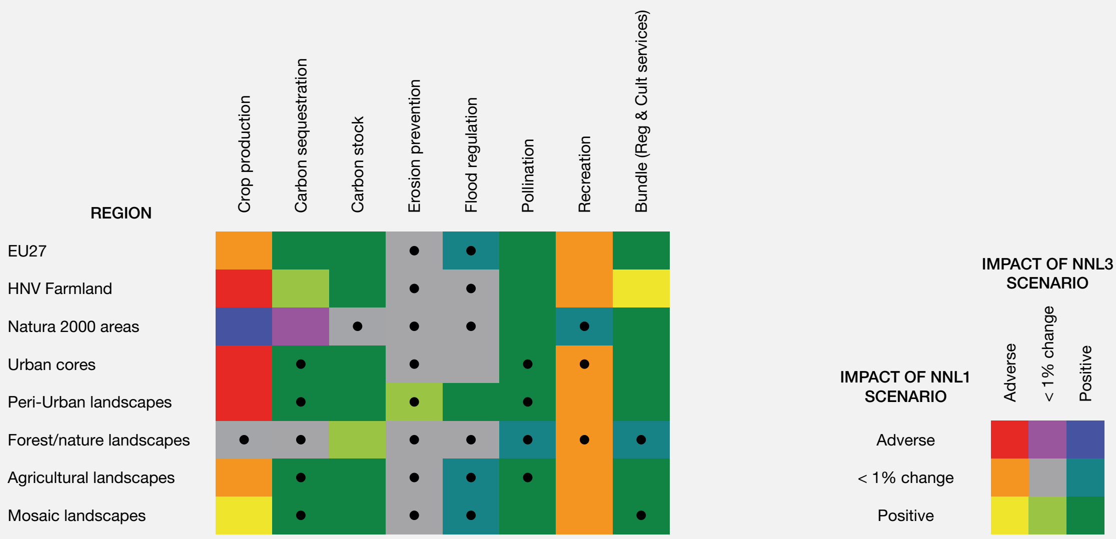
There are fewer studies on the future of nature's non-material contributions to people and most of them relate to learning and inspiration and physical and psychological experiences linked to outdoor recreation and tourism. In northern Scandinavia and north-western Russia, tourism and recreation could decrease in winter due to climate change, but increase in summer, while cultural ties to the landscape and species unique to northern areas could decline (Forsius *et al.*, 2013; Jansson *et al.*, 2015).

Verkerk *et al.* (2014) showed that recreational attractiveness (an expert-based index (1–10) of the preference value for different forest stands for recreation) did not change in Western or Central Europe in either a reference (*business-as-usual*) scenario or wood energy scenario (see above). The biodiversity scenario, however, could lead to an improvement in the recreational attractiveness index by 0.5 points (+ 9.4%; range between countries: + 0.2 to +1.0 points). Overall, the changes were quite small as the index depends on broad age classes of people, which changed relatively slowly between 2010 and 2030.

No clear evidence of future trends in learning and inspiration from nature can be identified, but knowledge of urban habitats can contribute to future urban greening policy and scenario development (Camps-Calvet *et al.*, 2015; Colding *et al.*, 2013; Mortberg *et al.*, 2013). Scientific and indigenous and local knowledge of a range of nature's contributions to

Figure 2 54 **A comparison of changes in nature's contributions to people in different landscape types under a *no net loss* scenario with better implementation of existing biodiversity conservation measures (NNL1) and a *no net loss* scenario with offsetting of residual impacts on areas of high biodiversity and ecosystem service value (NNL3), compared to *business-as-usual*.**

• Indicates no net loss of the contributions from nature to people compared to baseline under the NNL3 scenario. Source: Schulp *et al.* (2016).



people is a key component of scenario development used to consider future strategies and options for environmental and conservation management, such as for transhumance networks in Spain (Oteros-Rozas *et al.*, 2013a), forests in Poland and Sweden (Carlsson *et al.*, 2015; Chmura *et al.*, 2010) and protected areas in Europe (Mattsson & Vacik, 2017). Emerging forms of learning, using virtual tools to develop environmental awareness amongst adults and young people will also rely on knowledge of biodiversity and drivers of change (Harwood *et al.*, 2015; Ulbrich *et al.*, 2015).

For many of nature's contributions to people, policies can also affect the future demand and supply. Simulations of how land use changes in the EU-27 could affect a range of contributions under a *business-as-usual* scenario and three biodiversity *no net loss* scenarios were undertaken by Schulp *et al.* (2016). The simulations found that while *no net loss* policies generally led to an improvement in most of nature's contributions to people, especially climate regulation and pollination, such policies would not totally address the loss of biodiversity and of nature's contributions to people because of the continued demand for land for human use **(Figure 2.54)**. Food provisioning could also be negatively affected under *no net loss* policies, while some of nature's regulating contributions to people and recreation could be little affected.

This, and other studies which consider a number of nature's contributions to people together (e.g. Kain *et al.*, 2016), highlight that trade-offs between contributions need to be taken into account when considering both current and future trends (Section 2.3.4.2).

2.3 EFFECTS OF TRENDS IN NATURE'S CONTRIBUTIONS ON QUALITY OF LIFE IN EUROPE AND CENTRAL ASIA

2.3.1 Contributions to food-energy-water security

Food, energy and water are essential for human well-being, poverty alleviation and sustainable development (FAO, 2014b). Food security, water security and energy security represent Sustainable Development Goals number 2, 6 and 7, respectively (see Section 2.4).

2.3.1.1 Food security

Food security is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2014b). A condition for the full realization of the right to food is "food sovereignty" (De Schutter, 2014), defined as "the right of nations and peoples to control their own food systems, including their own markets, production modes, food cultures and environments" (Wittman *et al.*, 2010). The situation and trends of food security and sovereignty in Europe and Central Asia have been mixed in the last century and vary greatly between and within subregions, with the best situation in Western Europe, and Central Asia showing the largest challenges (all data retrieved from FAOSTAT).

Food availability is adequate across Europe and Central Asia, where the average dietary energy supply adequacy ranges from 137% in Western Europe to 121% in Central Asia (see **Figure 2.55**). Food accessibility and utilization varies between subregions. The domestic food price level showed stability between 2001 and 2014, but also large inequalities within the region with the lowest price levels in Western Europe, intermediate levels and decreasing in Central Europe, and three times higher levels and increasing in Eastern Europe. Undernourishment has been very low in recent decades in Central and Western Europe; in Eastern Europe, although currently stable around 7%, it reached almost 45% in the early 1990s; and in Central Asia, it has fluctuated and currently reaches 20%. The percentage of adults who are underweight increased to almost 4% in Central and Western Europe from the late 1990s to the end of the century. During the recession of 2007-2009 daily nutritional intake and the consumption of nutritious food declined in Eastern and Central Europe, so that after 2008 the percentage of households with children unable to afford a meal with meat, chicken, fish, or a vegetable equivalent every second day more than doubled in some countries reaching up to 18% in Greece in 2012 (UNICEF, 2014). Overall food stability is improving: domestic food price volatility is quite low and relatively stable in the last decades, except for a peak in Eastern Europe in 2005. However, the food production variability per capita is increasing since 2010, particularly in Eastern Europe, which might be considered a threat to food security. A global nutrition transition is affecting the quality of diet in Europe and Central Asia (see **Figure 2.56**), with rapid increases in the rates of obesity and overweight (Popkin *et al.*, 2011), which is linked to inefficiencies and waste in the global food system. In fact, the average fat supply and protein supply are increasing and the former is almost double in Western Europe than in Central Asia and Eastern Europe, which instead show the largest index of diet diversification **(see Figure 2.56)**. The prevalence of food over-acquisition is almost 50% in Western Europe and, although it is lower in the other subregions, it is increasing for these.

Figure 2 55 **Trends in indicators of food security for Europe and Central Asia. Source: Own representation based on data from FAO (2017).**

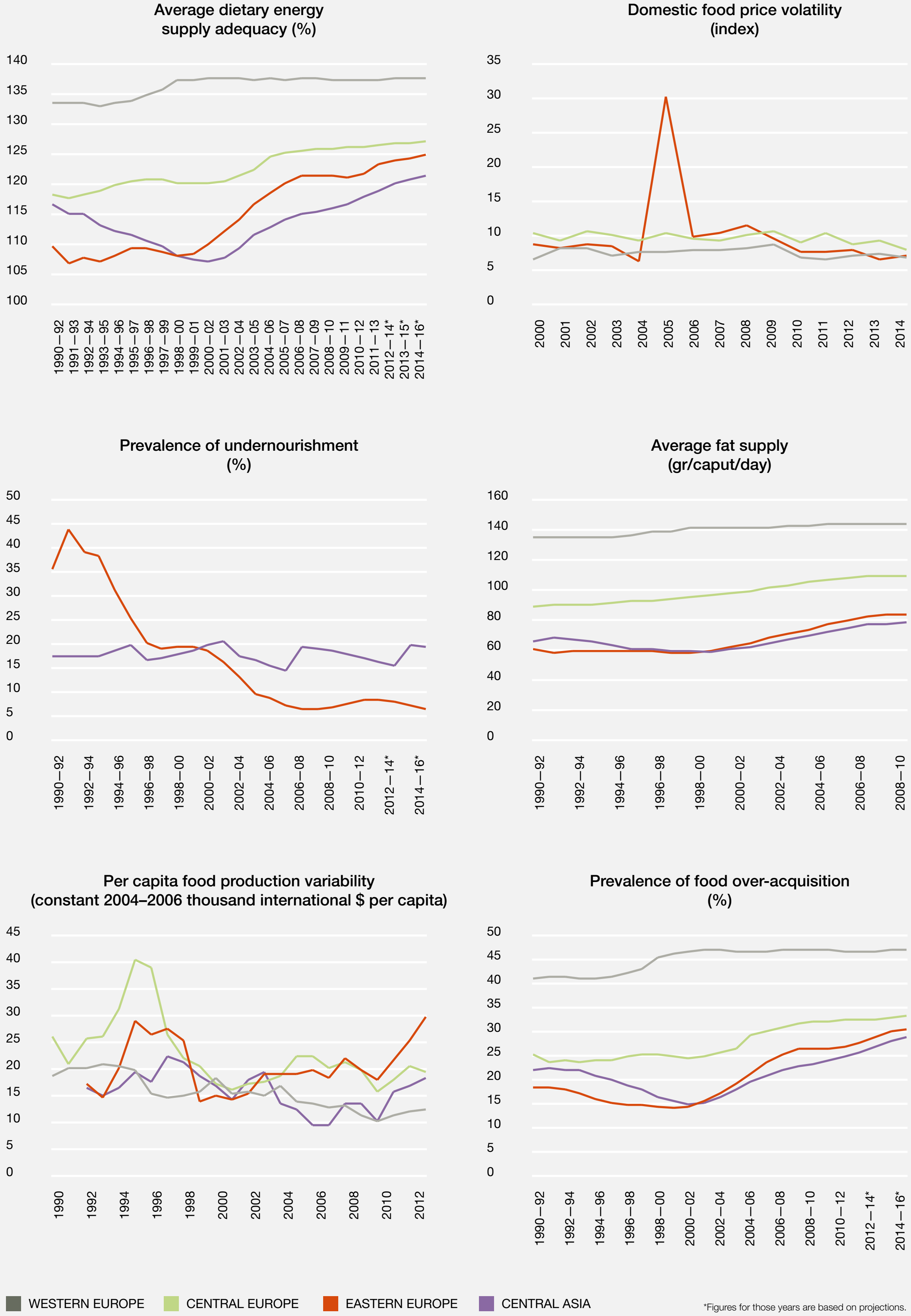
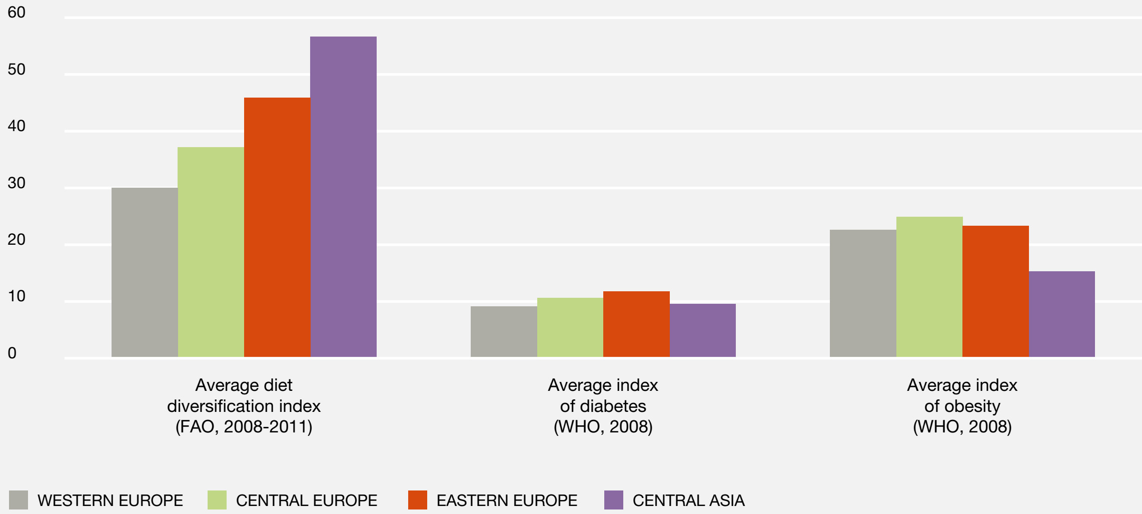


Figure 2 56 **Average indices of the quality of the diet and its impacts on health in subregions of Europe and Central Asia. Source: Own representation based on data from WHO (2008a, 2008b) and FAO (2017).**



Food security and food sovereignty are threatened by large-scale control of extended tracts of land by large investment companies (land deals or land grabs) (van der Ploeg *et al.*, 2015). In 2012 there were 51 documented cases in Europe and Central Asia occupying a total area of 4.4 million ha (see **Figure 2.57**): Russia, Ukraine and Romania are the countries with the largest land-grabbed areas (GRAIN, 2016). Countries from the region are also grabbing land abroad (0.63% of worldwide croplands), particularly Western Europe countries (0.57% of worldwide croplands). However, official statistics do not capture the real dimensions of the phenomenon, which leads to crop production being intensified and oriented to distant markets other than local needs (TNI, 2016). Finally, both food security and sovereignty are challenged by the loss of agri-food related indigenous and local knowledge and agrobiodiversity (see Chapter 3 and **Box 2.2**).

2.3.1.2 Energy security

Energy security has been defined by the United Nations as "access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses" and by the International Energy Agency as "uninterrupted physical availability (of energy) at a price which is affordable, while respecting environment concerns". Energy production was highest in Eastern Europe and lowest in Central Europe in 2014 (see **Figure 2.58**). For heating, "energy poverty" affects at least 10% of the population and is more likely for low-income groups in the European Union (see **Figure 2.60**). Energy poverty is more pronounced in Eastern Europe (Dubois & Meier, 2016).

The highest share of bioenergy (biofuels and waste) relative to the total production in the region is produced in Western and Central Europe. The highest share of hydropower relative to total production is produced in Western and Eastern Europe. Western Europe is a net importer of fossil energy carriers (coal, oil products, and natural gas), whereas Eastern Europe is the largest, and Central Asia the second largest exporter in the region. The net imports or exports by subregion are negligible for bioenergy (biofuels and waste) and other renewables compared with other energy carriers (see **Figure 2.59**).

At the country levels, the trade balance for biofuels in Central Asia and Eastern Europe are mostly equalized. Net exporters are mostly found in Western and Central Europe, the biggest being The Netherlands, Latvia and Germany. Similarly, Western European countries also strongly depend on imports (Italy, the United Kingdom, Denmark, Austria, and Belgium) (see **Figure 2.61**).

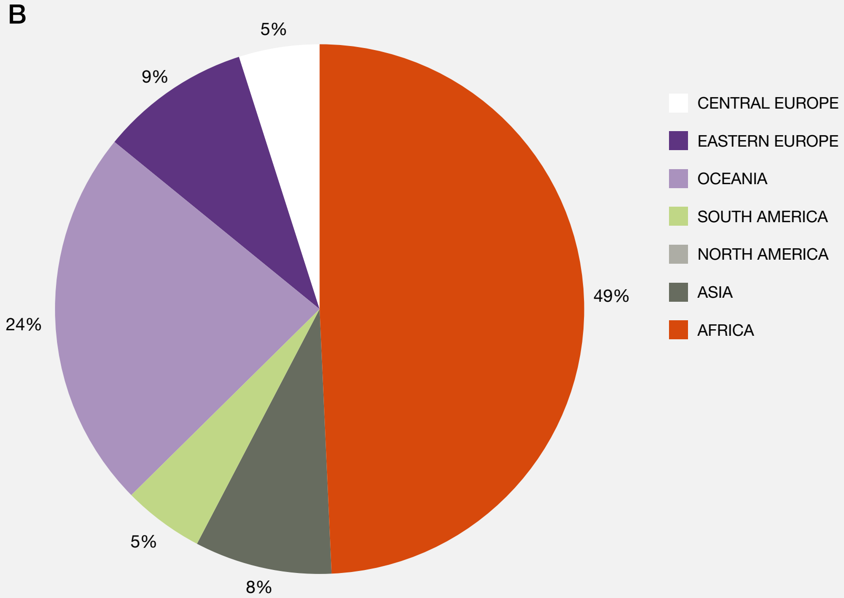
Currently, biomass supplies in the European Union are mostly based on domestic sources (4% of the biomass for bioenergy imported) (European Commission, 2014a). In scenarios for 2020 and 2030, biomass for bioenergy may even fill other supply shortages for industry, replacing coal power plants (Dafnomilis *et al.*, 2017).

In total, the actual contribution of bioenergy to energy security is weakly captured in existing research (Popp *et al.*, 2014) as the multitude of biomass sources, energy carriers, and conversion pathways impede tracking of this renewable energy source. In addition, there are not

Figure 2 57 **A A global map of the large-scale acquisitions of land (also known as land-grabbing) network: land-grabbed countries (green disks) are connected to their grabbers (red triangles) by a network link. Source: Rulli *et al.* (2013).**
B Percentage of surface grabbed by Western Europe in each subregion in Europe and Central Asia and world regions.

A

B



Box 2 2 **Custodians of food, seeds and traditions: biocultural diversity – the diversity exhibited collectively by natural and cultural systems - of people in the Pamir mountains of Tajikistan.**

"*Lonely, desolate, and inhospitable as these mountains for the most part are, one may still find secluded valleys cut deep down into the mountain masses where some hardy hill-men till the ground and form villages*."

The remote plains of the Pamir mountains are a challenging place to transform rock into life-giving soil, primarily rain-fed. Yet, that is what Pamiri people have done over millennia at between 2,000 and 4,000 metres, nurturing a centre of origin for grain and fruit varieties which have become staple crops all around the world, along with domesticated varieties of walnuts, apples, pears, apricots and mulberries.

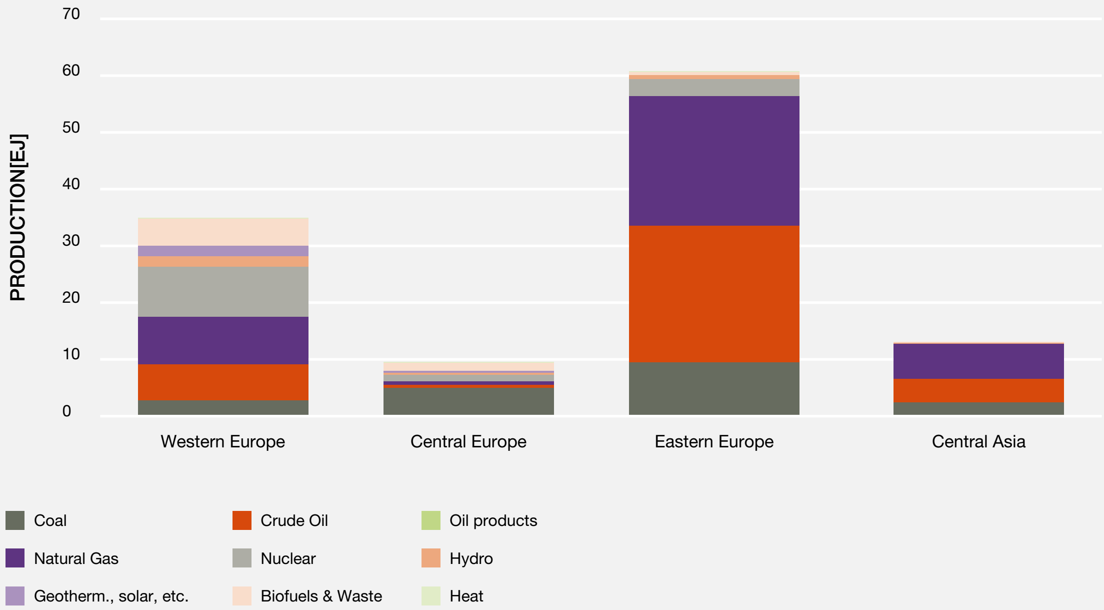
The rich agrobiodiversity of the Pamirs co-evolved with language, culture and spirituality, and as a result of local cooking traditions. Food embodies the interconnectedness of sustenance, health, spirituality, and ecosystem structure and function. *Baht,* a sweet festive porridge of flour and ice water, that is made in celebration of the new year, *Nawruz*, exemplifies these interconnections. The isolated Bartang Valley is well-known for the sweetest tasting *Baht*, because of a variety of wheat called *rush-kakht,* which is grown only in the upper reaches of the valley with the sole purpose to make *baht.* Women use small amounts of the flour of *rush-kakht* to bless the pillars of the house for a productive new year.

This text box is based on van Oudenhoven & Haider (2015).

Red wheat growing in Bartang valley. Photo: Judith Quax.

During *Nawruz*, little animals made of bread (Nazrak) are covered in Baht and provided as offerings. Photo: Judith Quax.

Figure 2 58 **Energy production (in exajoule) by energy source and region in Europe and Central Asia (2014). Source: Own representation based on IEA/OECD (2016).**



only rather novel bioenergy carriers such as biofuels, but also woodfuels, which are extensively used, but roughly estimated in statistics of the United Nations Food and Agriculture Organization. This is especially a problem for the numerous countries analyzed in Eastern Europe and Central Asia. The countries of Central Asia have a negligible share of bioenergy in their energy supply (see **Figure 2.58**). However, given the difficulties of affordable and reliable access, the use of biomass from traditional sources such as charcoal is weakly accounted for, which might be an indication that the figures underestimated nature's contributions to people from bioenergy (biofuels and waste) in this region (IEA/OECD, 2015).

2.3.1.3 Water security

Water security is assessed here as people's capacity to safeguard sustainable access to adequate quantities of water of acceptable quality (UN-Water, 2013). The indicators "percentage of population with access to improved drinking water sources" and "freshwater withdrawal as percentage of total renewable water resources" are used to describe general trends for water security in Europe and Central Asia. The former identifies adequate water availability of improved quality (World Bank, 2016), the latter reveals the extent to which long-term available water resources are exploited (FAO, 2016).

Overall, water security has increased in the region since the late 1980s (Animesh *et al.*, 2016; FAO, 2016; World Bank, 2016). Safe drinking water is secured for 95% of the Europe and Central Asian population, with higher percentages in Western Europe and Central Europe, while Eastern Europe (95%) and Central Asia (85%) have lower, but increasing access to improved drinking water since 1995 (see **Figure 2.62**). The trend in per capita water consumption has increased in all regions, due to increased population, except in Eastern Europe and Central Asia (Kummu *et al.*, 2016). On-going water pollution, especially in Eastern Europe and Central Asia, continues to threaten the availability of safe drinking water, while decreased water levels in natural reservoirs have led to increased water pollution (UN-Water, 2011). Freshwater extraction as a percentage of total renewable water resources decreased between 1993 and 2012 for the Europe and Central Asia region, most notably for Western Europe and Central Asia (see **Figure 2.62**). It coincides with a 15% decrease in water availability per capita since 1990 (see Section 2.2.1.5).

Although water is generally abundant in the European Union, droughts and over-exploitation have led to seasonal water scarcity in some water basins, especially in densely populated and agricultural areas (EEA, 2015e, 2016f; Karabulut *et al.*, 2016). Water stress in most countries of the European Union has decreased slightly since the 1990s, but many areas are considered close to being water scarce (EEA, 2011). In winter, around 6% of the European Union's population live under waterstressed conditions, while the figure is 14% in summer (EEA, 2016f). Around 20 river basin districts, including the Danube basin but mainly in the Mediterranean region, face structural water stress issues

Figure 2 59 **Net energy imports (in exajoules) by energy carrier and region in Europe and Central Asia (2014) (uncorrected for intra-regional trade). Source: Own representation based on IEA/OECD (2016).**

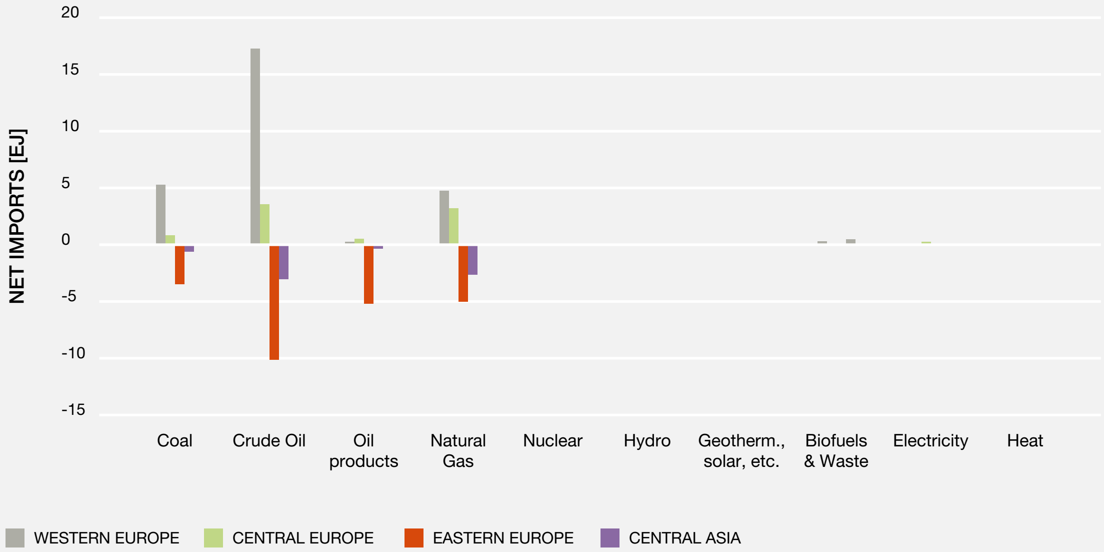
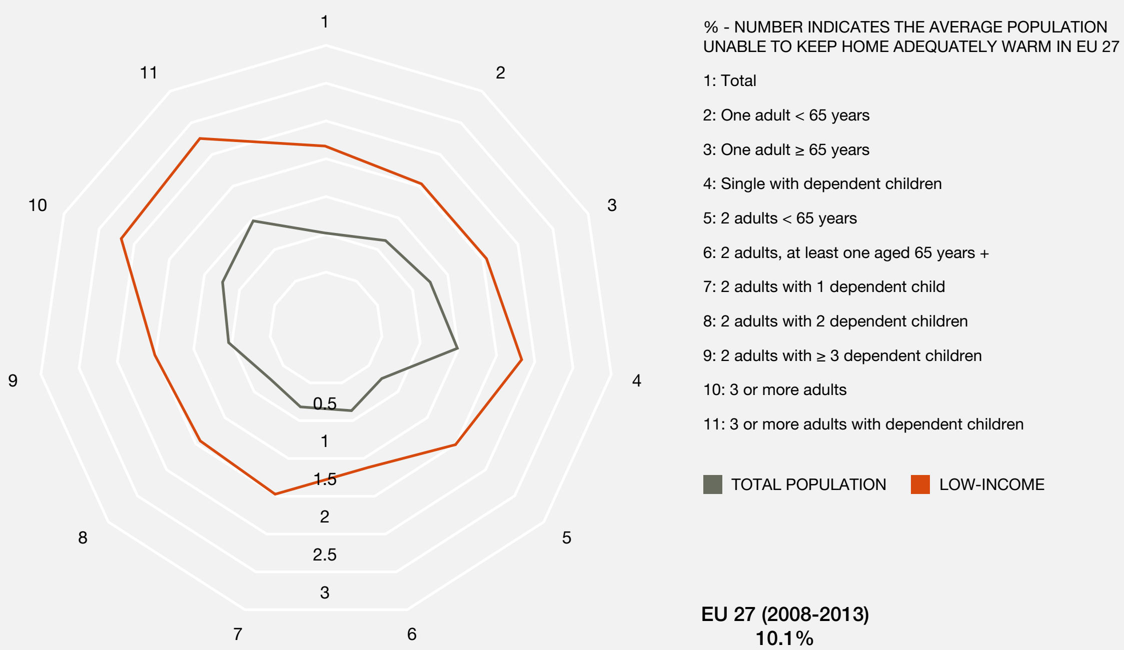


Figure 2 60 **Inequality in access to heating in the EU-27. Source: Dubois & Meier (2016).**

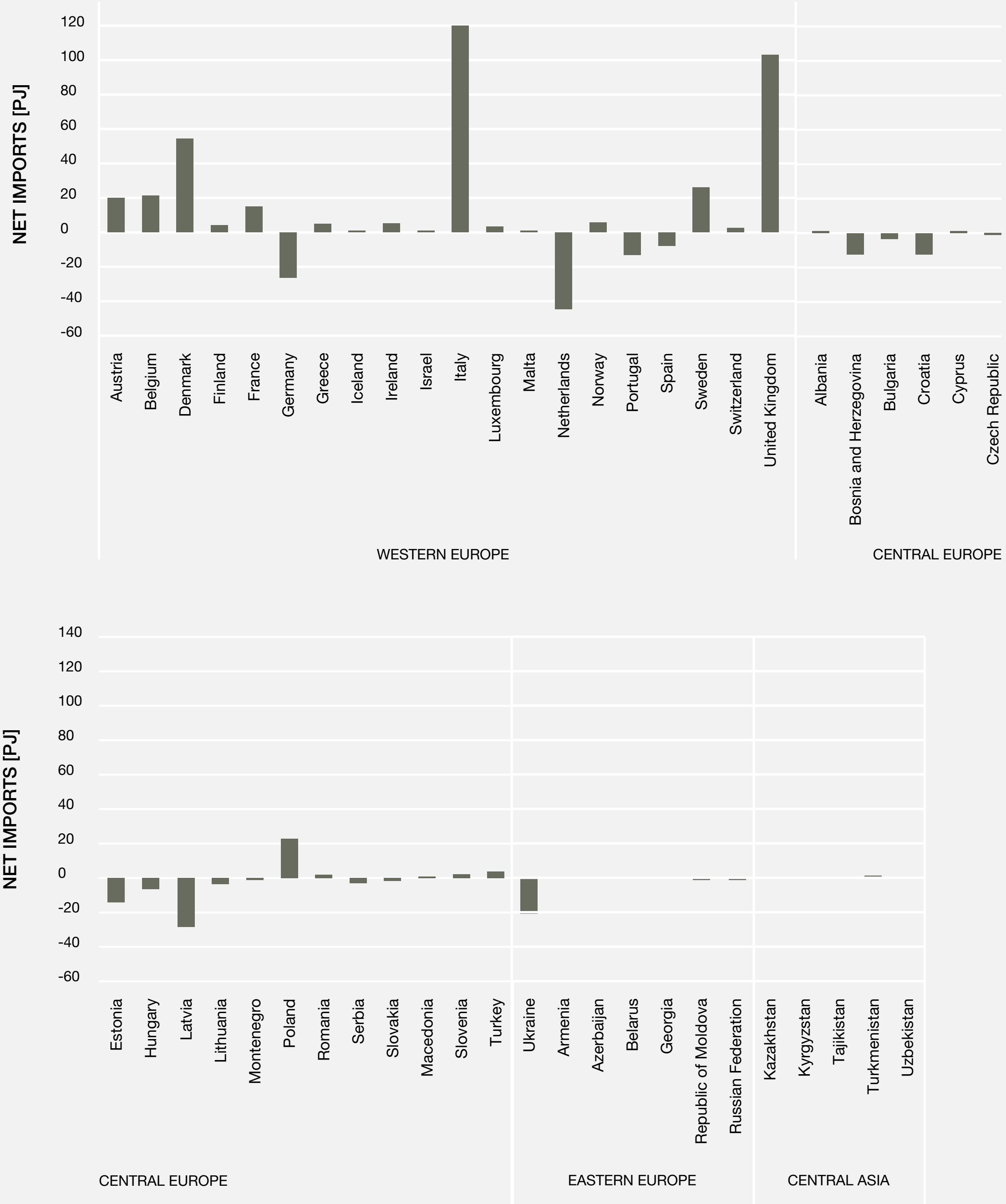


(EEA, 2016g), due to climate change and unsustainable water extraction (Skoulikidis *et al.*, 2017).

The spatial coverage of freshwater ecosystems in the European Union with a good ecological quality, which are crucial for providing clean water, has decreased from 42% to 32% (see Section 2.2.1.6).

Water security in Western Europe and Central Europe has remained stable since the late 1980s, despite a 40% and 5% decrease, respectively, in per capita freshwater availability since the 1960s (see Section 2.2.1.5) and a slight increase in water quality but on-going decrease in water quality regulation (see Section 2.2.1.6). Water security in

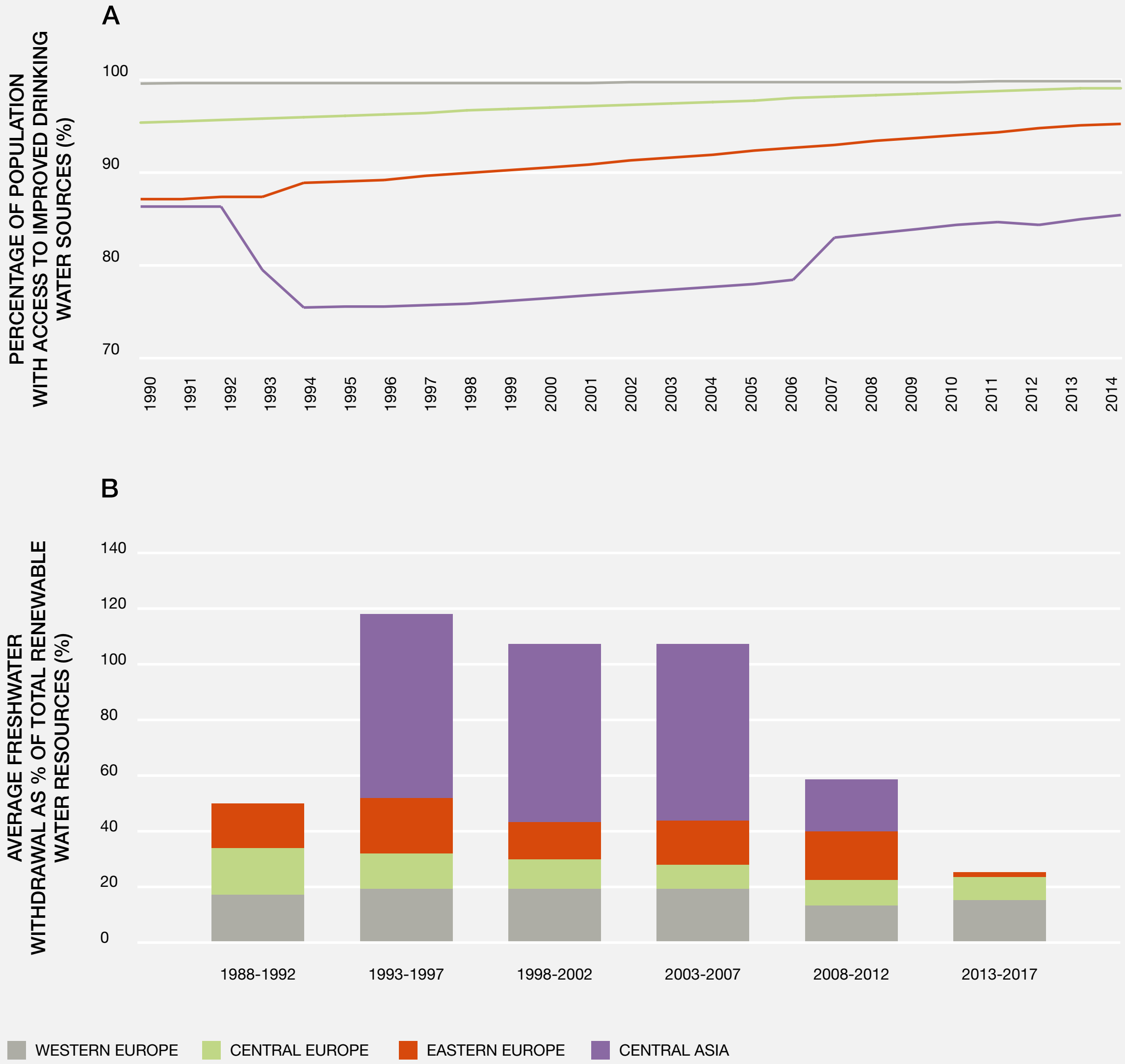
Figure 2 61 **Net imports of biofuels and waste by country (2014) (uncorrected for intra-regional trade). Source: Own representation based on IEA/OECD (2016).**



Eastern Europe shows mixed but generally increasing trends since the late 1980s, while per capita freshwater availability has increased by 10% since the 1990s. Several Danube river sub-basins in Eastern Europe were highlighted as being at risk of becoming waterscarce (Karabulut *et al.*, 2016).

Central Asia is considered to be facing water scarcity and shows mixed trends since the early 1990s (Animesh *et al.*, 2016; UNEP & UNECE, 2016). Access to safe drinking water has increased since 1994-2007, while recent trends for freshwater extraction as a percentage of available water are mixed and even decreasing (Alexander & West, 2011). This coincides with a mixed, but recent decrease in per capita freshwater availability since the 1990s (see Section 2.2.1.5). Ensuring water security in Central Asia depends on the distribution of, and access to, water resources,

Figure 2 62 **Temporal trends in water security in Europe and Central Asia according to: A access to safe drinking water. Source: Own representation based on World Bank (2016); and B freshwater withdrawal as percentage of total renewable water resources. Source: Own representation based on FAO (2016). Note that information for 2013-2017 is incomplete.**



especially between different countries (Abdolvand *et al.*, 2014; Conrad *et al.*, 2016; FLERMONECA, 2015).

2.3.1.4 Food-energy-water security nexus

Water, food and energy systems are characterized by complex interrelations. Energy is required to process and distribute water; water is central to nearly all forms of energy production; and both energy and water are key to any food enterprise (Harvey & Pilgrim, 2011; Hussey & Pittock, 2012; Karabulut *et al.*, 2016). Pursuing one particular security objective (either food or water or energy security) is sometimes achieved to the detriment of another, reflecting competing claims over limited natural resources and nature's contributions to people.

Agriculture intensification in Europe and Central Asia since the early 1950s has contributed significantly to an increase in the provision of food and feed (see Section 2.2.2.1) and to enhancing food security (see Section 2.3.1.1). However, it has had severe adverse effects on water security in many parts of the region (see the example of the Aral Sea in **Box 2.3**). Intensive agriculture has been one of the main causes of the pollution (eutrophication and contamination) and

Box 2 3 **The Aral Sea disaster.**

The Aral Sea provides clear evidence of how the pursuit of one security objective can be to the detriment of others. During the Soviet era, pressure on the water resource in the Aral Sea region was mainly due to the massive development of irrigation for rice and cotton production. After the dissolution of the Soviet Union, cotton production was reduced but remained key for generating currency revenues. Besides, irrigated winter wheat production grew rapidly to gain grain self-sufficiency (Jalilov *et al.*, 2016). In Central Asia as a whole, the areas under irrigation increased from 4.51 million ha in 1960 to 6.92 million ha in 1980, and to 7.85 million ha in 2000 (Rakhmatullaev *et al.*, 2010). Irrigation systems in the region are highly inefficient with almost half of the water diverted for irrigation lost before reaching the field. Over 50% of the irrigated soils of the region are salinized and waterlogged, due to long-term surface irrigation practices (Qi *et al.*, 2012). Changes in the hydrological cycle caused by the massive irrigation led to a significant decrease of river runoff, changes in the area of lakes, and rise of groundwater levels. Hydrological changes, including desiccation of the Aral Sea, basin-wide land-use and land-cover changes, as well as the degradation of the Aral Sea have strongly contributed to climate change in the region (Lioubimtseva, 2015; Micklin, 2007). Dust storms, with dust contaminated by fertilizers, pesticides, heavy metals, and other chemicals; water and wind erosion; widespread land degradation; water pollution; and frequent droughts have negatively impacted populations' health (Jensena *et al.*, 1997; Wiggs *et al.*, 2003), agricultural productivity and economic development in the area (Cai *et al.*, 2003; Lioubimtseva, 2015). In Central Asia as a whole, access to improved drinking water declined from 57% in 1990 to 50% in 2013 (Abdullaev & Rakhmatullaev, 2016). Cai and co-authors (2003) estimate that thirty-five million people have lost access to the lake's water, fish, reed beds, and transport functions.

overexploitation of freshwater bodies and the decrease in the extent of floodplains and wetlands (UNEP & UNECE, 2016). These trends have impaired water quality and quantity regulation (see Sections 2.2.1.6 and 2.2.1.7). In addition, many of nature's other regulating contributions to people, especially pollination, erosion, soil formation and functioning, regulation of flood control; and non-material contributions, such as traditional farming knowledge, have been negatively impacted by agriculture intensification. Another major trade-off associated with agricultural intensification concerns climate. Intensive agriculture is characterized by a loss of carbon in agricultural soil, which impairs its climate regulation capacity and other contributions from nature to people associated with soil (see Section 2.2.1.4 and Section 2.2.1.8). It also entails increasing emissions of fossil carbon used for mechanization and fertilizer production, and of greenhouse gases from cattle and nitrogenous fertilizers (see Section 2.2.1.3 and Section 2.2.1.4). However, over the last 25 years, agricultural intensification has triggered the abandonment, reforestation and afforestation of former agricultural land, especially in Western Europe (see Chapter 4). An increase in forest areas was the main cause of a net increase in greenhouse gas storage in ecosystems in Western, Eastern and Central Europe between 1990 and 2012 (see Section 2.2.1.4).

Biofuels also pose major potential trade-offs between security objectives. Over the past 15 years, the European Union policy for renewable energy and its biofuels blending target for transportation fuel (set at 10% by 2020 in the European Union Renewable Energy Directive (2009/28/EC)), have fostered the production and consumption of biofuel in Western and Central Europe (Sections 2.2.2.2.2 and 2.3.1.2). Biofuel production carries the risk of competing with food production, increasing food prices, intensifying agricultural land and water use, and harming biodiversity and other contributions from nature to people (De Fraiture *et al.*, 2008; Gerbens-Leenes *et al.*, 2012; Rulli *et al.*, 2013; Rulli *et al.*, 2016). Moreover, the potential of biofuels to reduce greenhouse gas emissions may be offset by the contribution of their production to emissions arising from fertilizers, machinery, and especially land conversion. Projected change in cropland area within the EU-28 caused by compliance with the 10% blending target mainly takes the form of less land abandonment (Valin *et al.*, 2015). Nevertheless, the adverse effects of biofuels vary spatially and depend on the choice of biofuel crop (de Vries *et al.*, 2010; Eggers *et al.*, 2009; Valin *et al.*, 2015). Biofuel derived from properly managed feedstocks with much lower life cycle greenhouse gas emissions than fossil fuels, and which do not compete with food production (mainly biofuel produced from ligno-cellulosic materials), do not entail negative impacts on land and water use, biodiversity, or greenhouse gas emissions (Havlík *et al.*, 2011; Tilman *et al.*, 2009). However, biofuel production in north-western Europe is currently mainly produced from wheat and maize (for bioethanol), and sugar beet and rapeseed (for biodiesel), which perform rather poorly for nearly all environmental indicators, as well as for greenhouse gas emissions (de Vries *et al.*, 2010). Moreover, the European Union 2020 biofuel mandate impacts ecosystems, water and food security globally through European Union imports. In the scenarios developed by Valin *et al.* (2015), most of the land use change resulting from the European Union 10% blending target occurs outside the EU-28, especially through conversion to oil palm in Southeast Asia.

2.3.2 Contributions to physical, mental and social dimensions of health

The recent state of knowledge review coordinated by the World Health Organization and the Convention on Biological Diversity (WHO & CBD, 2015) provides a detailed global assessment of the interlinkages between biodiversity and human health. The review explores the evidence base across three broad areas of human health outcomes – non-communicable diseases, communicable (i.e. infectious) diseases, and injury – and considers the value of biodiversity to medical science (WHO & CBD, 2015). The role of biodiversity and ecosystem services in supporting human health, and the health risks arising as a result of loss of biodiversity and ecosystem degradation are also highlighted by the review.

The linkages between nature and health are of increasing research and policy interest. While research efforts are increasingly interdisciplinary, there is still a need for greater integration of different fields of expertise and recognition of the importance of accounting for different forms of knowledge, as with other aspects of biodiversity policy (Pullin *et al.*, 2016). With this perspective in mind, in addition to following the literature review methodology of this chapter we also engaged in a process of IPBES-approved expert elicitation to strengthen the quality of the assessment and literature review. This also supports a key aim of IPBES, which is to build capacity in this rapidly growing field. The expert elicitation was based on the consideration of the World Health Organization and Convention on Biological Diversity literature review and key messages by an expert panel. Further details are provided in the supporting material Appendix 2.8[28].

The importance of biodiversity and ecosystem services to human health is well established in some areas of health research, for example with regards to the contribution of biodiversity to contemporary and traditional medicine (Heinrichs & Jäger, 2015; Payyappallimana & Subramanian, 2015), to food and nutrition security (Hillel & Rosenzweig, 2008; Hodgkin-Hunter, 2015), and through linkages to infectious disease risk (Karesh & Formenty, 2015). Traditional medicinal practice has long been based on preparations derived from wild or domesticated species, and the value of biodiversity is recognized in contemporary medicinal research, with the development of new pharmaceuticals supported by bioprospecting and often based on lessons from traditional knowledge (Newman & Cragg, 2016). The evidence regarding the contribution of biodiversity to food and nutrition security is also well established. Globally, diets rich in biodiversity (cultivated varieties as well as wild sources such as fish, fruit, fungi, invertebrates and bushmeat) help to support good nutrition, with many communities relying heavily on wild biodiversity as a primary source of energy, protein and micronutrients; for Europe and Central Asia data are limited, but some work has highlighted the cultural and economic significance of wild foods (Fuchs *et al.*, 2016; Łuczaj *et al.*, 2012; Schulp *et al.*, 2014b). Schulp *et al.* (2014b) identified 38 species of game, 27 species of mushrooms, and 81 species of vascular plants that are regularly hunted, collected and consumed in the European Union, with over 100 million European Union citizens consuming wild food each year, and argue for greater attention to be given to wild foods in ecosystem service assessments. There is evidence that dietary diversity may help to reduce the risks associated with certain non-communicable diseases, though this is moderated by effects of lifestyle and other socio-economic factors (Hunter-Burlingame-Remans, 2015; Johnston *et al.*, 2014).

Ecosystem change and degradation of natural habitats are identified as risk factors for disease emergence, though the precise contribution of biodiversity, or its loss, to risk of infectious disease outbreaks in wildlife, livestock or humans is generally less certain (Ostfeld & Keesing, 2012; Wood *et al.*, 2017). Biodiversity may reduce disease rise through a phenomenon known as the "dilution effect", whereby, in ecosystems where hosts of an infectious agent vary in their ability to transmit an infection, increased diversity of potential hosts may reduce the risk of disease outbreak. This concept remains controversial, and any such effect is likely to be highly specific to pathogen, location or geographic scale (e.g. Randolph & Dobson, 2012; Wood & Lafferty, 2013). Some evidence for the dilution effect in at least some local contexts has been presented from several studies, mostly from Western Europe (e.g. Bolzoni *et al.*, 2012; Kedem *et al.*, 2014; Khalil, 2016; Ruyts *et al.*, 2016).

Another area where the relationship between biodiversity and ecosystems and health may be highly variable is the impact which exposure to nature can have on mental and physical well-being (Horwitz & Kretsch, 2015; Lee & Maheswaran, 2011; Van Den Berg *et al.*, 2015). The ways in which health is affected by biodiversity and nature's contributions to people is determined by the nature of specific social-ecological systems, including the degree and types of interactions between people or their communities and the natural environment. This highlights the importance of social, economic and cultural factors in determining the strength and direction of linkages between health and biodiversity (Clark *et al.*, 2014; WHO, 2017; European Commission, 2016b).

Increased urbanization in Europe and Central Asia poses significant challenges for human health including a rise in non-communicable diseases associated with modern lifestyles, including obesity and diabetes, cardiovascular diseases, depression and anxiety disorders, and diseases

28. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.8_assessment_of_health.pdf

associated with pollution (Benziger *et al.*, 2016). Efforts to increase access of urban dwellers to green space and open countryside may help to address some of these health issues. Scientific review literature shows there are many potential pathways between exposure to nature or natural spaces and positive health status. However, these pathways do not necessarily exist for all persons within any given community, even where different social groups (differentiated by, for example, age, gender, ethnicity, income level, or education) have access to, or utilize, common areas of natural space (Hartig *et al.*, 2014; Jackson *et al.*, 2013; Myers & Patz, 2009). Again, several social, cultural and economic factors are likely to be at play, and more research is needed in this regard (Clark *et al.*, 2014).

Differentials in the ways in which some communities or groups within wider society (e.g., indigenous groups, refugees, women, the elderly or poor) experience and interact with biodiversity and ecosystems may result in differences in the influence of biodiversity and ecosystems on their health status. There is, thus, potential for group-specific or community-specific dependencies and risks (WHO, 2017; Horwitz & Kretsch, 2015; Jay *et al.*, 2012). Individual groups within a community (defined by, for example, gender, age, ethnicity, infirmity, engagement in cultural practices) may experience greater or lesser health benefits from biodiversity and ecosystem services, or be at greater or lesser risk of ill health associated with biodiversity loss and ecosystem change, than others, as a result of a range of moderating social, economic and cultural factors. Any relationships which can be drawn between health outcomes and biodiversity or ecosystem services are, therefore, likely to be dependent upon the ways in which groups or individuals understand, acknowledge or experience their relationship with the natural environment (Clark *et al.*, 2014).

There is well established evidence from multiple studies that a healthy immune system is supported by exposure to biodiversity (Rook & Knight, 2015). Exposure to environmental microbiota has been associated with reduced risks of allergy, chronic inflammation and certain other autoimmune diseases. A growing body of evidence suggests that interactions between wild microbes and the human microbiome – the diverse community of microbes present in the intestinal, respiratory and urogenital tracts, and on our skin – may be key to healthy immune function. Conversely, loss of diversity in human microbiota, which may be associated with decreased exposure to wild microbes, has been linked to increased risk of a range of non-communicable diseases, including inflammatory diseases, diabetes and allergies (Hanski *et al.*, 2012; Ruokolainen *et al.*, 2017).

With so many significant linkages identified between health and biodiversity, and with increased knowledge of the health risks posed by ecosystem change and biodiversity loss, numerous opportunities exist for development of integrated policies and practical strategies to realize benefits for both biodiversity and human health and well-being. Biodiversity conservation provides opportunities to secure and enhance those ecosystems and ecosystem services that are of particular relevance to human health outcomes (Romagosa *et al.*, 2015; ten Brink *et al.*, 2016). A review of national reports to the Convention on Biological Diversity (see supporting material Appendix 2.8[29]) examined the extent to which countries in Europe and Central Asia consider nature–human health linkages. Almost all countries involved in the analysis (covering 93% of those in the region) explicitly recognized the importance of nature–human health linkages. Only 8% mentioned these linkages in general terms, while the majority considered key details such as the diversity of linkages, local specificities, challenges, opportunities and actions. Some countries also mentioned local practice examples regarding application of health-relevant insights. Most (63%) mentioned both human health benefits and risks of nature-human linkages, while 6% mentioned only risks and 27.5% only benefits.

2.3.3 Cultural heritage, identity and stewardship

2.3.3.1 Value through use

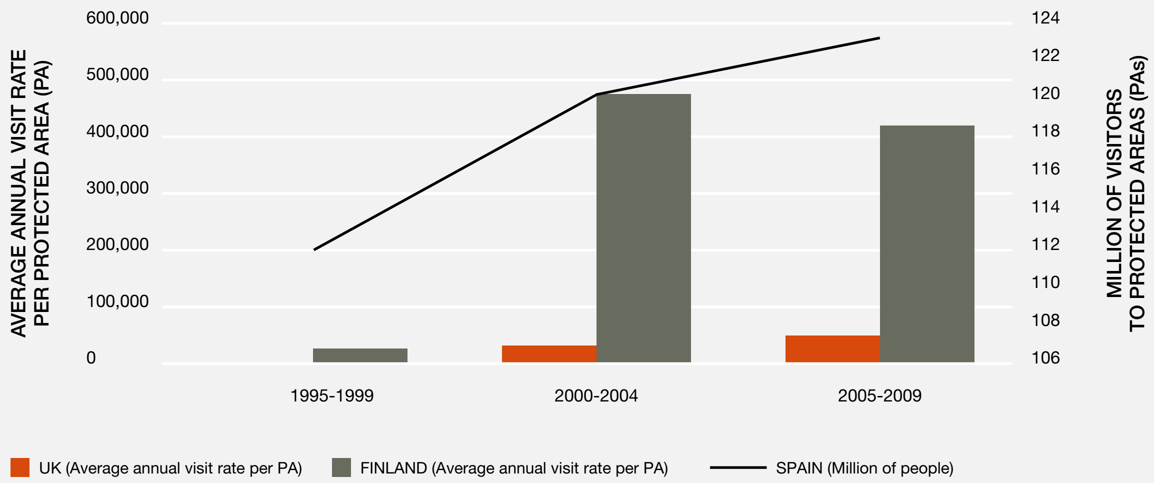
For different social groups in Europe and Central Asia, nature contributes to cultural heritage, identity and stewardship through providing opportunities for good quality of life beyond mere survival. It offers opportunities for leisure and tourism, maintaining indigenous and local knowledge, and being exposed to learning, inspiration and spiritual experiences. Evidence suggests that these contributions from nature to people show increasing trends (see Section 2.2.3).

Nature is in high demand for nature-based recreation activities by people in many parts of the region (see Section 2.2.3.2.1) (Hausner *et al.*, 2014; Martín-Lopez *et al.*, 2012; Rall *et al.*, 2017) and preferences for holidays of people in the European Union in the last decade, show an increasing interest in nature-based tourism (European Commission, 2016a). In addition, the number of visitors to protected areas increased between 1995 and 2009 in some Western European countries, such as Spain, Finland and the UK **(Figure 2.63)**.

Recreation and leisure are recognized by urban people as the most important benefits derived from urban green spaces. Other motivations to visit urban greenspaces

29. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.8_assessment_of_health.pdf

Figure 2 63 **Number of visitors to protected areas in the United Kingdom and Finland (measured as average annual visit rate per protected area) and Spain (measured as millions of visitors). Source: Own representation based on Balmford *et al.* (2015); Santos-Martín *et al.* (2013).**



include health, psychological well-being and emotional attachment to the site (Bolund & Hunhammar, 1999; Casado-Arzuaga *et al.*, 2013; Haase *et al.*, 2012). Green spaces and ecosystems are also used for formal learning by schools and universities in many countries in Europe and Central Asia, where outdoor learning provides additional value for learners and teachers in terms of knowledge and skill acquisition (Mocior & Kruse, 2016).

Indigenous and local knowledge has significant value for some local communities in Europe and Central Asia. A review of studies in Arctic regions argues that this knowledge plays an important role in land rights claims (Davis & Wagner, 2003). An in-depth study of resource-users and local organizations involved in a local fishery in Sweden shows how indigenous and local knowledge can contribute to fish management and conservation (Olsson & Folke, 2001). Co-production of knowledge by traditional herders and national park rangers for adaptive nature conservation management of wood-pastures and salt steppes can also lead to new occupations, like the so-called "conservation herders" (Molnár *et al.* 2016). Furthermore, the conservation of indigenous and local knowledge and related landscapes can support the economic development of rural areas by fostering tourism and consumption of local products, and contributing to the quality of life of people (Fernández-Giménez & Fillat Estaque, 2012; Parrotta & Agnoletti, 2007).

However, in many areas of Europe and Central Asia the value of local ecological knowledge has been eroded with a decline in indigenous and local knowledge. Studies comparing the UK to developing countries have argued that indigenous and local knowledge declines as nations become wealthier and ecological knowledge becomes less valued (Pilgrim *et al.*, 2008). Changes in culture are partly responsible for the devaluation of indigenous and local knowledge among younger generations, which consider these traditional practices and knowledge as symbols of poverty or backwardness.

The use of some of nature's material contributions to people is also strongly connected to values arising from non-material contributions, which contribute to cultural practices that enhance identity (see Sections 2.2.3.2 and 2.2.3.3). For example, in many Central and Western European countries, mushroom collecting is a part of culture and tradition (Hansen & Malmaeus, 2016; Martínez de Aragón *et al.*, 2011; Stoyneva-Gärtner, 2015). Recreational berry picking is also often a family and cultural tradition, which has been kept alive during recent decades (Schulp *et al.*, 2014b), mostly in Scandinavian countries (Kangas & Markkanen, 2001). It has been estimated that 56-58% of households in Scandinavian countries collect berries for domestic purposes (Jonsson *et al.*, 2002).

Belief systems are a fundamental aspect of people's culture that strongly influence their engagement with nature (Groot *et al.*, 2005). Religious or spiritual interactions with nature have been shaped over decades or centuries, and influence human endeavour directly or indirectly (IPBES, 2015). Many traditional knowledge systems in Europe and Central Asia depict ecosystems as fully alive, incorporating spirits of animals and other natural objects and spirits of human ancestors (Berkes *et al.*, 1998). Pre-monotheistic belief systems integrated elements of nature to give meaning to the world and humans' place in it (Verschuuren, 2006).

Similarly, myths and related rites have existed in Europe and Central Asia since the dawn of humanity (see **Box 2.4**). For a number of local and indigenous communities in Europe and Central Asia, especially those that have pagan, animistic or shamanistic roots, land is alive and full of various kinds of energies or life forces and nature's organizing principles are depicted as entities, spirits or natural law (UNEP, 1999).

2.3.3.2 Value through protection and beyond use

Different social groups indicate the value of their relationship with nature by expressing their desire to conserve and protect areas and iconic species that they do not use directly. People can express this form of value through willingness-to-pay and indications of other preferences for the protection of species irrespective of actual aesthetic or recreational use (see Section 2.2.3.4).

Protected areas are increasingly valued for their use and recreation potential. European Union people increasingly acknowledge their importance for eco-tourism and nature-related recreational experiences and 43% of European Union citizens identified this role of protected areas as very important (European Commission, 2015a). In addition, visitors to protected areas and UNESCO World Cultural Heritage Sites around Western and Central Europe have

Box 2 4 The Cult of Hızır as an Expression of Revering Nature's cycles.

Seasonal changes are important components of folk calendars throughout the world. In the Turkic world (including Yakuts, Mongols, Kalmyks, Buryats and Tungusic people in Central Asia), Hıdrellez (known as Ruz-ı Hızır or day of Hızır) is one of the most important seasonal celebrations and represents the revival of the warm and productive summer days (Uca, 2007). Based on folk calendar traditions, the year is divided into two, the summer known as "Days of Hızır" and the winter, known as "Days of Kasım". Hıdrellez Day falls on May 6 and is the day on which Prophets Hızır and Ilyas met on the seashore between dry land and water (Artun, 1990).

The awakening of nature is actively celebrated throughout the Turkic world on Hıdrellez day with rites that are dependent on water (Walker & Uysal, 1973). These ceremonies generally take place in nature, near sources of water, or near tombs and shrines. In rituals before sunrise on that day, Turks construct, in their gardens, models of the things they wish for most such as good health, or write their wishes on pieces of paper which are then either released into rivers and other water bodies or hung on trees (Walker & Uysal, 1973).

Tahtacı Turkmen villagers in the northern Aegean Kaz Mountains line up to wash their face in the early morning of Hıdrellez to receive health and bounty from the river waters.
Photo: Solmaz Karabaşa

expressed substantial willingness to pay to enjoy the recreational services provided (Martín-Lopez *et al.*, 2009), including in Turkey (Gürlük & Rehber, 2008) and Albania (Seidl, 2014).

A further value of tangible and intangible protected heritage associated with nature is that it helps to maintain cultural meanings and a sense of identity (Klinar & Geršič, 2014; Tengberg *et al.*, 2012)**.** This can be based on the tangible material outcomes of cultural activities on landscapes (e.g., wood pastures, viticulture terraces) as well as individual species that are linked to intangible heritage such as through myths, legends, and religious practices (Daniel *et al.*, 2012).

Figure 2 64 **Distribution of the different types of protected areas among Europe and Central Asia subregions. Source: Own representation.**

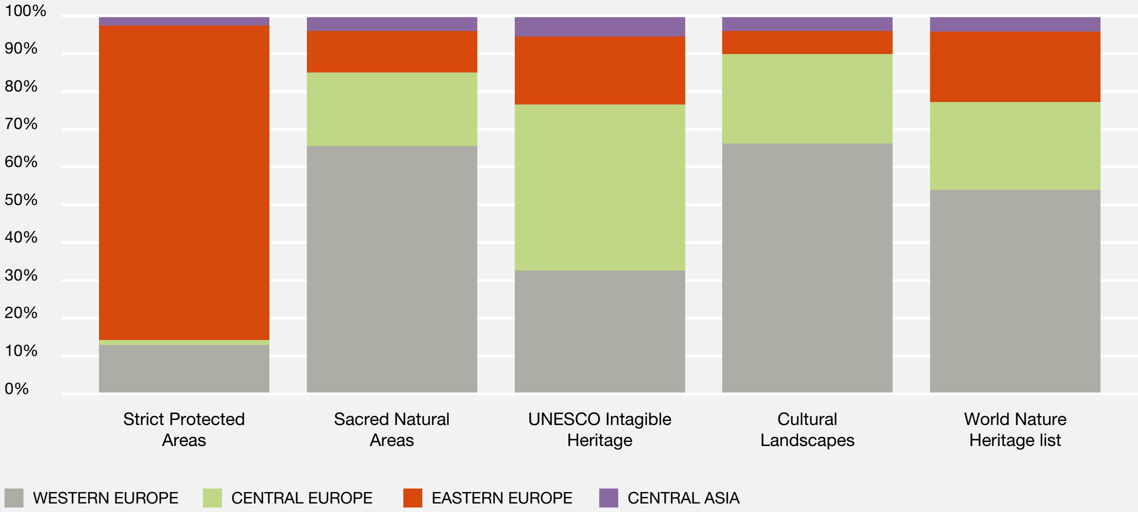
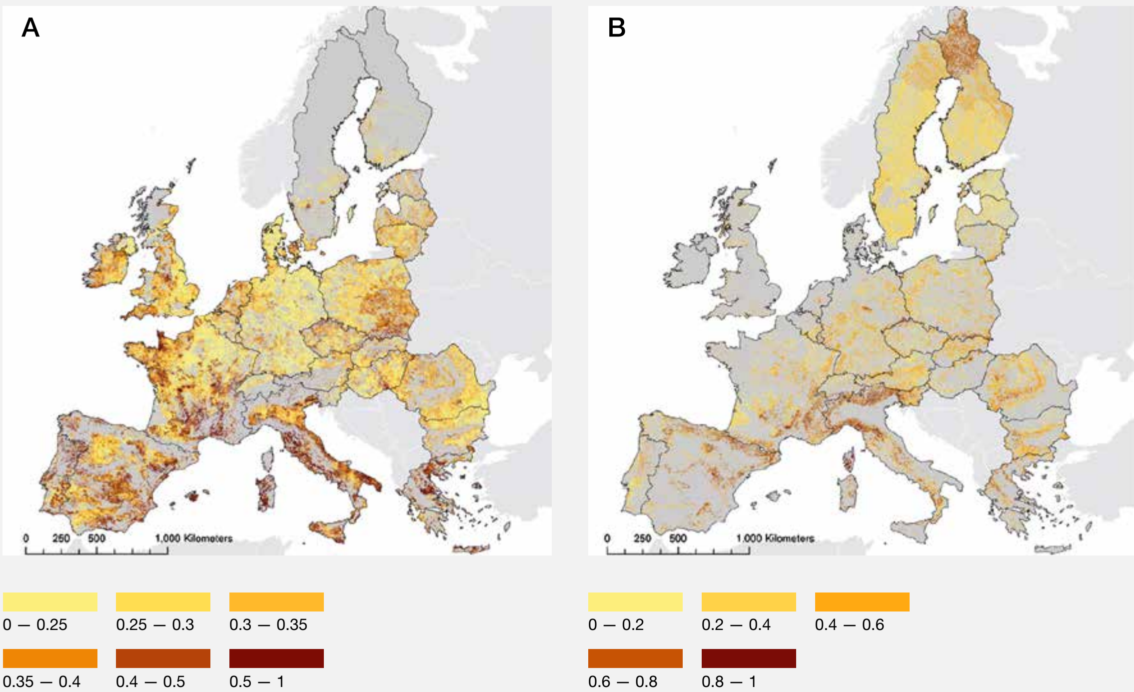


Figure 2 65 **Cultural Landscape Index (CLI) of Western and Central European A agricultural land and B forest that characterizes rural landscapes according to landscape structure, management intensity, and value and meaning. Source: Tieskens *et al.* (2017).**



The value placed on the protection of tangible heritage linked to nature is shown in UNESCO's World Heritage List in 2015, comprising 1,031 properties of which 22% were natural sites (Osipova *et al.*, 2014). Currently, 23.5% of these protected natural sites are located in Europe and Central Asia, with an unequal distribution among subregions (see **Figure 2.64**). Tangible heritage linked to cultural landscapes in Western, Central and Eastern Europe is also recognized in UNESCO's "list of cultural landscapes" (Besio, 2003). 51% of the landscapes in the UNESCO list (i.e. 49 landscapes) are situated in Europe and Central Asia, but again with uneven distribution among subregions (see **Figure 2.65**).

Yet, tangible heritage linked to European cultural landscapes is increasingly threatened by land-use intensification and abandonment (Tieskens *et al.*, 2017) that derive from cultural, political and economic drivers of change (see Chapter 4) (Plieninger *et al.*, 2016). The decreasing trends of the cultural and local identity associated with these landscapes, as well as the emotional attachment of Western and Central European people to these landscapes, is also acknowledged by indigenous and local knowledge holders (supporting material Appendix 2.2[30]).

The *Convention for the Safeguarding of the Intangible Cultural Heritage* is the international agreement that aims to acknowledge and protect intangible heritage. Out of 130 elements of intangible heritage from countries in Europe and Central Asia currently inscribed on the List of Intangible Cultural Heritage (UNESCO, 2003), 53 are directly linked to nature. They are linked to both the direct use of animals (e.g. falconry, and horse-riding games) and plants, or draw on the natural environment as a source of inspiration for songs, poetry and handicrafts.

Despite the value and protection of intangible and tangible heritage linked to nature, it continues to be threatened. In Western, Central and Eastern Europe, 30% of natural World Heritage sites are of significant concern (Osipova *et al.*, 2014) and five protected sacred natural sites in Europe and Central Asia are threatened (one in Central Europe, one in Eastern Europe, two in Western Europe and one in Central Asia).

2.3.4 Environmental equity and justice

2.3.4.1 Framing equity and justice

Aspects of equity and justice associated with nature's contributions to people relate to questions of who benefits from them (Daw *et al*., 2011; McDermott *et al.*, 2013), who bears the costs of a change in the provision of these contributions due to trade-offs (Bennett *et al.*, 2009; Howe *et al.*, 2014), who decides how societies influence the provision of the contributions (Berbés-Blázquez *et al.*, 2016), who is recognized in these decisions (Martin *et al.*, 2016; Zafra-Calvo *et al.*, 2017) and whose needs are fulfilled by nature's contributions to people (Chan *et al.*, 2012; Jax *et al.*, 2013). Equity is associated with fairness and justice (Konow, 2003; McDermott *et al.*, 2013; Pascual *et al.*, 2010). *Fairness* is often defined as the shared, dynamically constructed view of a given social group of distributive justice (Pascual *et al.*, 2010; Schokkaert & Devooght, 2003). The term *justice* refers here to fundamental moral rights and obligations. The term *equity* is used to evaluate comparatively the relationships between particular groups in society.

Distributive equity and justice focuses on the fair allocation, among individuals within a social group or among stakeholders, of costs (see **Box 2.5**) and benefits resulting from any management decision or action (McDermott *et al.*, 2013). *Procedural equity and justice*, in the context of the present assessment, relates to the procedural aspects of decisions on ecosystem management. It is assessed in terms of the degree of recognition, representation, involvement and inclusiveness in decision-making of different societal groups, determined e.g. by cultural identities, level of education and gender (Berbés-Blázquez *et al.*, 2016; McDermott *et al.*, 2013; Pascual *et al.*, 2010; Pascual *et al.*, 2014). Distributive justice and equity regarding the benefits derived from nature's contributions to people and harms from a loss of these contributions have a spatial component, as changes in ecosystems providing them will have uneven geographical impacts linked to where beneficiaries live (Liu *et al.*, 2016), see Section 2.1.2. There is also a temporal component (Jax *et al.*, 2013) as ecosystem service utilization today may destroy the basis for future service provision (Section 2.2.3.4).

2.3.4.2 Intra-generational distributive equity and justice

Nature's material contributions to people are often commodities traded in (global) markets. On the one hand, distributional equity and justice reflects the distribution of access to markets (UNEP, 2004). On the other hand, distributive equity and justice are influenced by global patterns in the distribution of benefits and costs from the production and consumption of nature's material contributions (such as biofuels, soy for animal feed, timber, pharmaceutical products from wild and domesticated biodiversity) (Section 2.2.4).

Whereas access to safe and adequate drinking water is generally well secured in Europe, people in Central Asia, especially children, bear disproportionate environmental

30. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

Box 2 5 **Human-wildlife conflicts (additional references can be found in supporting material Appendix 2.3*).**

Certain species cause human-wildlife conflicts and raise justice concerns in terms of the distribution of their damages (Jacobsen & Linnell, 2016). Human-wildlife conflicts in Europe and Central Asia are reported related to carnivores, mainly wolves (*Canis lupus*), brown bears (*Ursus arctos*) and European lynxes (*Lynx lynx*) (e.g. Imbert *et al.*, 2016; Knarrum *et al.*, 2006; Mattisson *et al.*, 2015; Rigg *et al.*, 2011), although conflicts with meso-carnivores (e.g. European badgers (*Meles meles*) and red foxes (*Vulpes vulpes*)) are also reported in Western Europe (Baker *et al.*, 2008; Delibes-Mateos *et al.*, 2013). The most frequent conflicts in Eastern, Central and Western Europe (no available data for Central Asia) are those related with damage to livestock and domestic animals (Kovařík *et al.*, 2014), damage to game species (Lozano *et al.*, 2013) and attacks on humans (Sahlén *et al.*, 2015). Other mammal species, such as moose (*Alces alces*) and wild boars (*Sus scrofa*), cause damage to agriculture and forest plantations (Horne & Petäjistö, 2003; Schley *et al.*, 2008). Many alien insect and mite species cause nuisances as pests of agriculture, horticulture, stored products and forestry (Kenis & Branco, 2010; Roques *et al.*, 2009).

* Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.3_extra-references.pdf

threats to their health due to a lack of access to safe drinking water – with the Aral Sea region and rural areas in Tajikistan being specific problem areas (see Section 2.3.1.3) (Carpenter *et al.*, 2006).

Urban green space can provide different regulating contributions such as prevention of urban heat islands, air quality regulation and noise reduction (Konijnendijk *et al.*, 2013). Its distribution has been shown to differ across a city resulting in lower access in residential areas with specific ethnic groups (Comber *et al.*, 2008) or a high proportion of immigrants (Kabisch & Haase, 2014).

Regarding flood regulation and flood protection measures (Section 2.2.1.6), a socio-economic investigation within the flood plains of England and Wales revealed significant inequalities in the distribution of flooding risk between the middle classes and less privileged groups (working classes, unemployed classes) – with inequality being especially influential in exposure to flooding risk within the tidal flood plains and in the Eastern regions of England (Benzie, 2014; Fielding, 2007, 2012; Walker & Burningham, 2011).

Nature's non-material contributions to people, in particular recreation, can be distributed unevenly across social groups. In the UK protected areas are largely enjoyed by older people and men, while minorities are underrepresented in the use of protected areas, and hence the more privileged people benefit (Booth *et al.*, 2010). Access to green space in cities provides opportunities for recreational experiences, but urban green space is distributed unequally within cities, leading to potential injustice (Comber *et al.*, 2008; Kabisch & Haase, 2014). Access to green space in cities differs across Europe, with more green space available to residents in cities in northern, western and central parts of the European Union than in cities in the south (Kabisch *et al.*, 2016). Access to green recreational areas reduced inequality in mental well-being in the Europe Union (Mitchell *et al.*, 2015). In Europe and Central Asia national reports to the Convention on Biological Diversity, several countries mention how health equality is influenced by human interactions with nature's contributions and biodiversity (see supporting material Appendix 2.8[31]).

In several countries in Europe and Central Asia, people have public access to forests that provide recreational experiences, but the uneven distribution of access raises justice issues. A high level (98-100%) of forests and wooded land were reported in 2010 as available for recreational purposes in Nordic and some Baltic countries as well as in several Central Europe countries including Bosnia and Herzegovina, Slovenia and Serbia. Lower levels of availability are found in some Western European countries such as UK (46%) and France (25%) (Forest Europe, 2015). The free use of some non-timber forest products is mostly allowed in Nordic countries as well as some other countries with high forest cover, and allowed to some extent in other countries. In some cases permission or payment is required (e.g. private forests in Croatia, France, UK, Turkey) (Bauer *et al.*, 2004).

2.3.4.3 Intergenerational distributive equity and justice

Intergenerational equity and justice require the maintenance of resilient and productive ecosystems for the future provision of nature's contributions to people (Davidson, 2012; Glotzbach & Baumgärtner, 2012; Jax *et al.*, 2013). This capacity of ecosystems, "maintenance of options", is considered an overarching contribution category. Regarding intergenerational equity there are philosophical and practical arguments for an absolute sufficientarian threshold (Page, 2007), which defines a minimum level of ecosystem services that every future person is presumed to need for good

31. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.8_assessment_of_health.pdf

quality of life. Regarding intergenerational equity in the distribution of beneficial contributions from nature to people, the sufficientarian threshold can be translated into a criterion for society to keep a constant stock of intact ecosystems (Ekins *et al.*, 2003) and a dynamic criterion of ecosystem resilience. The first criterion has been operationalized by general principles of sustainability (Daly, 1992) and specified principles, such as sufficiency, efficiency and persistence for the context of nature's contributions to people (Schröter *et al.*, 2017). The ecosystem resilience criterion captures the reliability of future provision of (life-sustaining) contributions. It has been operationalized into policy-relevant principles for enhancing the resilience of desired contributions, such as maintaining biodiversity and redundancy (Biggs *et al.*, 2012) and into the concept of safe operating space in the global context (Rockström *et al.*, 2009; Steffen *et al.*, 2015). An example of putting intergenerational equity into policy practice is the Swedish *generational goal* which was adopted by the Swedish Parliament in 2010 (Government of Sweden, 2014). The goal is to pass on to the next generation a society in which the major environmental problems have been solved, ensuring that ecosystems recover, biodiversity and the natural and cultural environment are preserved, promoted and used sustainably.

2.3.4.4 Procedural equity and justice

Distributive justice regarding nature's contributions to people and biodiversity is linked to historical injustices, i.e. historically determined unequitable distribution of property rights on which access rights to nature's contributions are frequently based (Berbés-Blázquez *et al.*, 2016). Historically, certain societal groups have been absent from decision-making arenas. Indigenous and local knowledge holders, such as farmers, indigenous communities, elders and women, are frequently among those whose participation is not sought or whose perceptions of nature-society relationships might differ from those who formulate and implement policy. This "procedural inequity" can result in trade-offs between nature's contributions to people that contribute to the well-being of some at the expense of others' (e.g. Daw *et al.*, 2015). The fact that certain social agents such as indigenous and local knowledge holders are not represented in decision-making can entail distributional inequity in the access and use of nature's contributions to people (Felipe-Lucia *et al.*, 2015) and can result in social conflicts (Kovács *et al.*, 2015).

The Aarhus convention on access to environmental information promotes public participation in decision-making and access to justice in environmental matters, which can be supportive to procedural empowerment granted to NGOs (De Santo, 2011). There are, however, large differences in terms of access to information and participation in decision-making, both nationally and regionally, with Western Europe being the most advanced (Mauerhofer, 2016). A UK case study shows the importance of early stakeholder participation: planning proposals not involving stakeholders at an early stage came to a halt and had to be changed due to stakeholder objections (Lange & Hehl-Lange, 2011).

Procedural justice is also influenced by levels of empowerment defined as "enhancing an individual's or group's capacity to make effective choices, effective in the sense of enabling them to transform those choices into desired actions and outcomes" (Alsop & Heinsohn, 2005). Key elements of empowerment are personal agency (the capacity to make meaningful choices) and opportunity structure (the formal and informal institutional contexts within which actors operate). Ecosystem management approaches have been shown to contribute to the empowerment of marginalized groups through increased knowledge and gaining a political voice (Charron, 2012). Deer management in Scotland through collaborative governance has the potential to help reconcile statutory obligations with stakeholder empowerment (Davies & White, 2012). In Poland the institutional context of urban greening has led to social empowerment failures: society perceives other issues as more pressing, trees are perceived as a problem, and there is a lack of knowledge on the possibilities of preventing tree damage (Kronenberg, 2015).

2.3.5 Valuing nature's contributions to people

The importance of nature's contributions to people can be measured from different value framings, including economic and socio-cultural value domains (Martín-López *et al.*, 2014; Pascual *et al.*, 2017). A range of valuation tools can be used to elicit the different aspects of the value of nature's contributions to people (Jacobs *et al.*, 2017). Economic approaches are capable of eliciting the monetary value of these contributions through market-based approaches (e.g. market pricing) and non-market approaches (e.g. travel cost method, hedonic pricing or stated preference methods). Other approaches avoid using monetary calculations and instead elicit both instrumental and relational values in socio-cultural metrics (e.g. preference assessment, narratives or time use method) (Jacobs *et al.*, 2017). While economic valuation is often framed in the so-called "total economic value" framework that captures use and non-use values (Pearce & Moran, 1994), social dominated valuation examines the importance, preferences or needs expressed by people towards nature (Chan *et al.*, 2012). IPBES adheres to value pluralism recognizing the multiple and often conflicting valuation languages to show the multiple ways nature contributes to human well-being (Gómez-Baggethun & Martín-López, 2015; IPBES 2016). Below, we provide a synthesis of the plurality of values of nature's contributions

Table 2 7 **Values for agriculture and forestry production.**

Land Use	Measure	Mean $ (2017) / ha	Min $ (2017) / ha	Max $ (2017) / ha
Cereals*	Net profit	233	5	759
Dairy*	Net profit	718	14	6,443
Mixed crop*	Net profit	916	243	2,870
Sheep and Goats*	Net profit	434	79	8,438
Specialist cattle*	Net profit	381	55	1,320
Forestry (wood supply)**	Gross value added	255	14	891

Notes:
* Source: Farm Accountancy Data Network (2017) http://www.farmbusinesssurvey.co.uk/benchmarking/Default.aspx?module=FADN. Original data were converted to $ (2017) using appropriate GDP deflators and the average £ to $ exchange rate (2015)
** Source: Eurostat (2016a). Forests, forestry and logging. http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Economic_indicators_for_forestry_and_logging,_2005_and_2013.png#file. Original data were converted to $ (2017) using appropriate GDP deflators and the average € to $ exchange rate (2013).

to people across Europe and Central Asia by reviewing value evidence published over the last decade. In doing so, we advocate a value assessment framework that extends beyond conventional market-based monetary approaches to also incorporate non-market monetary and non-monetary socio-cultural values.

2.3.5.1 Market-based monetary values

Market-based monetary values are predominantly focused on nature's material contributions to people, for which a value can usually be estimated based on market prices. For example, net profits from agricultural production (across EU-28 countries) range from $233 / ha / yr (cereals) to $916 / ha / yr (mix crop), while the annual gross value added from wood supply in forests was $255 / ha / yr **(Table 2.7)**. Other market-based monetary values include avoided costs, replacement costs, mitigation costs, which may also be used to assess a wider range of nature's contributions to people.

2.3.5.2 Non-market monetary values

Studies reporting the non-market monetary values of nature's contributions to people in Europe and Central Asia (supporting material Appendix 2.9[32]) are predominantly focused on Western Europe, with very little evidence found for Eastern Europe and Central Asia **(Figure 2.66)**. There was some evidence that people in Central Europe have higher (standardized Int $)[33] values for contributions from nature to people than those from Western Europe (supporting material Appendix 2.9[32]).

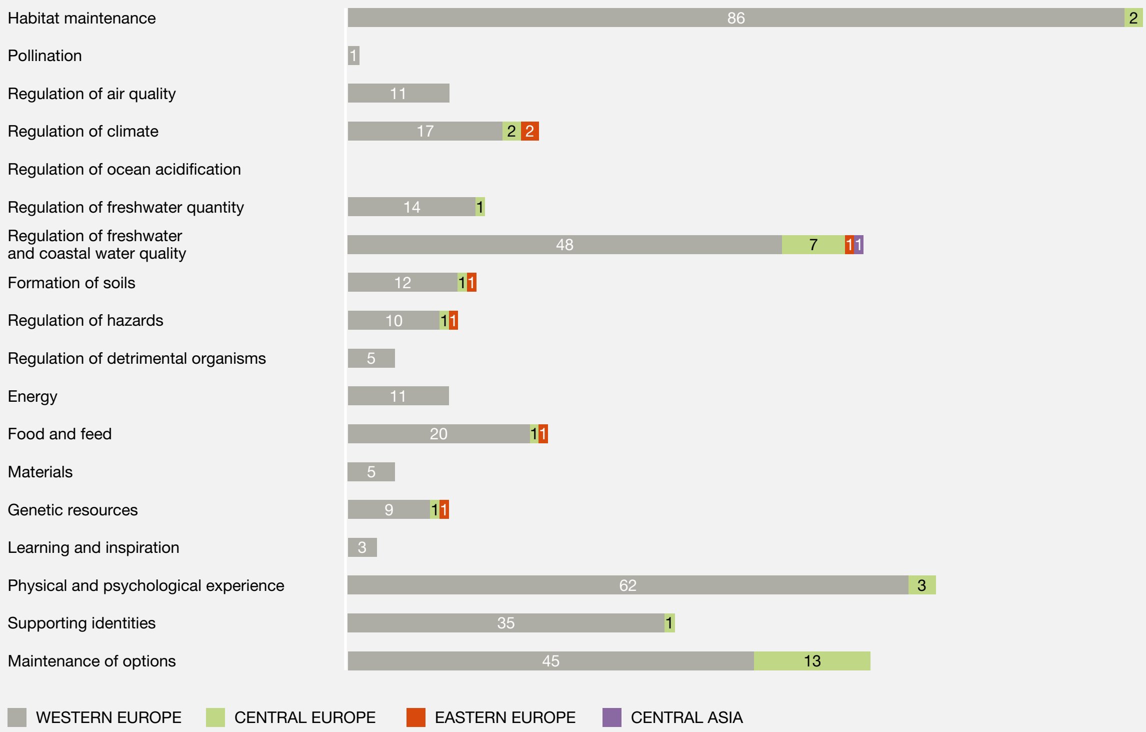
Across all countries in Europe and Central Asia, nature's regulating contributions to people were generally the most highly valued by people for their non-market benefits **(Table 2.8)**. Regulation of organisms detrimental to humans (median value = (2017) Int $149 / person / yr), regulation of air quality (2017 Int $127 / person / yr) and regulation of hazardous and extreme events (2017 Int $112 / person / yr) achieved the highest values. Material and non-material contributions tended to have lower non-market values, with the exception of material and assistance (2017 Int $171 / person / yr).

Analysis also explored non-market values on a per hectare basis **(Table 2.9)**, although fewer data were available for these. Again, the highest values were found for nature's regulating contributions to people. Regulation of freshwater and coastal water quality (2017 Int $1,965 / ha / yr) and habitat creation and maintenance (2017 Int $765 / ha / yr). Non-material contributions, such as physical and psychological experiences were also highly valued (2017 Int $1,117 / ha / yr). Across units of analysis, freshwater systems (2017 Int $867 / ha / yr) and mountains (2017 Int $603 / ha / yr) were most highly valued (supporting material Appendix 2.9[32]).

32. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.9_economic_values.pdf

33. Following the approach adopted by The Economics of Ecosystems and Biodiversity study (TEEB, 2010), we standardized NCP monetary values to a common currency and base year (International $ 2017). The standardization procedure adjusts values elicited in a particular currency and year to a standard currency and year using appropriate GDP deflators and purchasing power parity (PPP) exchange rates.

Figure 2 66 **Number of value data points (i.e. individual value estimates) found for each contribution from nature to people by subregion in Europe and Central Asia. Source: Own representation based on data sources shown in supporting material Appendix 2.9*.**



* Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.9_economic_values.pdf

It should be noted that there was a wide range in the non-market values found for each of nature's contributions to people (**Table 2.8** and **Table 2.9**). The range in values reflects differences in both the scope and size of the contribution evaluated and differences in the methods used to assess the values. Caution is therefore advised with respect to directly transferring the reported values to other policy contexts, particularly where the valuation is based on fewer than five observations.

2.3.5.3 Non-monetary values

Studies reporting social-cultural values of nature's contributions to people in Western Europe and Central Europe (see supporting material Appendix 2.7[34]) show that non-material contributions (including physical and psychological experiences and supporting identities) are considered among the most important contributions by people in Western and Central Europe in non-monetary terms. Food and feed, an important category of material contributions, is also highly valued in social terms. Among regulating contributions, habitat maintenance and regulation of freshwater quantity and quality are also important **(Figure 2.67)**. The highest proportion of research in social valuation of nature's contributions to people in Western and Central Europe was undertaken in mountain grassland areas, followed by urban and semi-urban areas, cultivated areas and Mediterranean and temperate forests.

2.3.5.4 Integrating values into policy

Nature in Europe and Central Asia is important for making a wide range of contributions to people, to which they attach value. These values are expressed in multiple dimensions. Conventionally, nature's material contributions to people have been valued through market prices. Evidence from Europe and Central Asia demonstrates that regulating contributions have significant non-market monetary values, while non-material contributions were demonstrated to be the most valued by people in social-cultural terms.

Assessments of nature's contributions to people (for example to meet the Aichi Biodiversity Targets, Sustainable

34. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.7_assessment_references_synthetic_table.pdf

Table 2 8 **Value per person of nature's contributions to people in Europe and Central Asia (2017 Int $ / person / year).**

		All of Europe and Central Asia	Mean	Median	Minimum	Maximum	N
REGULATING	1	Habitat creation and maintenance	114.17	41.56	1.88	913.58	59
	2	Pollination and dispersal of seeds and other propagules	53.23	53.23	53.23	53.23	1
	3	Regulation of air quality	112.94	127.50	30.37	189.86	9
	4	Regulation of climate	104.74	26.41	0.82	420.11	12
	5	Regulation of ocean acidification	-		-	-	0
	6	Regulation of freshwater quantity, location and timing	151.49	46.13	0.19	528.25	8
	7	Regulation of freshwater and coastal water quality	104.16	65.66	0.15	938.30	51
	8	Formation, protection and decontamination of soils and sediments	11.81	4.03	0.03	48.33	9
	9	Regulation of hazards and extreme events	121.63	112.34	15.07	304.58	8
	10	Regulation of organisms detrimental to humans	144.31	149.91	1.18	281.85	3
MATERIAL	11	Energy	165.02	75.29	0.78	614.08	10
	12	Food and feed	63.26	20.81	0.95	327.35	15
	13	Materials and assistance	280.13	171.41	0.31	777.37	4
	14	Medicinal, biochemical and genetic resources	138.24	33.88	4.45	844.96	11
NON-MATERIAL	15	Learning and inspiration	43.16	43.16	43.16	43.16	1
	16	Physical and psychological experience	111.44	13.57	1.35	1,314.79	51
	17	Supporting identities	127.07	53.09	1.06	1,399.60	32
	18	Maintenance of options	109.66	79.39	4.34	960.13	53

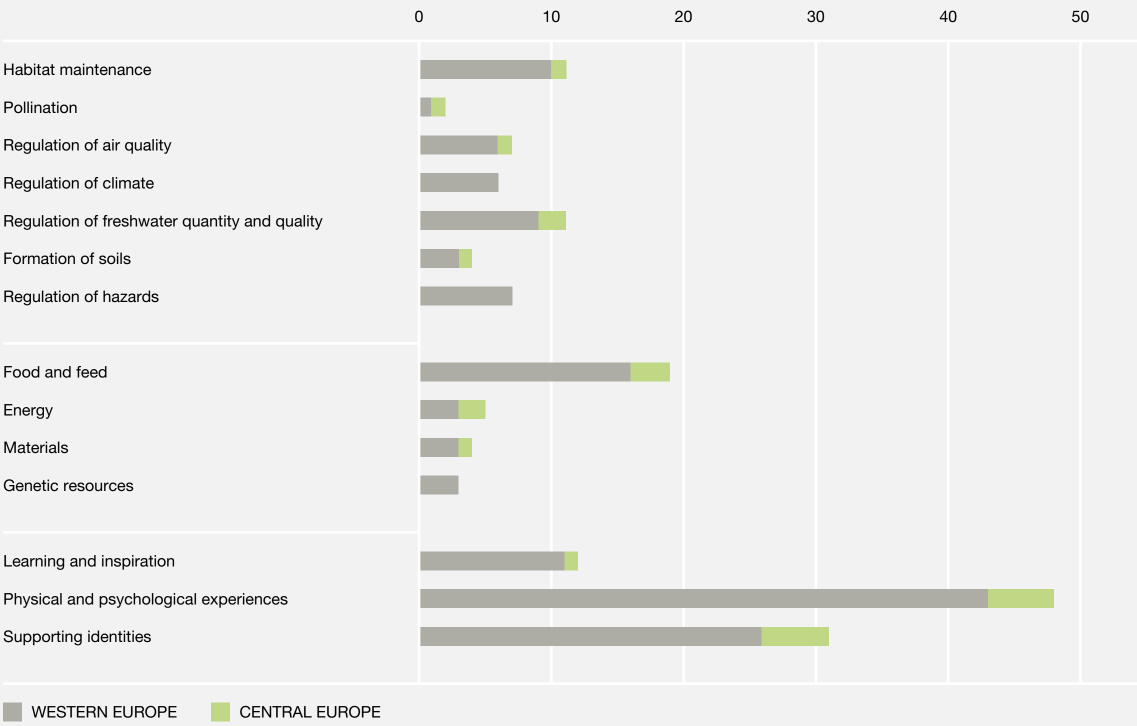
Supporting material Appendix 2.9 (available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.9_economic_values.pdf) provides a list of data sources.

Table 2 9 **Value per hectare of nature's contributions to people in Europe and Central Asia (2017 Int $ / ha / year).**

		All of Europe and Central Asia	Mean	Median	Minimum	Maximum	N
REGULATING	1	Habitat creation and maintenance	1,387.50	765.98	0.23	15,955.53	22
	2	Pollination and dispersal of seeds and other propagules	.	.	.	.	0
	3	Regulation of air quality	289.43	289.43	289.43	289.43	1
	4	Regulation of climate	464.53	464.53	61.67	867.38	2
	5	Regulation of ocean acidification					0
	6	Regulation of freshwater quantity, location and timing	27.13	30.71	10.50	40.18	3
	7	Regulation of freshwater and coastal water quality	3,202.54	1,965.22	1,546.62	6,095.77	3
	8	Formation, protection and decontamination of soils and sediments	32.32	32.32	4.75	59.89	2
	9	Regulation of hazards and extreme events	.	.	.	.	0
	10	Regulation of organisms detrimental to humans	.	.	.	.	0
MATERIAL	11	Energy	.	.	.	.	0
	12	Food and feed	112.84	9.63	1.53	327.35	3
	13	Materials and assistance	0.66	0.66	0.66	0.66	1
	14	Medicinal, biochemical and genetic resources	.	.	.	.	0
NON-MATERIAL	15	Learning and inspiration	7.47	7.47	4.62	10.31	2
	16	Physical and psychological experience	1,473.50	1,117.25	22.33	3,767.95	6
	17	Supporting identities	684	658.77	0.71	1,392.52	3
	18	Maintenance of options	0.80	0.80	0.65	0.95	2

Supporting material Appendix 2.9 (available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.9_economic_values.pdf) provides a list of data sources.

Figure 2 67 **Number of publications that found each contribution from nature to people among the five most valued by people in Western and Central Europe (no data were found for Eastern Europe and Central Asia). Source: Own representation based on data sources shown in supporting material Appendix 2.7*.**



* Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.7_assessment_references_synthetic_table.pdf

Development Goals) should account for this plurality of values. This conclusion goes beyond the recommendations of TEEB (2010), which focused on the inclusion of non-market monetary values and concurs with ideas developed in the UK NEA (2011) and IPBES, which highlight the need to include social, cultural and shared values in decision-making through, for example, deliberation with various stakeholders (Kenter *et al.*, 2015).

We demonstrate that alternative components of values of nature's contributions to people are expressed in different units, and therefore may not be directly compared through, for example, conventional benefit-cost analysis. Thus, researchers and policymakers require novel approaches to integrate value plurality into decision-making (Christie *et al.*, 2012; IPBES, 2016; Kenter *et al.*, 2016; UK NEA, 2011). One such approach is multi-stakeholder spatial decision analysis (Cerreta & Panaro, 2017).

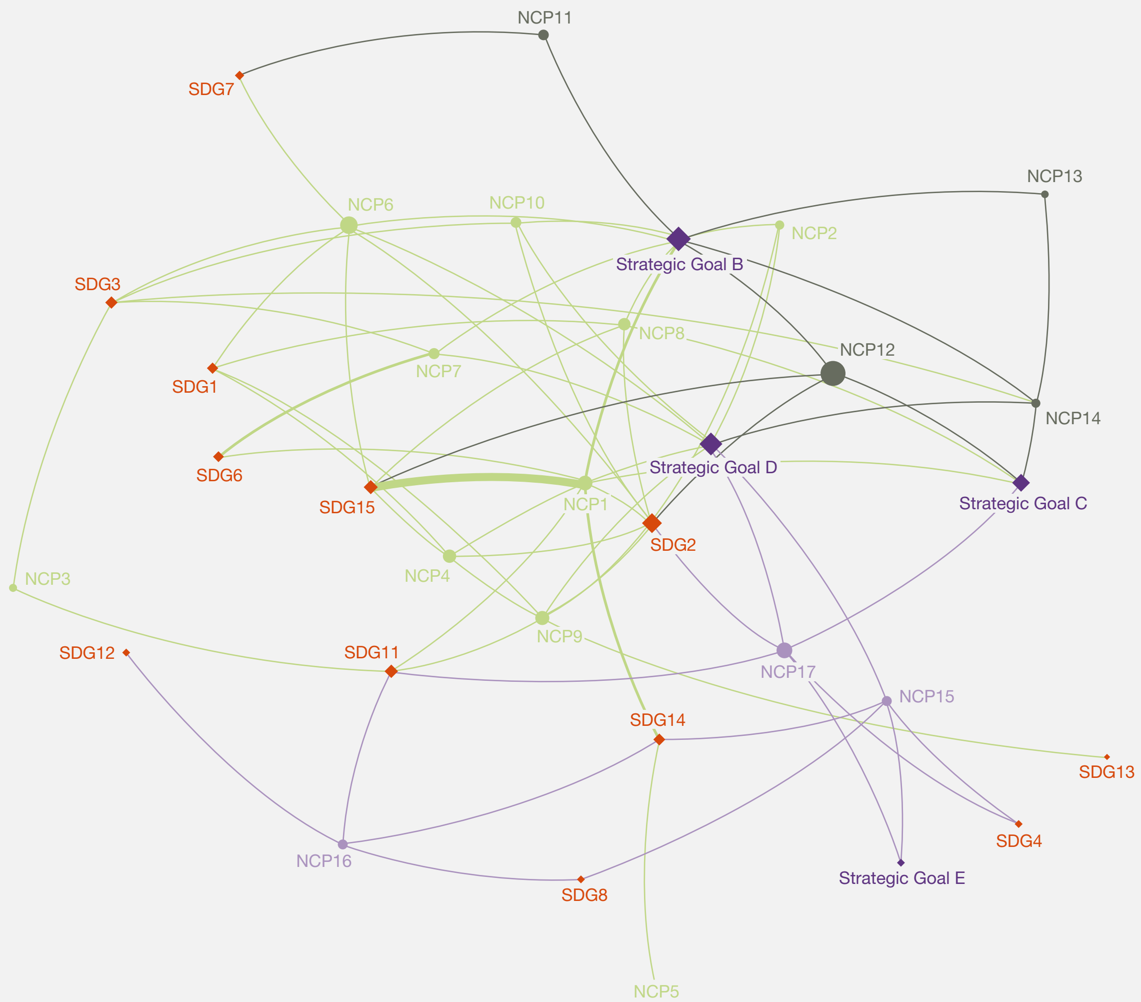
Good data on the plurality of values of nature's contributions to people exist for Western Europe, but are lacking for Central and Eastern Europe and Central Asia. There needs to be a greater focus on reporting more standardized per unit values for these contributions, where the units are clearly specified and can be compared across contributions, as this will facilitate (i) the assessment of the trade-offs of contributions between competing land uses, and (ii) the aggregation of values of contributions across the region.

2.4 RELEVANCE TO AICHI BIODIVERSITY TARGETS AND SUSTAINABLE DEVELOPMENT GOALS

Progress towards the Sustainable Development Goals (SDGs) and the Aichi Biodiversity Targets can be evaluated through the nature's contributions to people concept (Geijzendorffer *et al*., 2017). Considering the frequency with which specific contributions are mentioned in the strategies that contain these two sets of targets and goals, the direct relevance of all contributions is clear (see **Figure 2.68**). The top 25% most cited contributions across both strategies are the non-material contributions supporting identities (existence of species and ecosystems, and symbolic meaning of nature), the material contributions food and feed, and the regulating contributions habitat

Figure 2 68 **Relative importance of nature's contributions to people (NCP) for the Sustainable Development Goals (SDGs) and the Strategic Goals of the Strategic Plan for Biodiversity 2011–2020.**

The width of the lines indicates the frequency at which a certain contribution was mentioned in relation to a specific Sustainable Development Goal or Aichi Biodiversity Target (goals for which no relation to nature's contributions to people was found are not shown). The colour of the lines indicates whether the specific goal is connected with regulating (green), material (grey) or non-material (purple) contribution. The size of the nodes is proportional to the number of ties that a node has. Complete names of contributions are in Table 2.1. Source: Own representation.



creation and maintenance and regulation of water quality (see **Figure 2.68**) (Geijzendorffer *et al.*, 2017). For assessing progress towards policy goals and targets, especially Goal 2 (*zero hunger*) and Goal B of the Strategic Plan for Biodiversity 2011-2020 (*reduce the direct pressures on biodiversity and promote sustainable use*) information is required mainly on material contributions, with the latter also requiring information on regulating contributions. Information on non-material contributions are more equally needed over a range of goals and targets (Geijzendorffer *et al.*, 2017).

To interpret whether these sustainability goals are likely to be achieved, **Figure 2.68** combines the information depicted with the assessment of each contribution from nature to people (Section 2.2.5). According to this analysis, Europe and Central Asia is not advancing in *enhancing the benefits to all people from biodiversity and ecosystem services* (Strategic Goal D of the Strategic Plan for Biodiversity 2011-2020) because of the deteriorating status of many regulating and non-material contributions from nature to people (Section 2.2.5) and because the unequal access and distribution of contributions within the region (Section 2.3.4). Finally, because the practices and knowledge of indigenous peoples and local communities in Western and Central Europe have been eroded since the 1960s, the achievement of Strategic Goal E of the Strategic Plan for Biodiversity

2011-2020 (*enhance implementation through participatory planning, knowledge management and capacity building*) is threatened. However, it is worth noting that by including indigenous and local knowledge, the IPBES Regional Assessment for Europe and Central Asia respects, and thus contributes to, the achievement of Aichi Biodiversity Target 18 (*traditional knowledge respected*).

Regarding the interlinkages between the status and trends of nature's contributions to people and the achievement of the Sustainable Development Goals, it seems that some advances have been made to accomplish those related to environmental protection (Goals 13-15). Furthermore, the active contribution of multiple contributions from nature to health is supporting the achievement of Goal 3 (*good health and well-being*). However, the impact of biofuels and agriculture expansion on increasing land grabbing rates in other regions of the world and in Eastern Europe and Central Asia due to Western European consumption (Sections 2.2.4 and 2.3.1.1) jeopardizes the possibility of achieving Goal 2 (*zero hunger*), Goal 7 (*affordable and clean energy*) and Goal 12 (*responsible consumption and production*) in Europe and Central Asia. Further, future climate and land-use change are likely to exacerbate the decrease of water security (Goal 6). In fact, the number of water-stressed countries in Europe and Central Asia is projected to increase by 2030. Finally, the erosion of indigenous and local knowledge prevents some people from acquiring the relevant knowledge and skills needed to foster sustainable development and sustainable lifestyles and, thus, threatens the accomplishment of Goal 4 (*quality education*).

2.5 KNOWLEDGE GAPS

2.5.1 The unevenness of knowledge of nature's contributions to people in Europe and Central Asia

An important conclusion of this chapter's assessment of the status and trends of nature's contributions to people and their influence on quality of life is that, although there are thousands of publications and reports that are relevant to these contributions in Europe and Central Asia, a much smaller set of documents actually assess the status and trends of contributions. Furthermore, even fewer consider relationships between nature's contributions to people and good quality of life. The studies that do exist on the status and trends of nature's contributions to people are also uneven in their coverage of the different contributions. There are more accurate data on status and trends for material contributions, especially food and feed, than some regulating and non-material contributions. National ecosystem assessments often seek to analyze a range of contributions, but many publications and reports focus on individual ones. Western Europe has the most published literature on the status of nature's contributions to people and trends and their influence on the quality of life, contrasting with a very limited literature for Central Asia. Furthermore, very limited information on the status and trends in contributions is available for making comparisons between units of analysis since studies tend to focus on one or a small number of units of analysis. This conclusion, however, should be considered with caution as this chapter mostly reviewed English-language literature. *The uneven coverage in the existing literature of the different contributions for nature to people and subregions of Europe and Central Asia represents a key knowledge gap identified by the chapter.*

The limited availability of indicators for certain of nature's contributions to people in Europe and Central Asia is also a significant knowledge gap. Existing literature suggests indicator development for monitoring nature's contributions to people should cover the different components of these contributions (i.e. capacity, use and value; Section 2.1.2), provide data at multiple scales and address differences in contributions use based on societal characteristics (Balvanera *et al.*, 2017). However, according to existing studies the kind of information and indicators that are recommended for monitoring progress towards the Aichi Biodiversity Targets indicates a bias towards information related to capacity of nature's contributions to people (Geijzendorffer *et al.*, 2017). To implement regional and global assessment programmes of nature's contributions to people, existing studies highlight the need for indicator data at national scale for several contributions (Balvanera *et al.*, 2017). However, there are few indicators suitable and with available data to monitor contributions properly at the national scale (IPBES, 2017b). This chapter as a whole also confirms *there is a knowledge gap regarding indicators on the use of* nature's contributions to people*, demand and governance, which are less developed for the Europe and Central Asia region than capacity indicators*.

Even when data are available, *a further knowledge gap is that data and indicators focus on certain points in time, and evidence on long-term historical and future trends is missing for many of nature's contributions to people*. For example, for physical and psychological experiences of nature, little information exists on temporal trends of recreationists and visitors to the different ecosystems and their related recreational benefits, particularly in marine systems (Jobstvogt *et al.*, 2014; Ruiz-Frau *et al.*, 2011) and forests (Turtiainen & Nuutinen, 2012). To be able to establish future trends in nature's contributions to people, more work on quantitative (e.g. modelling) and qualitative projections of the impacts of different drivers is needed and a consistency of methods and scenarios would facilitate comparison, within and across Europe and Central Asia subregions (Section 2.2.6).

Existing analyses of monitoring and indicator development for nature's contributions to people identify that this should also take place at the local scale, but local indicators must be consistent with those at the regional and international scale in a manner that is integrated with efforts at higher levels (Balvanera *et al.*, 2017). For particular contributions, such as spiritual experiences or medicinal resources, methodological development and assessment may fit best to the local scale, due to the importance of local differences. This chapter has identified that at the local level indigenous and local knowledge on the interactions between nature's contributions to people and quality of life should be considered alongside scientific knowledge and used for setting future management policies. *There is a knowledge gap, however, relating to the recording of indigenous and local knowledge and such information needs to be collected before it disappears* (see Section 2.2.3.1) for its own value and because it has a role to play in guiding societies towards sustainability.

This chapter has also identified specific knowledge gaps in terms of the availability of indicator data for status and trends for the following aspects of nature's contributions to people:

- *Indicators of the trends in habitat creation and maintenance*; a number of indicators can be used to evaluate its current state such as some key migratory and breeding species and their habitat and indigenous and local knowledge can also be used to assess the status and trends of this contribution from nature to people (see supporting material Appendix 2.2[35]).
- *The relationship between water use and water availability*; indicator data for freshwater quantity for Eastern Europe and Central Asia is also lacking.
- *Soil quality;* encompassing its physical, chemical and biological components.
- *Carcass removal* by vertebrate and invertebrate scavengers and marine organisms (Donázar *et al.*, 2016; Martín-Vega & Baz, 2011; Moleón & Sánchez-Zapata, 2015).
- *The use of medicinal resources and plants;* ethnobotanical research is central to a better understanding of the medicinal potential of medicinal plants and national measures and indicators need to become comparable on an international scale, regarding health, ecological, cultural, legal or socio-economic aspects.
- *Wildlife-based tourism;* a data gap exists about accurate statistical information on the number of users developing recreational activities around wildlife (i.e. whale-watching, bird-watching).
- *Supporting identities;* there is a lack of consensus on suitable indicators but these could be developed using attitudes towards nature protection and species or ecosystem attributes or characteristics that are particularly valued for their existence (e.g. iconic, emblematic, symbolic species)
- *Interregional flows of nature's regulating and non-material* contributions to people; especially between Europe and Central Asia and other regions of the world.

This chapter also highlights some *significant knowledge gaps regarding the influence of nature's contributions to people on quality of life.* In particular, despite a large number of studies on the health aspects of nature's contributions to people in Western Europe, there are still *knowledge gaps on nature-human health linkages* in Europe and Central Asia and other regions. The current evidence base needs expanding to illuminate the scope and complexity of biodiversity-health relationships and their importance to health outcomes. More knowledge is needed on the degree to which social, cultural and economic factors influence the relationship between biodiversity, nature's contributions to people, and human health outcomes including the ways in which socio-economic status, age, gender and ethnicity can mediate health risks and benefits of nature. Such research can help to illuminate how health-biodiversity relationships are framed or understood by different communities or vulnerable groups.

The analysis of the relationships between nature's contributions to people and environmental equity and justice across Europe and Central Asia has to address the different understandings in countries and communities as to what constitutes equity and justice. Partly because of these differences there is *limited understanding of the plural values of nature's contributions to people endorsed by different societal groups and genders*. Moreover, there is even less empirical evidence about the inequities emerging from the different control over and access to these contributions (Bennett *et al.*, 2015). This knowledge is essential to understand fully how these contributions are likely to contribute to the quality of life of different societal groups and regions.

35. Available at https://www.ipbes.net/sites/default/files/eca_ch_2_appendix_2.2_ilk_content_of_ncp.pdf

2.5.2 The challenges of knowledge generation on nature's contributions to people

This chapter has indicated that if status and trends in nature's contributions to people and their impact on quality of life are to be better understood across Europe and Central Asia, four key changes are required in approaches to knowledge generation on these contributions.

First, there is a need for agreed *methods that allow comparison of results and syntheses*. Each of nature's contributions to people is often studied and described in different ways and for different units of analysis, which makes it challenging to summarize status and trends for a region. For example, for the regulation of water quality, the large uncertainty in measurements and the absence of consensus on the most appropriate methods for its quantification make its assessment difficult (Clec'h *et al.*, 2016; Grizzetti *et al.*, 2012).

Second, there is a need for *integrative approaches that assess the multiple benefits derived from a particular contribution from nature to people*. For example, it is widely recognized that pollinators and animal-pollinated plants provide benefits not only as food and feed, but also through medicinal and symbolic plants, fibres (e.g. cotton), construction materials (e.g. some timbers), aesthetically significant landscapes (e.g. flower meadows), musical instruments (e.g. bees wax used for violins), and as sources of inspiration for art, music, literature, traditions, education and technology throughout Europe and Central Asia (IPBES, 2016). This information on pollinators was compiled for a specific IPBES assessment on the topic, and such evidence is not available for many other contributions from nature to people.

Third, there is *limited empirical evidence on how individual contribution from nature s to people can contribute to the different dimensions of quality of life.* For example, there is only empirical evidence in Western Europe about how nature-based tourism can contribute to physical and mental health, but comprehensive information about its contributions to food security, cultural heritage and identity is missing for the whole of Europe and Central Asia.

Finally, there is a need for *more integrated approaches to the development of knowledge regarding nature's contributions to people that involve multiple social actors, including indigenous and local knowledge holders.* For example, in the case of medicinal resources, there is a need for a much more rigorous multidisciplinary science-driven approach to local and traditional medicines, which also empowers the local keepers of this knowledge and their users (Leonti & Casu, 2013). More integrated research approaches would be beneficial to better explore the knowledge and health potential of medicinal plants. It is essential to ensure that bioprospecting preserves traditional knowledge systems, and works with local communities in a manner that protects those values and protects habitats and species. Involving communities in the sustainable use of biodiversity may also provide important opportunities for local enterprise, and support the continuance of local cultural traditions. This requires direct engagement and collaboration between community organizations, biotech and pharmaceutical industries, national institutes of health and medicine, conservationists, and research funding agencies.

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