Preparatory work for developing

GUIDANCE ON THE MAINTENANCE OF LANDSCAPE CONNECTIVITY FEATURES OF MAJOR IMPORTANCE FOR WILD FLORA AND FAUNA

Guidance on the implementation of Article 3 of the Birds Directive (79/409/EEC) and Article 10 of the Habitats Directive (92/43/EEC)

A proposal for terms and definitions

EC Project 'Guidelines: Adaptation, Fragmentation'
ENV.B.2/ETU/2006/0042r

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1 INTRODUCTION

In the European Union, the Directive 79/409/EEC on the conservation of wild birds (Birds directive) and the Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats directive) set out the legal basis for the establishment of a European Union network of protected areas under the banner of Natura 2000. The Directives contain provisions for the identification and designation of individual sites. In addition, they also contain specific provisions relating to the use of measures to promote connectivity between sites and overall coherence to form the Natura 2000 Network (see Box 1).

The importance of ecological connectivity has become increasingly recognised from the sub-national to the global level, with initiatives and policies being developed in most EU countries and within the Convention on Biological Diversity (CBD) Programme of Work on Protected Areas. This thrust in effort comes from the awareness that although the amount of protected areas has increased rapidly in the last fifty years, these areas will always remain in the minority (e.g. 18 per cent of terrestrial EU is covered by Natura 2000). Protected areas will remain 'core areas' that are vital for biodiversity conservation, but species survival and ecosystem functioning are reliant on interactions with the wider landscape.

The dependence of the wider landscape is exacerbated by the increasing threat being posed by climate change for which there is now a broad base of research showing the differing responses of species (Parmesan and Yohe 2003) and serious future impacts (Thuiller et al. 2005, Broennimann et al. 2006). The effects of climate change are likely to interact with those of fragmentation to present significant barriers to species trying to track changing ecological conditions. This means that one of the most pressing issues facing protected areas management and the Natura 2000 network is the promotion of connectivity and coherence within the wider land and seascape.

1.1 Aim of the report

The terms used to describe connectivity or nature-friendly planning have gained diverse meanings and have often changed over time. The review assesses the terms and definitions related to nature and biodiversity conservation, adaptation to climate change and habitat fragmentation. The aim of the review is to identify the key terms and definitions currently used in this context in Europe. Additionally, a more detailed assessment of the use of selected key terms in scientific, legislative and political context is carried out. In this context, possible inconsistencies between scientific and current legal definitions will be shortly addressed.

The review forms a part of a broader study (ENV.B.2/ETU/2006/0042R) aiming to provide the European Commission with scientifically robust advice on how to guide the Member States in implementing connectivity and coherence related provisions of the Habitats and Birds directives.

The terms and definitions identified and defined in this review are the ones proposed to be used in later stages of the above mentioned study, including when developing guidance to the Member States (task 4 of the project)[1]. This review applies to the terrestrial components of the Natura 2000 network and concepts associated with connectivity on land. However, it is accepted that in general terms the concepts and discussions apply equally to the marine component of the network.

Box 1. Connectivity and coherence related provisions in Habitats and Birds directives

Article 10 of the Habitats directive

'Member States shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species.'

Article 3 of the Birds directive

'…Member States shall take the requisite measures to preserve, maintain or re-establish a sufficient diversity and area of habitats for all the species of birds referred to in Article 1. 2. The preservation, maintenance and re-establishment of biotopes and habitats shall include […] (b) upkeep and management in accordance with the ecological needs of habitats inside and outside the protected zones…'

[1] The definitions are consider to be in consistent with the terminology used in the Habitats Directive

2 APPROACH AND METHODOLOGY

The identification of key terms and assessment of their definitions has been carried out by using the most relevant international, European and national reference points (e.g. legal, policy-relevant and scientific). These include: international conventions/agreements (e.g. United Nations Convention on Biological Diversity (CBD), the Ramsar Convention on Wetlands, and Intergovernmental Panel on Climate Change (IPCC)), relevant European Community legislation, guidance and policy documents. Many terms have been adopted during the work on different guidance documents developed to facilitate implementation of the Habitats directive. They are not legally binding but their scope has been agreed between the Commission and the Member States. Some of terms are provided as agreed by the workshop organized on the island of Vilm by the Netherlands and Germany in May 2005 (CAM 2005). The report has also been commented by the Scientific Working Group for the Habitats Committee.

The review concentrates on terms relating to ecological processes associated with the impacts of climate change on ecosystems or attempts to mitigate them. In cases where identified key terms have different definitions the most relevant, up-to-date and, if possible, generally applied/accepted definition have been identified and selected. Additionally, for a number of key terms, i.e. terms considered to form a core of the over all project, a more detailed review of their use has been carried out (e.g. scientific, legislative and political contexts).

The key terms and definitions related to climate change adaptation and habitat fragmentation identified by the review are listed in Chapter 3. More detailed discussion on selected key terms, including the definitions to be adopted in the context of this study, is included in Chapter 4.

3 IDENTIFIED KEY TERMS AND THEIR DEFINITIONS

Table 1. Terms and definitions related to climate change adaptation and habitat fragmentation.

Term	Definition	Source
Category: Ecosystem characteristics		
adaptive capacity	The ability of a system / individuals to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.	Corresponding definitions from different sources: IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
biodiversity	Variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems	Convention on Biological Diversity (CBD) (Article 2) (http://www.biodiv.org/convention/articles.shtml?lg=0&a=cbd-02) Corresponding definition also, for example, by: Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp.

biomass	General definition: The total mass of living organisms in a given area or volume; recently dead plant material is often included as dead biomass In the context of EC energy policy: the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.	**General definition:** IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Secretariat of the Convention on Biological Diversity. 2003. Interlinkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol. Montreal, SCBD, 154 pp. (CBD Technical Series no. 10) **EC energy policy context:** Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market
biome	A large, regional ecological unit, usually defined by some dominant vegetative pattern.	Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp.
carbon sequestration	The process of increasing the carbon content of a carbon reservoir other than the atmosphere. Biological approaches to sequestration include direct removal of carbon dioxide from the atmosphere through land-use change, afforestation, reforestation, and practices that enhance soil carbon in agriculture. Physical approaches include separation and disposal of carbon dioxide from flue gases or from processing fossil fuels to produce hydrogen- and carbon dioxide-rich fractions and long-term storage in underground in depleted oil and gas reservoirs, coal seams, and saline aquifers.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)

connectivity – structural and functional	Structural connectivity is equal to habitat continuity and is measured by analysing landscape structure, independent of any attributes of organisms. This definition is often used in the context of metapopulation ecology. Functional connectivity is the response of the organism to the landscape elements other than its habitats (ie the non-habitat matrix). This definition is often used in the context of landscape ecology. See also: *landscape connectivity; habitat continuity, wildlife corridors, stepping stones, connecting structures*	*According to*: Tischendorf, L. and Fahrig, L. 2000. On the usage and measurement of landscape connectivity. Oikos 90: 7-19.
ecological coherence of Natura 2000	Sufficient representation of habitats / species to ensure favourable conservation status of habitats and species across their whole natural range. 'Sufficient representation' is a function of patch quality, total patch area, patch configuration and landscape permeability.	COM (2005) Note to the Scientific Working Group: Conclusions of workshop 'Ecological networks and coherence according to article 10 of the Habitats Directive', Vilm, Germany, May 2005; and Ssymank, A., Balzer, S. and Ullrich, K. 2006. Biotopverbund und Kohärenz nach Artikel 10 der Fauna-Flora-Habitat Richtlinie. Natur und Landschaft 38(2): 45-49.
ecological stability	Ability of a community or ecosystem to withstand or recover from changes or stress imposed from outside. Within the concept of stability there are a number of terms and types that warrant further discussions. Generally ecologists have included the concepts of resilience and resistance of communities within the concept of stability. In this case resilience is the speed with which a community can return to its original state after being perturbed and resistance is the ability to avoid the perturbation in the first place (See '*ecosystem resilience*' and '*ecosystem resistance*' below). These two ideas are now generally subsumed with the definition of ecosystem resilience.	Lawrence, E. (ed.). 2002. Henderson's dictionary of biological terms (12th edition). Pearson Education Limited, Essex, England. Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii.

	Stability can be further divided into local and global stability. Local stability describes the tendency of a community to return to its original state when subjected to a small perturbation, whereas global stability describes this ability when faced with large perturbations. Furthermore, the stability of a community depends on the ecological conditions within which exists. If a community is stable within a narrow range of conditions it is said to be dynamically fragile whereas if it is stable within a broad range of conditions it is dynamically robust. Previously it was thought that stability was a function of the community complexity, i.e. the more species that occurred within a community and the more interactions between them led to a more stable community. However this was shown to not be the case and has been shown to vary dramatically with community (Begon et al 1996).	
ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. The ecosystem boundaries are defined by the dynamic interactions, sometimes termed ecosystem processes, among the components of an ecosystem (i.e. plants, wildlife, climate, landforms and human activities). The ecosystem boundaries are irrespective of scale or location for ecosystem processes occur at a multitude of scales. Generally ecologists take a pragmatic approach that looks for assemblages of strong links between components within an ecosystem compared to weak interactions with components outside them. As biological diversity relates to the sum of the variability within species (e.g. genetic), between species and between ecosystems, it can be seen as a key structural feature of	Convention on Biological Diversity (CBD) (Article 2) (http://www.biodiv.org/convention/articles.shtml?lg=0&a=cbd-02) Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)

	ecosystems.	
ecosystem functions / functioning[2]	Ecosystem functions are defined as the capacity of natural [ecosystem] processes and components to provide goods and services that satisfy human needs, directly or indirectly. These functions have been broadly grouped into four categories: 1) regulation, 2) habitat, 3) production and 4) information (de Groot et al 2002). In short, ecosystem functions can be seen as an observable outcome (a subset) of *ecosystem processes* and *ecosystem structure*. Out of the group of ecosystem functions, a set of *ecosystem services* having visible benefits to human society can be identified.	de Groot, R. S., Wilson, M. A., Boumans, R. M. J. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services Ecological Economics, 41/3: 367-567
ecosystem services	Ecosystem services are the benefits people obtain from ecosystems. These include four different categories, namely *provisioning services* such as food, water, timber, and fibre; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis, and nutrient cycling. Please note: provisioning ecosystem services can also be referred to as *ecosystem goods.* Therefore, the term '*ecosystem goods and services'* is also often used in literature (particularly prior to the Millennium Ecosystem Assessment (MEA)). The term '*ecosystem goods and services'* is equivalent to the MEA four-category definition of ecosystem services (above). The term '*ecosystem goods and services'* has been used by a number of pioneering	Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx) This definition also adopted by the European Commission 'Halting the loss of biodiversity by 2010 – and beyond' (COM/2006/216) (http://ec.europa.eu/environment/nature/biodiversity/current_biodiversity_policy/biodiversity_com_2006/index_en.htm)

[2] Depending on the source, the definition/classification of following terms differs slightly: ecological processes and ecosystem functioning / functions. The definitions / classification adopted in the context of this study is compatible with the one used by Millennium Ecosystem Assessment (2005). For different definitions / classification see, for example: Hooper, D. U., Chapin, F. S., Ewel, J. J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J. H., Lodge, D. M., Loreau, M., Naeem, S., Schmid, B., Setala, H., Symstad, A. J., Vandermeer J. and Wardle, A. 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecological Monographs, 75/1: 3-35.

	scientists in the field, for example Prof. Gretchen Daily and Prof. Robert Constanza. *References:* Daily, G.C. (ed.). 1997. Nature's Services: Societal Dependence on Natural Ecosystems, Island Press, Washington, DC; Costanza, R., d'Arge, R., de Groot, R.S., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. Nature, 387: 253–260.	
ecosystem process	An intrinsic ecosystem characteristic whereby an ecosystem maintains its integrity. Ecosystem processes include decomposition, production, nutrient cycling, and fluxes of nutrients and energy.	Millennium Ecosystem Assessment (MEA). 2005. Our human planet: summary for decision-makers. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
ecosystem resilience	The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al 2004). Resilience depends on ecological dynamics as well as the organizational and institutional capacity to understand, manage, and respond to these dynamics.	Millennium Ecosystem Assessment (MEA). 2005. Our human planet : summary for decision-makers. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx) Walker, B. H., C. S. Holling, S. C. Carpenter and Kinzig, A. P. 2004. Resilience, adaptability and transformability. Ecology and Society 9:5.
ecosystem resistance	The capacity of an ecosystem to withstand the impacts of drivers without displacement from its present state. This is an analogous definition for community resistance which is discussed under the definition for ecological stability.	Millennium Ecosystem Assessment (MEA). 2005. Our human planet: summary for decision-makers. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
ecosystem structure	Attributes related to the instantaneous physical state of an ecosystem; examples include species population density, species richness or evenness, and standing crop biomass	US Environmental Protection Agency Glossary of terms (http://www.epa.gov/OCEPAterms/eterms.html)

ecotone	Zone / transition areas between two ecosystems where these two systems overlap. Ecotones support species from both of the over lapping ecosystems and also species found only in this zone. Consequently, the species richness in ecotones might be higher than in surrounding areas. In principle, fragmentation causes an increase in habitat edges, therefore increasing the proportion of ecotones within a landscape. In this context, it has also been considered that habitat edges have a negative influence on interior conditions of habitat (e.g. through increased predation and invasion), i.e. the edge effect.	*Based on:* Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii; and Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp.
habitat continuity	Permanent and long term stock of all necessary habitat requirements for an organism within a given landscape/ecosystem, including dynamic/spatial mosaics.	*Based on:* COM (2005) Note to the Scientific Working Group: Conclusions of workshop 'Ecological networks and coherence according to article 10 of the Habitats Directive', Vilm, Germany, May 2005.
habitat / landscape heterogeneity / diversity	Landscapes' quality or state of being heterogeneous, eg being composed of parts of different habitats.	*Based on:* Franklin, A., B. Noon and George, T. 2002. What is habitat fragmentation? Studies in Avian Biology 25: 20-29 and Murphy, H. T. and Lovett-Doust, J. 2004. Context and connectivity in plant metapopulations and landscape mosaics: does the matrix matter? Oikos 105: 3-14.
landscape	Landscapes can be defined as one of the lower levels of ecological organisation within regional ecosystems (i.e. biomes). Alternatively, landscapes can also be considered as areas defined by different resource management such as forestry and agriculture. The latter definition strongly corresponds to human perceptions.	Wiens, J. A. 2002. Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47:501-515.

landscape connectivity	The degree to which the landscape facilitates or impedes movement among patches. Landscape connectivity is a combined effect of structural and functional connectivity, i.e. effect of landscape structure and the species' use, ability to move and risk of mortality in various landscape elements on the movement rate among habitat patches in the landscape. See also: *connectivity - structural and functional*	Tischendorf, L. and Fahrig, L. 2000. On the usage and measurement of landscape connectivity. Oikos 90: 7-19 (*and the references within*).
landscape pattern	The spatial distribution and arrangement of patches within landscape.	*Based on:* Forman, R.T.T. and Godron, M. 1986. Landscape ecology. John Wiley & Sons, NewYork. 620 pp; Forman, R. T. T. 1995. Land mosaics. The ecology of landscapes and regions. - 632 p.; Cambridge.
primary production	Rate of biomass produced by an ecosystem, generally expressed as biomass produced per unit of time per unit of surface or volume. Net primary productivity (NPP) is defined as the energy fixed by plants minus their respiration. Global terrestrial NPP is estimated to be 110-120 x 10^9 tonnes dry weight per year, and 50-60 x 10^9 tonnes in the seas. Therefore although marine ecosystems cover two-thirds of the Earth's surface, they provide one third to one half of its production. There is a general latitudinal trend where productivity is concentrated in tropical and temperate regions and is primarily constrained by solar radiation (as a resource) and temperature (as a condition). Other factors also limit productivity within more narrow bounds including availability of nutrients, water availability and altitude. It should also be remembered that measures of NPP are biased towards above-ground NPP in terrestrial ecosystems due to the difficultly of measuring below ground NPP.	Millennium Ecosystem Assessment (MEA). 2005. Our human planet: summary for decision-makers. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx) Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii.

succession (ecological)	The more or less predictable changes in the composition of communities following a natural or human disturbance. As an ecological concept, succession can be defined as the non-seasonal, directional and continuous pattern of colonisation and extinction on a site by species populations (Begon et al 1996). This definition encompasses a range of different sequences that occur over widely varying time scales and often as a result of different mechanisms. A number of different forms of succession can be identified: Degradative succession These events can occur over a relatively short time scale and occur when a degradable resource (e.g. dead organic matter) is utilised successively by a number of species. As the matter continues to degrade the conditions tend to favour one group of species over another. Ultimately this process terminates as the resource is used up. Allogenic succession This involves the creation of new habitat that is opened up for invasion by green plants or other sessile organisms. In this case the new habitat does not degrade but becomes occupied. This form of succession is caused by changing external geophysicochemical forces. Autogenic succession This occurs when species occupy newly exposed areas in the absence of abiotic influences. If this exposed area has not previously been influenced by a community the sequence of species is referred to primary succession. Whereas cases where substrate becomes exposed due to the removal of species, but seeds	IUCN / World Conservation Monitoring Centre Glossary of Biodiversity Terms (http://www.unep-cmc.org/reception/glossaryA-E.htm) Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii.

	or spores remain – the subsequent sequence of species is termed secondary succession.	
Category: Pressures on ecosystems (including those of climate change)		
coral bleaching	The paling in colour of corals resulting from a loss of symbiotic algae. Bleaching occurs in response to physiological shock in response to abrupt changes in temperature, salinity, and turbidity.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
deforestation	Conversion of forest to non-forest land.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
desertification	Land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities. Further, the United Nations Convention to Combat Desertification defines land degradation as a reduction or loss in arid, semi-arid, and dry sub-humid areas of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical, and biological or economic properties of soil; and (iii) long-term loss of natural vegetation.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)

disturbance	A discrete event, either natural or human induced, that causes a change in the existing condition of an ecological system. In community ecology, disturbance generally relates to the interruption of, or interference with, interspecific competition and the settled state the community structure would assume if the conditions remained constant. Therefore a disturbance is a discrete event in time that removes organisms or otherwise disrupts the community by influencing the availability of space and/or food resources, or by changing the physical environment. A general consequence of this is that space or resources become available to new individuals. The most commonly identified causes of disturbance are predators, parasites, disease, temporal heterogeneity and changes to physical structures. Changes to each of these factors can be naturally occurring or anthropogenically induced (Begon et al 1996). However this term becomes more vague when applied to conservation issues. Habitat disturbance is identified as one of the three ways in which habitats can be disrupted (destruction and degradation being the others). In this sense disturbance refers to discrete events that cause minor but accumulating impacts on a species. For example repeated visits to caves have been shown to disrupt grey bat (*Myotis grisescens*) populations leading to declines in the USA (Begon et al 1996).	Kaufmann, M. R., Graham, R. T., Boyce, D. A., Jr., Moir, W. H., Perry, L., Reynolds, R. T., Bassett, R. L., Mehlhop, P., Edminster, C. B., Block, W. M., and Corn, P. S. 1994. An ecological basis for ecosystem management. Gen. Tech. Rep. RM 246. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 22 pp. Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii.
disturbance regime	Frequency, intensity, and types of disturbances, such as fires, insect or pest outbreaks, floods, and droughts.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm)
erosion	The process of removal and transport of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, winds, and underground water.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Secretariat of the Convention on Biological Diversity. 2003.

		Interlinkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol. Montreal, SCBD, 154 pp. (CBD Technical Series no. 10)
eutrophication	Increase in the amount of nutrients in the soil and waterbodies, with an impact on ecological processes. The most important nutrients causing eutrophication are phosphorus and nitrogen.	Dumortier, M., De Bruyn, L., Hens, M., Peymen, J., Schneiders, A., Van Daele, T., Van Reeth, W., Weyemberh, G. & Kuijken, E. 2005. Natuurrapport 2005. Toestand van de natuur in Vlaanderen: cijfers voor het beleid. Mededelingen van het Instituut voor Natuurbehoud nr. 24, Brussel. (Translation provided by the Flemish Research Institute for Nature And Forest (INBO).
extinction	The complete disappearance of an entire species. Extinction can happen at different spatial scales and relates to the complete disappearance of a species from a specified area. Local extinctions of small populations in insular habitats are common events for a diverse range of taxa. In most cases local extinctions can be countered by recolonisation of the area from a larger 'mainland' population. A local extinction of an endemic species is the same as a global extinction since recolonisation is impossible. Remote islands with high species diversity and many endemics are there also the centres for high rates of extinction. The most pervasive factors associated with extinction are habitat or island area (Begon et al 1996)	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Secretariat of the Convention on Biological Diversity. 2003. Interlinkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol. Montreal, SCBD, 154 pp. (CBD Technical Series no. 10) Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii.

fragmentation / habitat fragmentation	The breaking up of extensive landscape features into disjunct, isolated, or semi-isolated patches as a result of land-use changes. Fragmentation has two negative components for biota: loss of total habitat area and the creation of smaller, more isolated, remaining habitat patches (Meffe and Carroll 1997). Fragmentation can be seen as a landscape-scale process involving both habitat loss and the breaking apart of habitat with a net increase in the area of habitat edges (i.e. habitat fragmentation). (Fahrig 2003) Direct habitat loss has large, consistently negative effects on biodiversity, while process of habitat fragmentation has weaker effects which may be negative (increased exposure to external pressures; reduced migration; higher local extinction rates) or positive (enhanced persistence of predator-prey system by providing refugia for prey species; enhanced stability of two-species competition) (Fahrig 2003). Populations caught in a non-equilibirum metapopulation dynamic are also referred to as fragmented. This occurs when there is too little migration between metapopulations to maintain the overall population.	**General definition:** European Community Biodiversity Clearing House Mechanism Glossary of Terms (http://biodiversity-chm.eea.europa.eu/nyglossary_terms/) Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp; and Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annu. Rev. Ecol. Evol. Syst. 34: 487-515.
invasive alien species	An alien species whose introduction and/or spread threaten biological diversity. See also: *alien species*	Convention on Biological Diversity, CBD Guiding Principles (CBD Decision VI/23) (http://www.biodiv.org/decisions/default.aspx?dec=VI/23)
Category: Responses		

adaptation	Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
afforestation	Planting of new forests on lands that historically have not contained forests. **Please note:** in practise the term 'afforestation' in Europe is often defined as planting of new forest on lands where the land-use has been different for a certain number of year, e.g. at least one forest generation. For example, in the context of the Kyoto Protocol the 'afforestation' has been defined as the human-conversion of land that has not been forested for a period of at least 50 years to forested land (FCCC/KP/CMP/2005/8/Add.3). See also: *reforestation*	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx) UNFCCC. 2005. Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005. Addendum. Part Two: Action taken by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol at its first session (FCCC/KP/CMP/2005/8/Add.3). http://unfccc.int/documentation/documents/advanced_search/items/3594.php?rec=j&priref=600003823&data=&title=&author=&keywords=&symbol=FCCC%2FKP%2FCMP+&meeting=&mo_from=01&year_from=2005&mo_to=&year_to=&last_days=&anf=0&sorted=date_sort&dirc=DESC&seite=1#beg
agro-forestry (system)	Mixed systems of crops and trees providing wood, non-wood forest products, food, fuel, fodder, and shelter.	Millennium Ecosystem Assessment (MEA). 2005. Our human planet : summary for decision-makers. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)

ecological network	A coherent system of natural and/or semi-natural landscape elements that is configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources (Bennett 2004). Ecological networks are, therefore, a tool to support the maintenance, restoration or reestablishment of functional ecological relations between different elements of a landscape (Finck & Riecken 2001, Riecken et al. 2004). Actions to maintain or restore these interactions include: conserving a representative array of habitats allowing species populations access to a sufficient surface area; allowing seasonal migration, permitting genetic exchange between different local populations, allowing local populations to move away from degrading habitats; and securing the integrity of vital environmental processes (Bruszik et al 2006). By focusing on the ecological interactions across landscapes, ecological networks explicitly include relations between semi natural to natural areas and cultivated areas and therefore identify appropriate opportunities within the landscape matrix for the sustainable use of natural resources - agriculture, forestry, fishing, human settlements, recreation, etc. (Finck & Riecken 2001, Bennett 2004, Riecken et al. 2004). Typically ecological networks are implemented through a planning approach that identifies core areas (protected areas), buffer zones of mixed landuse and connective structures that enable the movement of organisms between core areas (e.g. ecological corridors and/or permeable landscapes) (Bruszik et al 2006, Bennett 2004).	Bennett, G. 2004. Integrating Biodiversity Conservation and Sustainable Use: Lessons Learned From Ecological Networks. IUCN, Gland, Switzerland, and Cambridge, UK. vi + 55 pp. Bruszik, A., Rientjes, S., Delbaere, B., van Uden, G., Richard, D., Terry, A. and Bonin, M. 2006. Assessment of the state of affairs concerning the Pan-European Ecological Network (Final draft - 31 August 2006) 79 pp. Finck, P. & Riecken, U. (2001): Nationaler Biotopverbund aus Bundessicht. Flächenpool-Lösungen - ein Fortschritt für den Vollzug der Eingriffsregelung? : Tagungsband zur Oppenheimer Arbeitstagung ; 2. Teil: Planung vernetzter Biotopsysteme - Umsetzung und Konsequenzen : Tagungsband. - Oppenheim - (2001), Bd. 5: S. 4-12. Riecken, U., Ullrich, K. & Finck, P. (2004): Biotopverbund. - In: Konold, W., Böcker, R. & Hampicke, U.: Handbuch Naturschutz und Landschaftspflege. Handbuch Naturschutz und Landschaftspflege: Kompendium zu Schutz und Entwicklung von Lebensräumen und Landschaften. - 13. Erg. Lfg. 9/04. ecomed, Landsberg: 1-20 (Teil XI-4; Stand: 2004).

favourable conservation status	Habitats: The conservative status of a natural habitat will be taken as ‘favourable’ when: its natural range and areas it covers within that range are stable or increasing, and the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and the conservation status of its typical species is favourable as defined below (as in Habitats directive Article 2 (i)). Species: The conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in the habitat Directive’s Article 2. The conservation status will be taken as ‘favourable’ when: population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis. Please note: favourable conservation status was initially introduced by the Habitats directive, i.e. its origins are in political, not ecological, literature.	Article 2 of the habitat Directive (92/43/EEC)
landscape permeability	The quality of a heterogeneous land area to provide for passage of organisms. In contrast to focusing on the identification of corridors or connected habitat patches, the landscape permeability considers more broadly the resistance to organism movement and aims to provide a consistent estimate of the relative potential for organisms' passage across entire landscapes. This measure therefore considers the permeability of the matrix habitat as well as the degree of	Singleton, P. H., Gaines, W. L. and Lehmkuhl, J. F. 2002. Landscape Permeability for Large Carnivores in Washington: A Geographic Information System Weighted-Distance and Least-Cost Corridor Assessment. Unites States Department of Agriculture, USA, 74 pp.; and Tischendorf, L. and Fahrig, L. 2000. On the usage and measurement of landscape connectivity. Oikos 90: 7-19 *(and the references within)*.

	structural connectivity.	
land-use planning	The systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses. Land-use planning may be at international, national, district (project, catchment) or local (village) levels. It includes participation by land users, planners and decision-makers and covers educational, legal, fiscal and financial measures.	FAO. 1993. Guidelines for land use planning. FAO Development Series 1 (via European Environmental Agency (EEA) glossary of terms (http://glossary.eea.europa.eu/EEAGlossary)
minimum viable population	A minimum viable population for any given species in any given habitat is the smallest isolated population having a 99per cent chance of remaining extant for 1000 years despite the foreseeable effects of demographic, environmental and genetic stochasticity and natural catastrophes (Schaffer 1981). Schaffer emphasised that the specific survival probabilities and time periods were almost subjective in their designation, but what was important was the development of a quantitative estimate for the population size required to ensure long term survival. This approach has been increasingly taken over by population viability analysis as a means to model and predict extinction risk as a more accurate way of predicting population viability.	Schaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience. 31(2): 131-134.

mitigation	An anthropogenic intervention to reduce negative or unsustainable uses of ecosystems or to enhance sustainable practices. In the context of climate change: an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.	**General definition:** Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx) **Definition in the context of climate change:** IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Secretariat of the Convention on Biological Diversity. 2003. Inter-linkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol. Montreal, SCBD, 154 pp. (CBD Technical Series no. 10);
reforestation	Planting of forests on lands that have previously contained forests but that have been converted to some other use. For the definition of 'reforestation' in the European context, see also: *afforestation*	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx).
Category: Ecosystem management		
adaptive management	A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for purposes of learning.	Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
buffer zone	Zone / area around the network (ie around core areas and, if necessary, around linkage elements) which protects the network from potentially damaging external influences and which are essentially transitional areas characterized by compatible land uses.	Bennett, G. 2004. Integrating Biodiversity Conservation and Sustainable Use: Lessons Learned From Ecological Networks. IUCN, Gland, Switzerland, and Cambridge, UK. vi + 55 pp.

		Corresponding definition also, for example, by: Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp.
connecting structures	Connecting areas for specific species or habitats (eg within ecological networks). Landscape mosaics may provide these functions. See also: *ecological corridors, landscape permeability*	COM (2005) Note to the Scientific Working Group: Conclusions of workshop 'Ecological networks and coherence according to article 10 of the Habitats Directive', Vilm, Germany, 2006.
core area	Area where the conservation of biodiversity takes primary importance, even if the area is not legally protected.	**General definition:** Bennett, G. 2004. Integrating Biodiversity Conservation and Sustainable Use: Lessons Learned From Ecological Networks. IUCN, Gland, Switzerland, and Cambridge, UK. vi + 55 pp.
ecological corridors	Landscape elements which serve to maintain vital ecological or environmental connections by providing physical (though not necessarily linear) linkages between the core areas. The ecological functions of corridors are to enable species dispersal, migration, foraging and reproduction. Individual corridors are not necessarily linear features, but can be grouped in several ways according to their shapes (diffuse, belt-like, line-like, etc.), structure (continuous or interrupted like stepping stones), spatial position to the core area (conjunctive corridor or blind corridors), or by their services like migration corridors, commuting corridors and dispersal corridors. In practise, ecological corridors can be established at different scales, e.g. regional, national or local. At regional and national level ecological corridors refer to continuous habitat stretches (such as river valleys and water courses) and/or mosaic of habitat types	Bennett, G. 2004. Integrating Biodiversity Conservation and Sustainable Use: Lessons Learned From Ecological Networks. IUCN, Gland, Switzerland, and Cambridge, UK. vi + 55 pp. *Further elaborated in:* Bruszik, A., Rientjes, S., Delbaere, B., van Uden, G., Richard, D., Terry, A. and Bonin, M. 2006. Assessment of the state of affairs concerning the Pan-European Ecological Network (Final draft - 31 August 2006) 79 pp. (*and the references within*); and Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp.

	that allow movement of species within the landscape. At local level corridors can consist of landscape elements such as hedgerows, dikes and road verges. It is to be noted that the proper scale of implementation is to a large extent species dependent and these aspects should be, therefore, taken into consideration.	
ecosystem approach	A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use. An ecosystem approach is based on the application of appropriate scientific methods focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.	Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
ecosystem management	An approach to maintaining or restoring the composition, structure, function, and delivery of services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.	Corresponding definitions by: Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx); and Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp.
integrated coastal zone management	Environmentally sustainable, economically equitable, socially responsible, and culturally sensitive management of coastal zones, which maintains the integrity of this important resource while considering local traditional activities and customs that do not present a threat to sensitive natural areas and to the maintenance status of the wilds species of the coastal fauna and flora.	Recommendation of the European Parliament and the Council concerning the implementation of Integrated Coastal Zone Management in Europe (2002/413/EC)
landscape ecology	Landscape ecology is the study of structure, function, and change in a heterogeneous land area which contains interacting ecosystems. Landscape ecology focuses on 1) the spatial	Forman, R.T.T. and Godron, M. 1986. Landscape ecology. John Wiley & Sons, NewYork. 620 pp; Forman, R. T. T. 1995. Land mosaics. The ecology of landscapes and regions. - 632 p.;

	relationships among landscape elements, 2) the flows of energy, mineral nutrients, and species among the elements, and 3) the ecological dynamics of the landscape mosaic through time. In particular, landscape ecology is concerned with the effects of both natural and human disturbances on the landscape.	Cambridge.
multiple use - sustainable-use areas / multiple use zones	Multiple use: an on-site management strategy that encourages an optimum mix of several uses on a parcel of land or water or by creating a mosaic of land or water parcels, each with a designated use within a larger geographic area. Sustainable-use areas / multiple use zones: areas within the ecological networks where sufficient opportunities are provided within the landscape matrix for both the exploitation of natural resources and the maintenance of ecosystem functions.	Multiple use: IUCN / World Conservation Monitoring Centre Glossary of Biodiversity Terms *(*http://www.unep-wcmc.org/reception/glossaryA-E.htm*)* Sustainable-use areas / multiple use zones: Bennett, G. 2004. Integrating Biodiversity Conservation and Sustainable Use: Lessons Learned From Ecological Networks. IUCN, Gland, Switzerland, and Cambridge, UK. vi + 55 pp.
precautionary principle	When dealing with environmental policy, the precautionary principle states that: 'when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically'. At the EU level, precautionary approach also includes risk to animal and plant health (COM 2000/1).	Secretariat of the Convention on Biological Diversity. 2003. Interlinkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol. Montreal, SCBD, 154 pp. (CBD Technical Series no. 10). At the EU level the use of precautionary principle has been defined in the Commission Communication on the precautionary principle (COM 2000/1) (http://ec.europa.eu/dgs/health_consumer/library/pub/pub07_en.pdf). Reference to the precautionary principle is also included in the EC Treaty (in the context of environmental policy); however the Treaty provides no particular definition for the term (Maastricht Treaty of 1992 and the later EC Treaty.

protected area	A geographically defined area which is designated or regulated and managed to achieve specific conservation objectives	Convention on Biological Diversity (CBD) (Article 2) (http://www.biodiv.org/convention/articles.shtml?lg=0&a=cbd-02)
renewable and non-renewable resources	Renewable resource is an energy sources that are, within a short time frame relative to the Earth's natural cycles, sustainable, and include non-carbon technologies such as solar energy, hydropower, and wind, as well as carbon-neutral technologies such as biomass. In the context of EC energy policy: Renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases). Non-renewable energy resources: resources that do not fall under the above definitions	**General definition:** IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm) **EC energy policy context:** Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market
restoration (ecosystem)	The return of an ecosystem or habitat to its original community structure, natural complement of species, and natural functions.	IUCN / World Conservation Monitoring Centre Glossary of Biodiversity Terms (http://www.unep-wcmc.org/reception/glossaryA-E.htm) The SER International Primer on Ecological Restoration. 2004. Society for Ecological Restoration International, Science & Policy Working Group (Version 2: October, 2004) (http://www.ser.org/pdf/primer3.pdf)
stepping stones	An ecological corridor formed by non-linearly connected resource/habitat patches that allow organisms to disperse between the patches (e.g. core areas within an ecological network).	*According to* Prussic, A., Rientjes, S., Delbaere, B., van Uden, G., Richard, D., Terry, A. and Bonin, M. 2006. Assessment of the state of affairs concerning the Pan-European Ecological Network (Final draft - 31 August 2006) 79 pp. (*and the references within*).

sustainable forest management	The stewardship and use of forests and forest land in a way and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil now and in the future, relevant ecological, economic and social functions, at local, national and global levels and does not cause damage to other ecosystems. Alternatively according to FAO criteria: a group of forest management practises that centre around seven globally agreed core thematic areas: extent of forest resources; biological diversity; forest health and vitality; protective functions of forests; productive functions of forests; socio-economic functions; legal policy and institutional framework. The content and structure of sustainable forest management differs between regions / countries.	**General definition:** The Pan-European Process (ie the Helsinki Process) initiated by the Pan-European Forest Council in 1993. (http://www.pefc.org/internet/html/activities/4_1137_527.htm) FAO Criteria and indicators for sustainable forest management (http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=4462&sitetreeId=16587&langId=1&geoId=0)
wilderness area	Protected area managed mainly for wilderness protection. Large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.	Definitions of a protected area categories adopted by IUCN (Category 1b) (http://www.unep-wcmc.org/protected_areas/categories/index.html)
Category: Species / habitat ecology		
alien species	Alien species refers to a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.	Convention on Biological Diversity, CBD Guiding Principles (CBD Decision VI/23) (http://www.biodiv.org/decisions/default.aspx?dec=VI/23)

carrying capacity	The carrying capacity (usually denoted by *K*) represents the equilibrium point (i.e. the point at which density dependent birth and death rates cross) where intraspecific competition acting on birth and death rates regulate a population at a stable density. The maximum number of individuals of a particular species, that a given part of the environment can maintain (or 'carry') indefinitely. This concept is easier to illustrate theoretically where a population can be characterised by a sinmple carrying capacity. In natural populations the huge range of factors affecting density means that there will be a range of values that represent the carrying capacity. Also intraspecific competition will not hold a population to a predictable level, but will contain a population within certain bounds. This concept is closely linked to the establishment of quotas for harvesting wild living resources. Often the objective is drive the population to half its carrying capacity, where population growth is identified as maximal.	Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii. *For recent discussion see:* del Monte-Luna, P., Brook, P. W., Zetina-Rejón, M. J. and Cruz-Escalona1, V. H. 2004. The carrying capacity of ecosystems. Global Ecology & Biogeography, Volume 13, 485-495 pp.
climate envelope	The range of climatic variation within which the species can persist, provided its non-climatic environmental requirements are met. Estimating the climate envelope from distribution data provides a description of the climate within which the species has been recorded, and allows prediction of where a species' climate envelope will move under different scenarios of climate change (climate envelope modelling).	Harrison, P.A., Berry, P.M., Butt, N. and New, M. 2006. Modelling climate change impacts on species' distributions at the European scale: implications for conservation policy. Environmental Science and Policy, 9: 116-128. Walker, P. A. and Cocks, K.D. 1991. HABITAT: a procedure for modelling a disjoint environmental envelope for a plant or animal species. Global Ecology and Biogeography Letters 1:108-118.

dispersal capacity / ability	The capacity / ability of an organism to move away from place of birth. In the context of connectivity: The ability of an individual or population to move through a landscape mosaic, a function of landscape permeability, functional connectivity and the individual movement characteristics of the individual or species (Steven et al. 2004).	**General definition based on**: European Community Biodiversity Clearing House Mechanism Glossary of Terms (http://biodiversity-chm.eea.europa.eu/nyglossary_terms/) Stevens, V.M., Polus, E., Wesselingh, R.A., Schtickzelle, N. and Baguette, M. 2004. Quantifying functional connectivity: experimental evidence for patch-specific resistance in the Natterjack toad (*Bufo calamita*). Landscape Ecology, 19: 829-842
dispersal success	The number of successful immigrants into habitat patches in a landscape, or as search time, the number of movement steps individuals require to find a new habitat.	Tischendorf, L. and Fahrig, L. 2000b. How should we measure landscape connectivity? Landscape Ecol. 15: 633/641.
ecological community	An assemblage of species occurring in the same space or time, often linked by biotic interactions such as competition or predation.	Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
exposure	The nature and degree to which a system is exposed to significant climatic variations.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm)
keystone species	A species whose impact on the community is disproportionately large relative to its abundance. Effects can be produced by consumption (trophic interactions), competition, mutualism, dispersal, pollination, disease, or habitat modification (nontrophic interactions).	Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx) Corresponding definition also, for example, by: Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp.
landscape mosaic (mosaic, habitat mosaic)	Spatial configuration of habitats within a landscape, generally formed by patches arranged within a matrix. See also: *matrix, patch*	Hanski, I. and Simberloff, D. 1997. The metapopulation approach, its history, conceptual domain, and application to conservation. In: Hanski, I. and Gilpin, M. (eds), Metapopulation biology. Ecology, genetics, and evolution. Academic Press, pp. 5 /26.

matrix (habitat / environmental matrix)	The interstitial habitat / environment between habitat patches in a habitat mosaic, typically comprising the most extensive habitat / environment type in a landscape. See also: *patch, mosaic*	Dennis, R. L. H., Shreeve, T. G. and Van Dyck, H. 2003. Towards a functional resource-based concept for habitat: a butterfly biology viewpoint. Oikos 102: 417 /426.
metapopulation	Sets of local populations within some larger area, where typical migration from one local population to at least some other patches is possible (Hanski & Simberloff 1997). Metapopulations exist at a spatial scale where individuals can occasionally disperse among different patches but do not make frequent movements because the patches are separated by substantial expanses of unsuitable habitat. This rate of movement is usually sufficient to avoid long term genetic differentiation among patches, but low enough to allow each patch to be quite independent demographically. (Hunter 2002).	Hanski, I. and Simberloff, D. 1997. The metapopulation approach, its history, conceptual domain, and application to conservation. In: Hanski, I. and Gilpin, M. (eds), Metapopulation biology. Ecology, genetics, and evolution. Academic Press, p. 5-26. Corresponding definition also, for example, by: Meffe, G. K. and Carroll, C. R. 1997. Principles of Conservation Biology (second edition). Sinauer Associates , inc. Publishers, Sunderland, Massachusetts. 729 pp. Hunter, M. L. Jr. 2002. Fundamentals of Conservation Biology, Second edition, Blackwell Science, ISBN 0-86542-029-7
metapopulation ecology	Field of ecology that studies the dynamics of fragmented populations in heterogeneous landscapes, eg how these populations might respond to future perturbations such as climate change.	Hanski, I. and Simberloff, D. 1997. The metapopulation approach, its history, conceptual domain, and application to conservation. In: Hanski, I. and Gilpin, M. (eds), Metapopulation biology. Ecology, genetics, and evolution. Academic Press, p. 5-26.
patch (habitat or resource)	A particulate, invariant and homogeneous entity within an ecosystem. A concept forming the basis of metapopulation dynamics.	Dennis, R. L. H., Shreeve, T. G. and Van Dyck, H. 2003. Towards a functional resource-based concept for habitat: a butterfly biology viewpoint. Oikos 102: 417 /426.
patch configuration	The spatial arrangement of habitat patches within a mosaic, determined by patch size and isolation	Krawchuk. M. A. and Taylor, P. D. (2003) Changing importance of habitat structure across multiple spatial scales for three species of insects. Oikos 103/1: 153.

patch isolation	An attribute of a patch determined by the rate of immigration into the patch; the lower the immigration rate, the more isolated is the patch.	COM (2005) Note to the Scientific Working Group: Conclusions of workshop 'Ecological networks and coherence according to article 10 of the Habitats Directive', Vilm, Germany, May 2005.
patch quality	The quality of a patch or patches within a mosaic (from the perspective of a given organism).	Dennis, R. L. H., Shreeve, T. G. and Van Dyck, H. 2003. Towards a functional resource-based concept for habitat: a butterfly biology viewpoint. Oikos 102: 417 /426.
patch size	The size of a patch or patches within a mosaic.	Dennis, R. L. H., Shreeve, T. G. and Van Dyck, H. 2003. Towards a functional resource-based concept for habitat: a butterfly biology viewpoint. Oikos 102: 417 /426.
pioneer species	First species that colonise a bare site as the first stage in a primary succession. Pioneer species can also be found in secondary succession (an established ecosystem being reduced by an event such as a forest fire of a clearing), colonizing newly created open spaces.	Lawrence, E. (ed.). 2002. Henderson's dictionary of biological terms (12th edition). Pearson Education Limited, Essex, England.
population density	It is common to use the term population to describe a group of individuals of one species. However the boundaries defining that population are not always readily expressed. In cases were the limits of the population may be expressed arbitrarily, it is better to use the population density. This is usually defined as numbers of individuals per unity area. Density can be calculated in three different ways. The most common way is the 'resource weighted density' which assumes equal distribution of individuals per unit resource; 'organism weighted density' which finds the mean distribution of individuals per unit resource and the 'exploitation pressure' which measures the mean density experienced by the resource (see Lewontin & Levins 1989 for more details).	Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii. Lewontin, R.C. and Levins, R. 1989. On the characterisation of density and resource availability. American Naturalist. 134: 513-524.
response latency / time	The time interval between a stimulus and response.	Lawrence, E. (ed.). 2002. Henderson's dictionary of biological terms (12th edition). Pearson Education Limited, Essex, England.

sensitivity	Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (eg a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (eg damages caused by an increase in the frequency of coastal flooding due to sea-level rise). This definition can also be considered to apply to species.	IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx)
specialist and generalist species	Specialist species: Species which can survive and thrive only within a narrow range of habitat and/or climate conditions, or which can use only a very limited range of food, and is therefore usually less able to adapt to changing environmental conditions. Generalist species: Organism or species with a very broad ecological niche, which can tolerate a wide range of environmental conditions and eat a variety of foods. Specialisation is linked to the predictability of the environment in which the species are found. The main source of this predictability comes from climatic variation. Generally speaking seasonal environments (temperate areas) should contain a broader range of conditions for species than seasonally constant ones (i.e. the tropics), but constant environments allow for greater specialisation due to a stability of resource conditions. There are some studies that indicate a relationship between species richness and climate variability, with increasing variability and decreasing richness. In general when talking about predatory species, those that require a shorter handling time of the prey compared to searching time should be generalists. Whereas predators with a long handling time relative to searching, should become specialists. When either	Lawrence, E. (ed.). 2002. Henderson's dictionary of biological terms (12th edition). Pearson Education Limited, Essex, England. Begon, M., Harper, J.L., and Townsend, C.R. 1996. Ecology: individuals, populations and communities (3rd ed.). Blackwell, Oxford, UK. 1068 pp + xii.

	prey density decreases or interspecific competition increases, specialist predators are more like to switch search areas, whereas generalist predators may switch prey species. Studies from tropical forests, also found that rare plant species tended to be specialists, whereas generalists tend to be more common.	
species range (natural)	The spatial limits within which the habitat or species occurs. A natural range is not static but dynamic: it can decrease and expand.	Guidance document on the strict protection of animal species of community interest provided by the 'Habitats' Directive 92/43/EEC, European Commission (autumn 2006 draft).
vulnerability – species and ecosystems/habitats	Exposure to contingencies and stress, and the difficulty in coping with them. Three major dimensions of vulnerability are involved: exposure to stresses, perturbations, and shocks; the sensitivity of people, places, ecosystems, and species to the stress or perturbation, including their capacity to anticipate and cope with the stress; and the resilience of the exposed people, places, ecosystems, and species in terms of their capacity to absorb shocks and perturbations while maintaining function. In the context of climate change: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.	**General definition:** Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. (http://www.maweb.org/en/index.aspx) **Definition in the context of climate change:** IPCC Glossary of Terms (as used in the IPCC Third Assessment Report 2001) (http://www.ipcc.ch/pub/gloss.htm); Secretariat of the Convention on Biological Diversity. 2003. Interlinkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol. Montreal, SCBD, 154 pp. (CBD Technical Series no. 10);

4 DISCUSSING THE USE AND DEFINITIONS OF SELECTED KEY TERMS

4.1 Habitats and Birds directives' terminology and its application

The Habitats directive's terminology relevant in the context of habitat fragmentation and climate change adaptation is associated with the coherence of the Natura 2000 network. The coherence related references in the Habitats directive were identified by a group of experts in a workshop held in the Isle of Vilm, Germany, in 2005 (COM 2005). The identified terms include: **coherent ecological network** (the preamble, Article 3), **ecological coherence** (Articles 3 and 10), **(overall) coherence** (Articles 4 and 6), **features of the landscape improving coherence**, e.g. linear and continuous structure and stepping stones (Article 10).

As regards the Birds directive, the Directive includes a reference to the established network for special protected areas for birds (SPAs) forming 'a coherent whole'. Consequently, the Vilm expert workshop concluded that in the context of this Directive the term 'network' is used in a similar sense to the phrase 'coherent ecological network' in the EU Habitats directive. Article 3 of the Birds directive also lists some features of coherence, including maintaining and managing the sites/network in accordance with the ecological needs of habitats inside and outside the protected zones, re-establishment of destroyed biotopes and creation of biotopes. (COM 2005)

Further clarification regarding the meaning of, and the relationship between, the above mentioned terms on coherence has been provided by the Commission guidance documents on Articles 6 and 12. The Article 6 guidance documents[3] published in 2000 and 2006 (draft) concluded that the word 'ecological' is used both in Article 3 and Article 10 to explain the character of the coherence and that the expression 'overall coherence' in Article 6(4) is used in the same meaning.

When considering the ecological coherence of Natura 2000, it is important to note that the completed Natura 2000 network, defined by the Habitats directive as the sum of all areas designated for conservation under the Birds and Habitats directives (Article 3.1 of the Habitats directive), is a collection of individual protected sites (COM 2005). In order for these protected sites to actually form an ecologically coherent network then necessary functional connections amongst the sites and their surroundings must be maintained. Therefore management measures may need to go beyond the designated sites' boundaries and apply to the wider environment. Consequently, even though the Habitats directive's definition of a completed Natura 2000 network appears to be synonymous with a 'coherent ecological network' (see Article 3.1) it is important to distinguish between the established Natura 2000 network (i.e. all the protected areas) and establishing/maintaining overall ecological coherence of the

[3] Managing Natura 2000 sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC, European Commission (2000) p.46; Guidance document ion Article 6(4) of the 'Habitats Directive' 92/43/EEC – Clarification of the concepts of : Alternative solutions, Imperative reasons of overriding public interest, Compensatory Measures, Overall Coherence, Opinion of the Commission, European Commission (September 2006 draft).

Natura 2000 network (which includes the necessary functional connections amongst the designated sites). Further guidance on the interpretation of the overall coherence of the Natura 2000 network has been provided by the European Commission with respect to Article 6(4) of the Habitats directive[4].

The term '**favourable conservation status**' (FCS) originates also from the Habitats directive and its application is therefore mainly associated with the implementation of the Directive and Natura 2000 network. In addition, the term has been used in the context of some other regional agreements, such as Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)[5].

The Habitats directive defines favourable conservation status both for habitats and species. The conservative status of a natural habitat is considered 'favourable' when a) its natural range and areas it covers within that range are stable or increasing; b) the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future and; c) the conservation status of its typical species is favourable.

As regards species, the conservation status can be defined favourable when a) population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats; b) the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future and; c) there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

There are no terminological differences in defining favourable conservation status, i.e. the Habitats directive is used as the general reference point. However, due to the broadness and certain ambiguity of the definition there has been a lack of clarity in the interpretation the FCS term and how it should be implemented. In order to clarify these aspects a number of studies/guidance documents have been produced (e.g. Halahan & May 2002, Charalambides 2004, Walder 2006, Article 12 guidance document[6]). In addition, a Commission guidance document adopted in 2006 provides further guidance to assessing, monitoring and reporting issues related to FCS[7].

The maintenance or restoration, at favourable conservation status, of the natural habitats and species of wild fauna and flora of Community interest is set out as a primary objective of the Habitats directive (see Section 4.1.1 below). Consequently, FCS is the underlying objective of all measures set out by the Habitats directive and it is also particularly relevant in the context of habitat fragmentation and climate change adaptation. In principle, therefore, in cases where Article 10 measures are identified as the only means by which FCS of habitats and species of Community interest can be achieved the general provisions of the Habitats directive require these connectivity related measures to be implemented (COM 2005).

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[4] Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC (http://ec.europa.eu/environment/nature/nature_conservation/eu_nature_legislation/specific_articles/art6/index_en.htm)

[5] ASCOBANS: http://www.ascpbans.org/index0101.html

[6] Guidance document on the strict protection of animal species of community interest provided by the 'Habitats' Directive 92/43/1992, European Commission (autumn 2006)

[7] Assessment, monitoring and reporting of conservation status – Preparing the 2001-2007 report under Article 17 of the Habitats Directive (DocHab-04-03/03 rev.3) (http://circa.europa.eu/Public/irc/env/monnat/library?l=/reporting_framework/dochab-04-03-03/_EN_1.0_&a=d)

Furthermore, the Commission guidance also states that 'The concept of FCS is not limited to the Natura 2000 network. The definition of FCS for habitats and species in Article 1 indicates clearly that the overall situation of species and habitats needs to be assessed and monitored (see Article 11) in order to judge if it is favourable or not.'[7] It therefore follows from this that Members States should implement connectivity measures where these are required to maintain or restore FCS whether they contribute to the coherence of the Natura 2000 network or not.

4.2 Terminology related to ecosystem, ecosystem processes, - services and – resilience

In the context of this project, the CBD definition of an **ecosystem** as a 'dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit' is used. In general, the boundaries of an ecosystem are defined by the dynamic interactions, sometimes termed **ecosystem processes**, between the components of an ecosystem (i.e. plants, wildlife, climate, landforms and human activities). The ecosystem boundaries are irrespective of scale or location for ecosystem processes occur at a multitude of scales. Therefore, finding the actual boundaries between ecosystems can be difficult. Generally ecologists take a pragmatic approach that looks for assemblages of strong links between components within an ecosystem compared to weak interactions with components outside them. As biodiversity relates to the sum of the variability both within/between species (e.g. genetic) and between ecosystems, it can be seen as a key structural feature of ecosystems (see below) (MEA 2005).

Generally the starting point for studying an ecosystem comes from its **structure**, i.e from the organisation and composition of ecosystem's components. The structure of an ecosystem is extremely important for its function (de Groot et al 2002). There is considerable variation between the roles of species and functional units (e.g. groups of species performing similar functions) within an ecosystem, which can also change between habitats and ecosystems.

Much of the complexity of an ecosystem (its structure and processes) can be reduced to contain a number of ecosystem **functions**, each of which represents the sum total of the processes within one particular system. A definition of an ecosystem function is 'the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly' (de Groot et al 2002). Based on this definition, de Groot et al (2002) broadly group these functions into four categories: 1) regulation, 2) habitat, 3) production and 4) information. It is important to remember that the functions themselves do not need to convey direct or even indirect benefits or value to humans. Sustained ecosystem processes and functions are necessary for the production of ecosystem services whether or not we value, or even understand, these processes and functions.

Out of this group of ecosystem functions, a set of **ecosystem services** which have observable benefits to human society can be identified. Early references to the concept of ecosystem functions, services and their economic value date back to the mid-1960s and early 1970s. However, the concept of ecosystem services (also referred to as nature's services or ecosystem/nature goods and services) became widely used only in the 1990s (see for example Daily 1997, Costanza et al. 1997, Pimentel and Wilson 1997, Daily et al. 2000). The definition of what is a service is anthropocentric and based on their value to humans (de Groot et al 2002). The Millennium Ecosystem Assessment (MEA 2005) developed a list of ecosystem services which include the functions identified by de Groot et al (2002), but focuses on their anthropogenic role. The MEA definition of ecosystem services divides the services into four different categories, including provisioning, regulating, cultural and supporting services (See Table 1 for more information). In the context of this study the recent definition provided by MEA will be used.

Biodiversity represents the sum of variation in genes, species and ecosystems (MEA 2005). This includes the variation found within species and also the interactions between different species and assemblages. As such biodiversity underpins the provision of all ecosystem services. In this context, the key feature of biodiversity is the functional relationships between species within an ecosystem. Within an ecosystem there maybe several species, or assemblages, that perform similar functions, such as nitrogen fixation. The loss of one of these species may be deemed as acceptable as other species can perform the same function and therefore there is redundancy in the system. Conversely there will be some species that have a key function within the ecosystem and their loss will have highly deleterious effects. With greater redundancy there is a greater 'insurance' that an ecosystem can function in the face of change. Therefore, although most current measures of biodiversity assess species richness, understanding the role of biodiversity within ecosystems (e.g. in providing ecosystem services) requires data on trophic relations between species, functional traits, abundance, distribution etc. Much of this information is lacking and as yet, there have been few studies into the relationship between biodiversity, ecosystem services and human wellbeing (MEA 2005).

This brings us to the concept of **ecosystem resilience**. Resilience in this context is defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al 2004). As with many of the terms used within ecosystem studies, resilience has a broad definition. But it is one that is closely linked to the assessment of the role of biodiversity within ecosystems and the ability of ecosystems to cope with human induced impacts (e.g. habitat destruction and fragmentation). It is important to note that within an ecosystem, the capacity to buffer negative effects is not enough (**ecosystem resistance**). The ecosystem must be able to reorganize after disturbance, adapt to the new situation, and sustain important ecosystem services. A non-resilient ecosystem facing disturbance will degrade or even flip into less desirable states (Holling 2001).

The case of **invasive alien species** illustrates the importance of understanding the different components of biodiversity within an ecosystem. These are species that can exist at normal densities within their native ranges, but on introduction into a novel ecosystem can spread at fast rates usually out-competing local species. Alien species may exist at low densities in particular habitats before becoming invasive and subtle changes in the ecosystem dynamics suddenly supply the necessary conditions for the species to spread. Currently invasive alien species are identified as one of the leading causes of biodiversity loss (MEA 2005). Invasive alien species also contribute significantly to the loss of ecosystem services.

4.3 Terminology related to spatial heterogeneity of ecosystems

Much of the early ecological theory considers the areas that species occupy to be spatially ‘homogeneous’ and populations to be numerous and widespread (Wiens 2002, Rockwood 2006). This is of course not reflected in reality in either natural or human-impacted areas. The realisation that spatial variation had important consequences for populations coupled with the development of more complex theoretical tools led to the development of spatial ecology. This discipline contains both **metapopulation ecology** and **landscape ecology** (Rockwood 2006).

4.3.1 Landscape ecology and patches

The term ‘landscape’ provides one of the few anthropomorphisms to be seen in ecological theory. This branch of ecology, came from the merging of ecological concepts with geography and land use planning, and implicitly recognises human’s role in shaping ecological settings and the impact of these actions on the population dynamics of species at a broad spatial scale. As such landscapes are sometimes defined as a level or ecological organisation within regional ecosystems (i.e. **biomes**), but they can also be defined in a natural resource management sense to relate to physical spatial scales that correspond to human perceptions (Wiens 2002). However within this range of definitions, two central concepts can be identified: a landscape is made up of discrete elements, and the arrangement and number of these elements creates heterogeneity (Wiens 2002). Landscape ecology therefore studies the causes and consequences of spatial heterogeneity. More specifically central approaches include 1) the development and dynamics of spatial heterogeneity, 2) interactions and exchanges across heterogeneous landscapes, 3) influences of spatial heterogeneity on biotic and abiotic processes, and 4) the management of spatial heterogeneity (Turner and Gardner 1991).

The elements of a landscape are generally termed **patches** and can be defined as particulate, invariant and homogeneous entities (Dennis et al 2003), or in a more functional sense, as relatively homogeneous areas that differ from their surroundings (Forman 1995). Patches have a definite shape and spatial configuration, and can be described compositionally by internal variables such as number of trees, number of tree species, height of trees, or other similar measurements. Therefore **patch dynamics** studies the changes and fluctuations within and between patches, and **patch configuration** provides a measure of the spatial arrangement of habitat patches within a **mosaic** (i.e. the pattern of patches, corridors and matrix that forms a landscape) (Krawchuk & Taylor 2003). This spatial arrangement is important because landscape ecology proposes that this arrangement has an impact on the interactions between species both within and between patches (Wiens 2002).

Matrix (environmental / habitat matrix) is the 'background ecological system' of a landscape with a high degree of connectivity. **Connectivity** is the measure of how connected or spatially continuous a corridor, network, or matrix is (for discussion on connectivity, corridors and networks see Chapter 4). For example, a forested landscape (the matrix) with fewer gaps in forest cover (open patches) will have higher connectivity. (Forman 1995)

The underlying principles of landscape ecology have also been influence by the work of Boris Rodoman (1974) who developed a theory of landscape polarisation. This theory divided the landscape between 'anthropocentric core areas', 'buffer zones' and 'ecotones' on the one hand and large natural ecosystems on the other hand with transition zones. The theory has been the basis for a number of national ecological networks (e.g. in Estonia, Lithuania and Russia) (Bruszik et al 2006).

4.3.2 Metapopulation ecology

Before the genesis of landscape ecology, ecologists had started to study species diversity and the spatial configuration of populations and their impacts on persistence and extinction. This field of biogeography became crystallised through the work of MacArthur and Wilson (1967) and the development of theory of island biogeography. This theory proposed that the diversity of species on an island was a function of its size and its isolation from a mainland, i.e. the balance between extinction and immigration. This theory identified an equilibrium between two previously observed relationships, that between the size of an island and its species diversity, and that between the distance of an island from a mainland and its diversity.

It was quickly realised that the theoretical basis provided by MacArthur and Wilson (1967) and shown to apply on islands, could be applied to non-island settings, in particular to conservation biology. In the seventies and eighties, the declaration of reserves was the primary conservation tool. However, biologists soon acknowledged that, in some sense, reserves acted liked islands of suitable habitats within seas of human modified landscapes created by **habitat fragmentation** (see Section 4.3.4 below). This led to a long lasting debate concerning ideal reserve design and whether protected areas should be large continuous areas or several smaller areas (the so-called Single Large Or Several Small (SLOSS) debate). The recommendation that single large reserves be established was quickly entered into conservation priority setting. However, it was shown by Daniel Simberloff that the theory was neutral (favouring neither a single large nor several small) with respect to reserve design because it did not take account of either colonisation ability among species and also it assumed that all species on the island existed on the mainland (Simberloff & Abele 1982).

The concept of the **metapopulation** as a population made up of local populations being regulated by local immigration and extinction was first formalised by Levins in 1970. Since then metapopulation theory has been further developed by Hanski and Gilpin (1991, 1997). Metapopulations can be regarded as spatially separated, but interacting, populations of the same species that exists in discrete habitat patches as a result of the fragmentation of intact habitat. The metapopulation theory concludes that rather than existing as stable, homogeneous populations, species are dynamic entities that are distributed unevenly across landscapes in habitats of varying quality. (Hanski & Gilpin 1991, 1997). According to metapopulation theory, local populations are vulnerable to extinction. However, as long as individuals from other local populations can re-colonize the empty habitat, the meta-population can continue to survive.

Whereas metapopulation can refer to any spatially structured population, metapopulation dynamics focuses on the population dynamics involving spatial patterns (Rockwood 2006). Metapopulations have also been classified into a series of sub-categories: classical metapopulations, non-equilibrium metapopulations, patchy metapopulations (see Harrison 1991 for more details).

This basic understanding of how populations could be structured in a spatially heterogeneous landscape was quickly adopted by conservation biologists and now forms the underpinning for most work on species threatened by habitat fragmentation. The insights given by metapopulation theory have led to conclude that habitat fragmentation increases the vulnerability of species populations by reducing the area of habitat available to local populations and limiting the opportunities for dispersal, migration and genetic exchange. There is now a solid evidence base for the existence of metapopulations, although it primarily comes from short-lived easily monitored species, for example butterflies (Hanski 1999, Ehrlich & Hanski 2004).

4.3.3 Habitat fragmentation

Fragmentation has been currently recognised as one of the main threats to biodiversity. Fragmentation is a cause of major ecosystem perturbation that can lead to a number of changes within ecosystems, e.g. changes in species composition, community structure, population dynamics and a range of ecological and ecosystem processes (see Donald 2005). Wildlife communities in habitat fragments have been shown by many studies to be less species rich than those in large continuous blocks, and to be more likely to suffer extinctions through a number of different mechanisms. This effect increases with increasing isolation from other blocks of similar habitat. Consequently, in the context of ecological networks (see Section 4.4.3 below) fragmentation of landscape/ecosystems (in particular outside core protected areas) can be seen as a threat to the coherence of / connectivity within the network.

The Habitats and Birds directives do not include a reference to fragmentation, however fragmentation has been identified as one of the main threats to biodiversity by a number of relevant EU policy documents, e.g. EU Biodiversity Strategy (COM (1998)42), Message from Malahide[8], Commission's Biodiversity Communication and Action Plan[9] and EU Forestry Action Plan (COM(2006)302). Similarly, the negative effects of fragmentation have been recognised at both international and national levels

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[8] Duke, Guy (ed.) (2005) Biodiversity and the EU – Sustaining Life, Sustaining Livelihoods. Conference Report. Stakeholder Conference held under the Irish Presidency of The European Union in partnership with the European Commission, 25th - 27th May 2004, Grand Hotel, Malahide, Ireland. http://ec.europa.eu/environment/nature/biodiversity/develop_biodiversity_policy/malahide_conference/index_en.htm

[9] Commission Communication on Halting the Loss of Biodiversity by 2010 and Beyond (COM(2006)216)

(e.g. CBD, Millennium Ecosystem Assessment (2005) and national biodiversity strategies).

In general, fragmentation can be defined as 'the breaking up of extensive landscape features into disjunct, isolated, or semi-isolated patches as a result of land-use changes' (Fahring 2003). According to recent scientific knowledge, fragmentation can be seen to encompass two components: the loss of habitat and the breaking up of the remaining habitat into smaller units (i.e. habitat fragmentation) (e.g. Fahring 2003, Donald 2005). As regards the two components, habitat loss has large and consistently negative effects on biodiversity whereas the effects of habitat fragmentation are often diffuse.

It is suggested that in the context of this study the term 'fragmentation' would be used to refer to the two above mentioned components. When specifically referring to only of these components terms 'habitat loss' and 'habitat fragmentation' would be used.

4.4 Concepts related to conservation and management responses

The above sections discussed the theoretical basis that has developed through community ecology over the past forty years and that are now applied within conservation biology and landscape ecology to the management and protection of habitats and species, including establishment of ecological networks. This section reviews some of the terms and their definitions related to the conservation measures that are based on these theories.

4.4.1 Ecological coherence

Ecological coherence is a term that is found within the applied and policy literature. However, there is no general definition for this term. In the context of Natura 2000, Ssymank et al (2006) provide a definition of ecological coherence as 'the sufficient representation (patch quality, total patch area, patch configuration, landscape permeability) of habitats/species to ensure favourable conservation status of habitats and species across their whole natural range'.

In general, Ssymank et al (2006) discuss that coherence has to the considered on a species by species and habitat by habitat basis. The concept of coherence builds strongly on the theoretical basis provided by metapopulation theory and landscape ecology. Approaches to monitor and enhance coherence should focus on **functional** and **physical connectivity** (see below).

Coherence is often used in relation to the establishment of ecological networks and references to 'coherent ecological networks' can be found in several legal and policy-related contexts, including international/regional biodiversity related agreements (e.g. Ramsar Convention, the Convention on Migratory Species and the Bern Convention) and EU legislation and policy (Habitats and Birds directives, Message from

Malahide[8], Commission's Biodiversity Communication and Action Plan[10]). The CBD[11] does not have a specific reference to 'coherence'. However, in the context of the Convention the aspects related to coherence are addressed by emphasising that protected areas should be connected to their broader landscapes taking into account ecological connectivity.

4.4.2 Connectivity

Connectivity can be seen as a characteristic of an ecosystem/landscape that facilitates (or impedes) the movement of organisms within ecological networks (see for example Crooks & Sanjayan 2006). In other words, connectivity plays an important role in ensuring networks' ecological coherence. In general, three different types of connectivity, namely structural and functional- and landscape connectivity, can be distinguished (see for example Tischendorf & Fahrig 2000). **Structural connectivity** is equal to habitat continuity. Habitat continuity can be defined as permanent and long term stock of all necessary habitat requirements for an organism within a given landscape/ecosystem, including dynamic and spatial habitat mosaics. In principle, structural connectivity is measured by analysing physical landscape structures independent of any attributes of organisms inhabiting/using the ecosystem. **Functional connectivity,** on the other hand, is the response of an organism to the landscape elements other than its habitats (i.e. so called non-habitat matrix, see Table 1). In summary, structural connectivity concentrates on the availability of suitable habitats within a landscape whereas functional connectivity considers the behavioural responses of an organism to the various elements of its landscape, including habitats and non-habitats. Finally, **landscape connectivity** is the general degree to which the landscape facilitates or impedes movement among resource patches. Consequently, landscape connectivity can be seen as a combined effect of structural and functional connectivity.

In the context of ecological networks (see Section 4.4.3 below), **ecological corridors** are the components used to provide structural connectivity within the network (see for example Hilty et al 2006 and references in Table 1). Ecological corridors are not necessarily linear features, but can be grouped in several ways according to, for example, their shapes (diffuse, belt-like, line-like etc), structure (continuous or interrupted like **stepping stones**) and services they provide (migration- commuting-, or dispersal corridors). The function of ecological corridors is to structurally connect a number of otherwise non-connected habitat patches. In general, they serve to maintain vital ecological or environmental connections by providing physical (though not necessarily linear) linkages between the core areas. The ecological functions of corridors and stepping stones are to enable species dispersal, migration, foraging and reproduction. The ability of ecological corridors to carry out these functions (ie to ensure functional connectivity), however, has been questioned (see for example Simberloff & Cox 1987, Beier & Noss 1998, Simberloff et al 1992).

[10] Halting the loss of biodiversity by 2010 – and beyond. Sustaining ecosystem services for human well–being (COM 2006/216)

[11] E.g. Article 8 of the Convention, CBD programme of work on protected areas

In terms of functional connectivity, the term '**landscape permeability**' is used to describe the quality of a heterogeneous land area (outside core areas) to provide for the passage of organisms. In contrast to focusing on the identification of corridors or connected habitat patches, landscape permeability considers more broadly the resistance a landscape provides to the movement of organisms and aims to provide a consistent estimate of the relative potential for organisms' passage across entire landscapes.

4.4.3 Ecological networks

Ecological networks are considered as one of the main measures enhancing ecological coherence and connectivity between protected areas and within landscapes. In general, the application of ecological networks in biodiversity conservation is strongly based on landscape and metapopulation ecology. Based on the review, ecological networks can be best defined based on their objective as 'coherent systems of natural and/or semi-natural landscape elements that are configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity while also providing appropriate opportunities for the sustainable use of natural resources' (Bennett 2004). Ecological networks are, therefore, a tool to support the maintenance, restoration or reestablishment of functional ecological relations between different elements of a landscape (Finck & Riecken 2001, Riecken et al. 2004) (See Table 1 for further details).

Typically ecological networks are implemented through a planning approach that identifies core areas (protected areas), buffer zones of mixed landuse and connective structures that enable the movement of organisms between core areas (e.g. ecological corridors and/or permeable landscapes) (Bruszik et al 2006, Bennett 2004).

It can be concluded, that differences in defining ecological networks arise when implementing the concept at national / regional level (e.g. Bruszik et al 2006). In particular, there is variation in approaches adopted to obtain connectivity within networks.

4.4.4 Application of different coherence and connectivity related definitions

In a scientific setting, different definitions of connectivity are associated with different ecological approaches. For example, structural connectivity is most often used to define connectivity in the framework of metapopulation theory (see Table 1) and when trying to assess the dynamics of fragmented populations in heterogeneous landscapes. Functional connectivity, on the other hand, is most commonly used in the context of landscape ecology. However it has to be recognised that it is difficult to describe connectivity in any form without taking the species that might use it into account. Measures used to promote connectivity for one species group may act as barriers to migration for others. Alternatively such measures can open new pathways for the movement of alien species or pathogens. Thus efforts to promote structural connectivity may not increase functional connectivity. On the other hand, noncontiguous habitat patches may sometimes be functionally connected. Therefore, more complex scientific approaches combining structural and functional connectivity are currently called for.

The review reveals that in the legal and policy context (e.g. international, European and national) the term ‘connectivity’ has traditionally been used in reference to structural connectivity (i.e. ecological corridors and stepping stones). For example, the connectivity related references in the Habitats directive clearly refers to structural features, eg linear and continuous structure and stepping stones. The ‘structure based’ approach to connectivity has also been adopted by the majority of individual EU Member states (see Bruszik et al 2006).

Aspects related functional connectivity and landscape permeability have only recently been taken more into consideration. In this context, the Commission’s Biodiversity Communication from May 2006[10] recognises that in addition to ‘structural tools’, such as flyways, stepping stone and corridors, enhancing the coherence of the Natura 2000 network involves ‘*enhancing the ability of the wider environmental matrix’* (page 53 of the impact assessment, Annex to the Communication). Consequently, the current Community approach seems to take into account both the structural and functional aspects of connectivity. At the national level, only the UK has so far adopted functional connectivity and landscape permeability as an integral part of its ecological network–approach.

It is suggested that in the context of this study both the structural and functional aspects of connectivity should be taken into account. Through out the study the term ‘connectivity’ will be systematically defined using the definitions provided above.

5 CONCLUSIONS

Based on the review, the terminology currently used at international, European and national level in the context of climate change adaptation and habitat fragmentation is quite similar. As could be expected, the related scientific terminology is more complex and versatile than the terms used in legal and policy settings. In the policy context, of climate change adaptation and habitat fragmentation is still mainly addressed as a part of the biodiversity policy and references to these issues (eg ecological networks, coherence and connectivity) were generally absent in other relevant policy documents such as climate change policy and rural development.

As regards the definition of terms, the review revealed that the definition and classification of individual terms varied widely depending on the source. However, it could be concluded that in the majority of the cases these variations were more related to different nuances in the description than the actual 'substance' of the term. Additionally, in several cases the terms were used without providing any particular definition (e.g. common ecological terminology).

For some key terms substantial differences between existing definitions could be identified. In particular, the definition of '*connectivity'* seemed to have developed during the last years to include/consider both structural and functional aspects. Additionally, according to latest scientific understanding '*fragmentation*' could be considered a combined effect of habitat loss and habitat fragmentation whereas in the past the term has been mainly used to refer only to the latter component.

One somewhat significant inconsistency between terms and definitions used in scientific and legal/policy settings could be detected. Based on the Article 10 of the Habitats directive, connectivity within the Natura 2000 network is defined along the lines of structural connectivity. According to current scientific knowledge, however, both structural and functional aspects of connectivity should be considered when establishing coherent ecological networks. Even though the Directive does not exclude the functional characteristics of connectivity as such, it provides no particular reference to these aspects.

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