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CONTENTS

1 Introduction

Extending from the Barents Sea to the Baltic Sea, the Green Belt of Fennoscandia (GBF) forms an ecological network located in the territory of three neighbouring countries: Finland, Norway and Russia. The core of the GBF consists of the established and planned protected areas along the border areas. The GBF is the northernmost part of the European Green Belt, a Pan-European ecological network that connects the Barents region to the Balkans. A Memorandum of Understanding between Finland, Norway and Russia was signed in 2010 to facilitate sustainable trans-boundary co-operation and development considering the GBF.

The GBF has the potential to become an international model area of successful cross-border nature conservation. Lots of valuable information exists on the protected areas and their biodiversity that can be used for the further development of the conservation area network. The core structure of the GBF consists of the conservation sites and other high value nature areas. In order to safeguard biodiversity, also other parts of the green infrastructure such as the areas between the protected areas are of a high importance. In addition to its conservation value, the GBF is valuable for the provision of many ecosystem services on a local, regional and global scale. The region provides many possibilities also for sustainable economic activities – especially for tourism where the local nature and local cultures play a vital role in attracting visitors into the area.

The ecosystem service approach provides a framework for observing multiple natural resources in a holistic way. A holistic approach is needed in order to supplement the existing knowledge base on the green infrastructure of the region. A broader knowledge base enables the development of the GBF as a whole so that the multiple social, economic and ecological benefits are accessible to people in and around the border zone. For example, sustainable industrial and commercial activities can be developed while safeguarding biodiversity and the multiple ecosystem services within the region.

Multiple aspects of the Green Belt of Fennoscandia can be studied with the help of spatially explicit data, geographic information systems (GIS) and related methods. Scientific knowledge in this field of study is continuously increasing, and there is currently no single established method for the study of ecosystem services and connectivity. The choice of method is affected by the scale of observation, the goals and information requirements of a specific project, and most restrictively by data availability. In order to deliver a concise assessment of the whole Green Belt of Fennoscandia, consistent data of sufficient quality is needed across the whole study area. In addition, to conduct a good quality assessment of the GBF, international cooperation among different organizations and experts is needed.

The goal of this study is to give insight on the existing and suitable sources of spatial data and the appropriate methods for analysing ecosystem services of the GBF and the connectivity of the protected area network. In addition, recommendations are given

and a suggestive outline is drafted for a full scale assessment of the whole region. In Section 2 of this report, the concepts of ecosystem services and connectivity are introduced and suitable methods for analysing ecosystem services and connectivity are reviewed. In Section 3, sources of spatial data are specified. Section 4 contains recommendations for suitable data and methods for analysing the connectivity and ecosystem services of the Green Belt of Fennoscandia.

2 Methods for assessing ecosystem services and connectivity

In this part, the concepts of 1) ecosystem services and 2) connectivity are clarified and appropriate existing methods for assessing these aspects of the GBF are reviewed. The review is based on results from recent reports and relevant scientific literature. Based on the results of this part, further recommendations for the most suitable methods for assessing the GBF are made in the concluding section of this report.

2.1 Ecosystem services – concepts and definitions

Ecosystem services are the various direct and indirect contributions to human well-being by ecosystems. According to the Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin, 2013), there are three broad categories of ecosystem services: *provisioning services, regulating and maintenance services and cultural ecosystem services.* Provisioning services are the tangible material goods that ecosystems provide, such as food, water and raw materials. Regulating and maintenance services refer to ecosystem processes that are crucial for human life and well-being: carbon sequestration, water cycle and pollination, for example. Cultural ecosystem services are immaterial and experiential by nature – they provide mental, psychological, spiritual, religious, or some other form of satisfaction through physical activity and/or sensory experiences. Since the Millennium Ecosystem Assessment (MA, 2005) several classifications for ecosystem services have been presented. At the moment, the Common International Classification of Ecosystem Services (CICES) developed for the natural capital accounting in EU Member States is widely used in Europe (Table 1).

The ecosystem service cascade model (Haines-Young and Potschin, 2010) is a schematic illustration of how ecosystem services are produced and how the benefits "flow" to people. Figure 1 is based on the five elements of the cascade model: ecosystem structure (in the figure: biodiversity), functions, services, benefits (human well-being), and values. The first two components relate to the supply of ecosystem services, while the last two components are linked to the demand for ecosystem services by people and the society. The ecosystem structure refers to all ecosystems and is thus closely related with the concept of green infrastructure.

Green infrastructure is the network of natural and semi-natural areas, features and green spaces in rural and urban, terrestrial, freshwater, coastal and marine areas, which together enhance ecosystem health and resilience, contribute to biodiversity conservation and benefit human populations through the maintenance and enhancement of ecosystem services (Naumann et al., 2011). In addition, it can be regarded as a conceptual tool for developing a strategically planned network of the

above-mentioned components, specifically designed and managed to deliver a wide range of ecosystem services (European Commission, 2013). In contrast to usually single-purpose grey infrastructure, green infrastructure can offer several benefits simultaneously, that is, it is multifunctional.

Table 1. Ecosystem Services[a]

Section	Ecosystem services group
Provisioning	Agricultural and aquacultural products
	Wild plants, animals and their outputs
	Surface and ground water for drinking
	Surface and ground water for non-drinking purposes
	Materials from plants, algae and animals and genetic materials from all biota
	Biomass-based energy sources (and animal-based mechanical energy)
Regulating and maintenance	Mediation of waste and toxics
	Mediation of smell, noise and visual impacts
	Mass stabilization and control of erosion rates, buffering and attenuation of mass flows
	Hydrological cycle and flood protection
	Mediation of air flows
	Pollination and seed dispersal
	Maintenance of nursery populations and habitats, gene pool protection
	Pest and disease control
	Soil formation and composition
	Maintenance of chemical condition of waters
	Global climate regulation
	Micro and regional climate regulation
Cultural	Recreational use of nature
	Nature as a site and subject matter for research and of education
	Aesthetics and cultural heritage
	Spiritual, sacred, symbolic or emblematic meanings of nature
	Existence and bequest values of nature

[a]Modified from the Common International Classification of Ecosystem Services (CICES) v.4.3 (Haines-Young and Potschin, 2013) by Itkonen & Kopperoinen.

Biodiversity is often valued and protected for its own sake; it has an intrinsic value. The ecosystem service approach takes into account humans and their needs by pointing out the benefits that ecosystems provide for people. Safeguarding biodiversity is seen as crucial for ecosystem resilience and the sustained flow of ecosystem services. However, also areas having lower biodiversity provide ecosystem services, as not all services necessarily depend on diversity of species and biotopes. For example, pervious land surface need not be rich in biodiversity to be able to infiltrate water. All in all, this does not mean that the importance of protecting and enhancing biodiversity in different ecosystems should be neglected. There is no knowledge on a minimum level of biodiversity which would ensure long-term functioning of ecosystems. More diverse ecosystems are more resilient and therefore have better adaptive capacity when facing disturbance and change caused by nature itself or people.

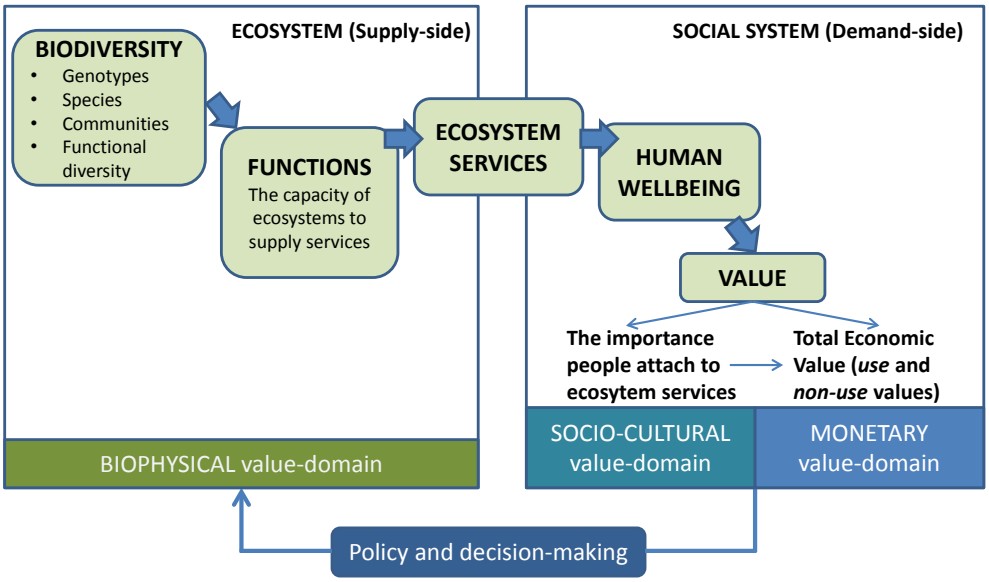

Figure 1. Methodological framework for assessing ecosystem services (Martín-López et al., 2014, p.222).

2.2

Analyzing the supply of ecosystem services

Ecosystem service provision potential means the perceived potential of an area to produce ecosystem services (Kopperoinen et al., 2014). A close concept of *potential supply of ecosystem services,* on the other hand, has been used as a synonym for the hypothetical maximum yield of selected ecosystem services. The pure word *supply of ecosystem services* has referred to the quantified actual used set of ecosystem services (Burkhard et al., 2012) or to *actual provision* which means that part of ecosystem service provision which is used or can be made use of (Kopperoinen et al., 2014). All the above-mentioned concepts have to be separated from *sustainable supply of ecosystem services,* which is that amount of ecosystem services which can be benefited from sustainably, not exceeding the limits that would lead to deterioration of the ecosystem and a diminishing flow of benefits.

Various methods to assess and map the ecosystem service provision have been developed. Quantification of ecosystem service supply is usually based on some kind of a model, such as carbon sequestration models (e.g. soil carbon model Yasso). Other examples of software and model assemblages for assessing the supply and/or benefits of selected ecosystem services are InVEST (http://www.naturalcapitalproject.org/InVEST.html), ARIES (http://www.ariesonline.org/about/approach.html), and TESSA toolkit (http://www.birdlife.org/worldwide/ science/assessing-ecosystem-services-tessa).

Quantifying the supply of all ecosystem services is extremely laborious and time consuming, which has led to the development of other more easily applicable methods for practical use. Such methods include various matrix-type methods based on expert scoring of land use and land cover data (e.g. Burkhard et al., 2009), biotope data (Vihervaara et al., 2012), or a wide spectrum of spatial datasets (Kopperoinen et al., 2014) according to their potential to describe the relative ecosystem service provision potential. These methods are relatively straightforward to use, and experience has shown that they can produce valid results. It has to be acknowledged, however, that in order to ensure the applicability and validity of the results, compiling and

synthesizing the required expert input usually requires considerable effort, such as organizing multiple expert and stakeholder workshops. However, the benefits of these interactive workshops extend beyond mere acquisition of input parameters for the analyses: using participatory methods coupled with expert scoring enables knowledge exchange and important interaction – both between researchers and stakeholders, and between different stakeholders (Kopperoinen et al., 2014).

GreenFrame

GreenFrame is a semi-quantitative place-based method for detecting key areas of green infrastructure based on their provision potential of various ecosystem services (Kopperoinen et al., 2014). In this context, provision potential means the perceived potential of an area to support the supply of ecosystem services. Areas with high provision potential have qualities that provide a good base for producing specified ecosystem services. GreenFrame has been developed at the Finnish Environmental Institute (SYKE) to serve as an operational and transparent tool for supporting land use planning at different scales.

Any classification of ecosystem services can be used when applying matrix approaches, such as GreenFrame. In recent studies, the sections and groups of ecosystem services of the Common International Classification of Ecosystem Services (CICES) have been used as a basis. In GreenFrame, the three sections of ecosystem services in the CICES – (1) provisioning services, (2) regulation and maintenance services and (3) cultural services – are further divided into a set of ecosystem service groups.

GreenFrame focuses on identifying spatial differences in the provision potential of ecosystem services based on spatially explicit datasets and expert assessments. The input data for the analysis can consist of both quantitative and qualitative datasets. Spatial data on the provision potential of intangible ecosystem services – such as various regulation and maintenance services and cultural ecosystem services – is often insufficient or missing. In matrix approaches such as GreenFrame, this information is derived from related thematic datasets and supporting expert assessments. Qualitative assessments are complemented with quantitative spatial data if such data exists. Quantitative data is more often available for provisioning services, such as timber volume.

The output maps allow ecosystem services to be observed one by one across the study area, or holistically as syntheses of bundles of ecosystem services. The provision potential of each individual ecosystem service is scaled to a common range [0-1], with value 0 representing the locations within the study area where the relative provision potential for the given ecosystem service is lowest. Similarly, value 1 represents the locations having the highest potential within the study region, and accordingly the values between 0 and 1 are determined in respect to each location's relative provision potential. Different weights can also be given to selected ecosystem services, or certain ecosystem services can even be omitted from the output, if desired.

2.3

Analyzing the demand for ecosystem services

The demand for ecosystem services has been defined as *the sum of all ecosystem goods and services currently consumed or used in a particular area over a given time period* (Burkhard et al., 2012). In some cases this can be called *actual demand*, but not always. In the case of a shortage of availability of a certain ecosystem service (i.e. shortage of supply), the sum of consumed ecosystem services shows only what is actually consumed, although there is a chance of greater demand that cannot be met. An extreme example of such a case could be an area where there is not enough food to meet the needs of a population; the amount of consumed food does not reflect the *actual demand* for food. Thus, food (end product of a provisioning service) needs to be imported to the area from elsewhere.

For the expected or required level of ecosystem service delivery, demand can be defined according to the *environmental standards* (Baró et al. manuscript). Using this definition, *expected demand* is the minimum amount of produced ecosystem service to reach those standards. This definition applies to non-transferrable ecosystem services, such as urban temperature regulation, which cannot be outsourced. We can also assess *potential demand* which is estimated based on, for example, the number of population within a certain distance from ecosystem service-producing areas, like in the case of recreation.

Based on all the above-mentioned aspects, a general definition for the demand for ecosystem services is simply "the amount of service required or desired by society".

Assessment and mapping of ecosystem service demand is important for the sake of the sustainable use of ecosystems and their services. The level of consumption, that is, the realized demand for ecosystem services, cannot exceed the sustainable level of supply without affecting the state and resilience of an ecosystem. Mapping both the supply and demand helps in balancing them. It is also crucial for managing ecosystem services. This can, for example, help in detecting areas where restoration is needed to meet a high demand for a specific ecosystem service or a bundle of them. Restoration may involve building new green infrastructure where, for example, there is need for better flood regulation or access to recreation in green spaces.

However, localizing the demand for ecosystem services can be troublesome, and even irrelevant, in some cases. For example, from the perspective of global climate regulation, there is an equal need for carbon sequestration in all areas. For many provisioning services (such as food production and timber) proximity is desirable, but not indispensable – the global markets, production and transport chains make it possible for us to consume also nondomestic provisioning services. Most regulation and maintenance services have regional importance, but mapping the spatial variation in their demand can be quite problematic.

Socio-cultural preferences are closely related to ecosystem service demand. Therefore, various participatory methods to assess and map such preferences have been developed. Methods applied in a group setting are called deliberative; they involve interaction between participants that are present, which influences the outcome. A mapping workshop to collect expert knowledge from local stakeholders and researchers is an example of deliberative methods. The participants can identify on printed or in digital maps, for example, the location and status of various ecosystem services and trends in their use, and the beneficiaries and flows (Palomo et al., 2013).

Lately, the use of public participatory GIS (PPGIS) methods via the Internet has gained popularity in assessing the demand for ecosystem services (see e.g. http://www.landscapevalues.org/) (Brown and Kyttä, 2014). Several platforms to set up a survey questionnaire with maps are available (e.g. http://maptionnaire.com/; https://www.eharava.fi/en/aboutharava/createasurvey/). The benefit of PPGIS is the large

volume of observations in terms of the number of people that can be reached, as well as the number of markers placed on maps. The PPGIS method is especially suitable for getting perceptional or experiential knowledge related to the use or need for ecosystem services (valued places, places of conflicts, areas needing development, etc.). However, when using deliberative and participatory mapping methods, it has to be noted that the locations marked on the maps do not reflect only the demand for ecosystem services. For example, the respondents may mark locations where they can actually consume or benefit from a given ecosystem service. In such case, not only the demand, but also the supply is located. In addition, the marked locations of ecosystem service consumption do not necessarily reveal all aspects and locations of ecosystem service demand. Therefore, the design of a PPGIS survey or a deliberative workshop determines the extent to which the supply and/or demand for ecosystem services are covered.

Mapping the demand for ecosystem services can also be approached by using matrix-based methods, similarly to the supply (e.g. Burkhard et al., 2012). In these approaches, the relative values for the demand matrices can be derived inter alia from statistics (e.g. Kroll et al., 2012), modeling or interviews, and then allocated to certain land cover types. However, statistical data or appropriate models are not available for all ecosystem services.

Potential demand for ecosystem services can also be evaluated by analyzing accessibility to different parts of green and blue infrastructure of varying quality. A simple, indicative analysis of spatial accessibility can be based on calculating Euclidian distances from roads or urban centers, for example. An example of a more sophisticated approach is to combine estimates on travel times via the road network with the spatial distribution of a population. These approaches can also be used when estimating the spatial distribution of immediate population pressure from the surrounding areas providing ecosystem services. Accessibility involves other aspects as well, such as land use ownership and the status of the area in question, which might restrict its use. In Finland, everyman's rights offer people a unique opportunity to enjoy nature independent of who owns the land (with exceptions, such as areas governed by the Finnish Defence Forces).

The analyses of accessibility and proximity of areas providing ecosystem services, combined with information on the spatial distribution of a population, can be used in estimating the local and regional aspects of ecosystem service demand. However, as noted above, the relevance of spatial assessments depends on the scale and the given ecosystem service. In the land use planning context, it is useful to map the spatial variation in the residents' demand for daily use of cultural ecosystem services, such as aesthetics and recreation – based on the location of their residence in relation to areas providing these ecosystem services. Also nature tourism is heavily reliant on the same exact cultural ecosystem services, but the significance of mapping the variation in their demand on the scale of international tourism is questionable.

2.4

Connectivity – concepts and definitions

A well-connected landscape facilitates the movement of animals and other ecological flows maintaining viable populations and safeguarding biodiversity. Changes in landscape structure reduce connectivity and possibly threaten the viability of species (Fischer and Lindenmayer, 2007) and lower landscape scale resilience, which is the ability of the system to cope with disturbance and to maintain key processes (Carpenter et al., 2001). Connectivity of the landscape promotes the provision potential of many ecosystem services, as connectivity is fundamentally linked to the ecological processes providing these services (Mitchell et al., 2013).

On a global scale, landscape modification and landscape fragmentation are recognized as significant threats to biodiversity (Fischer and Lindenmayer, 2007). The degree of fragmentation (patch size and connectedness) has been found to be an important factor determining species survival and distributions. By drawing on the equilibrium theory of island biogeography (MacArthur and Wilson, 1967) and the metapopulation theory (Hanski, 1999), it can be seen that the viability of a population within an 'island' or a habitat patch depends on its size and migration possibilities. In practice, maintaining and increasing connectivity between natural and semi-natural areas can be used as a practical planning and management tool for safeguarding and restoring biodiversity.

Structural connectivity and functional connectivity

In landscape ecology, *landscape connectivity* is defined as "the degree to which the landscape facilitates or impedes movement among resource patches" (Moilanen, 2007). Both biotic (the movement of animals and other organisms) and abiotic (e.g. the flow of water and nutrients) movements are included in this definition. Connectivity can be evaluated both in structural and functional terms (Uezu et al., 2005):

- *Structural connectivity* describes the physical composition and configuration of the landscape; for example, the size of habitat patches, distance between the patches and the existence of corridors.
- *Functional connectivity* considers the movement of organisms and matter as a response to the structure of the landscape.

Structural connectivity as such does not automatically signify actual functional connectivity, which limits the interpretability of observable landscape patterns. However, the mapping of physical connections provides a base for analyzing the dispersal and movement needs of certain species and gives applicable information for land use management and planning (Vogt et al., 2007).

Functional connectivity can be further divided into *potential connectivity* and *actual connectivity* for measuring connectivity (Calabrese and Fagan, 2004). Potential connectivity can be measured by combining the physical attributes of a landscape with limited data on species dispersal based on which connectivity can be predicted. For example, different dispersal thresholds can be included in the analysis for representing the potential movement possibilities of groups of species. Actual connectivity describes the observable movement and flows providing a concrete estimate of the connectedness of the landscape. Information on actual connectivity of multiple species across large regions is often limited.

Species-oriented and pattern-oriented approaches

There are different analytical frameworks for analyzing connectivity and the effect of landscape modification on species and assemblages in a landscape: 1) species-oriented and 2) pattern-oriented approaches (Fischer and Lindenmayer, 2007). *Species-oriented approaches* focus on individual species' responses and needs towards the environment. The challenge is to include every single species in the analysis when studying landscape-scale connectivity. In *pattern-oriented approaches* the focus is on landscape patterns (perceived by humans) that correlate with measures of species occurrence. The risk with pattern-oriented analysis is the oversimplification of complex ecological causalities.

Habitat connectivity, landscape connectivity and ecological connectivity

For conceptual clarity at different scales, the concepts of *habitat connectivity*, *landscape connectivity*, and *ecological connectivity* can be identified (Fischer and Lindenmayer, 2007). Habitat connectivity is a species-specific notion of connectivity with the focus on the connectedness of habitat for a given species. Landscape connectivity is a pattern-oriented understanding of the connectedness of native vegetation cover in a given landscape. Ecological connectivity refers to the connectedness of ecological processes (e.g. hydro-ecological flows and trophic relationships) at different scales (Fischer and Lindenmayer, 2007). Landscape connectivity (the observed vegetation cover) translates into habitat connectivity for some but not all species, and for some but not all ecological processes (Figure 2).

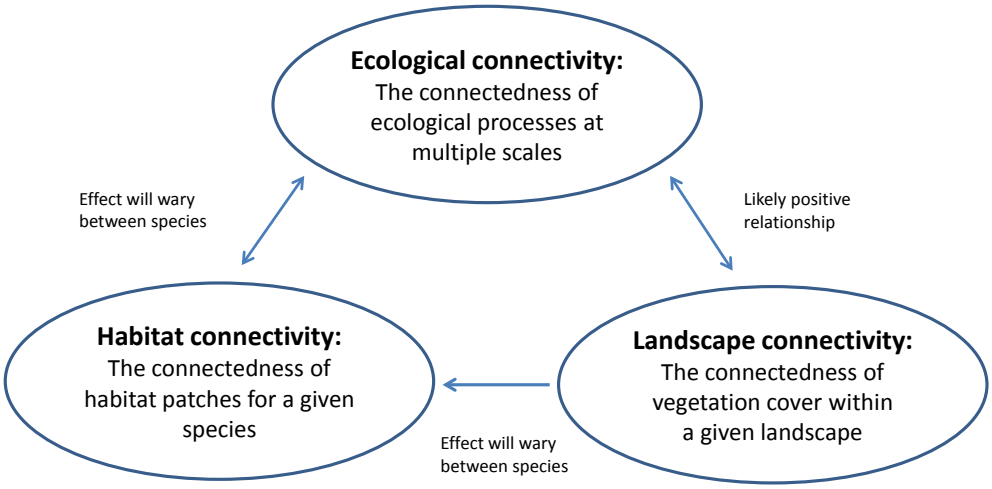

Figure 2. The relationship between three different connectivity concepts: 1) Habitat connectivity (single species perspective), 2) landscape connectivity (human-perceived patterns) and 3) ecological connectivity (ecosystem perspective). Modified from Fischer and Lindenmayer (2007).

Landscape modification and habitat fragmentation

Habitat fragmentation is a process where continuous and connected habitat areas are transformed into a set of separated, more isolated smaller patches. The process of fragmentation has three main components: 1) an overall loss of habitat in the landscape, 2) reduction in the size of remnant habitat patches, and 3) increased isolation of habitats (Bennett, 1998).

Fragmentation is usually the result of human modification of land, such as the expansion of urbanized and agricultural areas and transportation networks. As opposed to a connected landscape, a fragmented landscape is marked with a strong contrast between areas of native vegetation and their surroundings. Consequently, fragmentation also increases the number of habitat edges between different land cover types (Fischer and Lindenmayer, 2007).

Edge effects

In a modified (fragmented) landscape, an abrupt change (an 'edge') between two habitat types can have a significant influence on the habitat up to a certain degree of penetration. *Edge effects* are processes that change the environmental conditions and survival possibilities for species on and near the transition zone of two contrasting habitats (Murcia, 1995). For example, in a forest, the presence of an edge increases the number of light, wind and entry points into the forest. The response of species to habitat edges together with the suitability of human-modified habitats affect the survival of species in modified landscapes (Zurita et al., 2012). Different factors enhance edge effects in a landscape, such as high contrast in the vegetation structure, high wind speeds and temperature gradients, and the presence of invasive species that benefit from the presence of an abrupt change in vegetation (Fischer and Lindenmayer, 2007).

Core areas and connections in the ecological network

Core areas (large continuous areas of natural vegetation that provide suitable habitat for many species) are the most integral part of an ecological network in a landscape. Continuous corridors or discrete stepping stones facilitate the movement of species between habitat patches and from one core area to another through a more inhospitable land use matrix.

Corridors can be either natural (such as rivers and natural riparian zones) or man-made (remnant strips of unlogged forest, farm plantations). Also disturbed habitat strips (such as railway lines, transmission line clearings) can be seen as corridors in the landscape. In the relevant literature, habitat corridors are also called 'wildlife corridors', 'dispersal corridors' and 'movement corridors' (Bennett, 1998).

Stepping stones are patches that facilitate movement from an isolated patch to another through a more inhospitable and disturbed environment. Stepping stones can be either natural habitat, such as a sequence of wetland patches, or man-made such as a chain of urban green areas. A network of large-enough stepping stones can reduce the isolation of larger habitat patches and facilitate species dispersal over long distances (Saura et al., 2014).

2.5

Analyzing connectivity – a review of methods

Measuring connectivity and the choice of method is dependent on the availability of adequate datasets at the scale of observation. There is no consensus on the most applicable connectivity metrics, and the methods differ in data requirements and potential to provide adequate information. Spatially explicit dynamic population models can be used for studying the effect of landscape patterns on species distribution and expansion. However, such explicit models are difficult to implement especially in larger-scale studies due to their intensive data requirements and analytical complexity (Calabrese and Fagan, 2004).

Following Calabrese and Fagan (2004), three different categories of connectivity metrics are reviewed below according to the level of detail they provide: structural connectivity, potential connectivity and actual connectivity.

2.5.1

Analyzing structural connectivity

Landscape metrics as proxies for connectivity

Landscape metrics aim at describing the spatial characteristics (composition and/or configuration) of a landscape. Landscape metrics are calculated based on spatially explicit datasets (map layers) at different scales ranging from individual habitat patches to land cover classes up to the level of the whole landscape. A selection of these metrics can be used as proxies for species abundance and richness, as well as species dynamics and interactions (i.e. biodiversity and connectivity).

A variety of different landscape metrics exist related to the area, edge (e.g. edge density, m/ha), and shape of a habitat patch. Also different core area metrics (core area percentage of landscape), nearest neighbour metrics (proximity index) and diversity metrics (Simpson's diversity index) can be calculated.

Landscape metrics are not often applicable as exact measures of species occurrence or connectivity, but they are nevertheless useful in assessing general impact of habitat structure on biodiversity. Often, the lack of species-specific data limits the applicability of these metrics (Levin et al., 2008). For example, nearest-neighbour measures as such have been found to be too simplistic and not suitable proxies for connectivity (Moilanen and Nieminen, 2002).

The above-mentioned landscape metrics can be computed with the FRAGSTATS software (McGarigal et al., 2012, McGarigal and Marks, 1995). FRAGSTATS is a "Spatial Pattern Analysis Program for Categorical and Continuous Maps", developed at the University of Massachusetts. The software and supporting documentation are freely available online. FRAGSTATS can also be run under ArcGIS 10.0 and earlier versions. Running FRAGSTATS under ArcGIS 10.0 requires a valid Spatial Analyst license.

Effective mesh size – a landscape metric for measuring landscape fragmentation

Effective mesh size is a landscape metric for quantifying landscape fragmentation. Effective mesh size is based on the probability that two randomly selected locations are connected within a landscape (Jaeger, 2000). Effective mesh size can be interpreted as the average area size accessible to an animal that has been randomly placed in a landscape with obstacles that restrict movement.

In order to calculate the effective mesh size, the fragmentation geometry has to be defined. Fragmentation geometry includes all elements fragmenting the landscape. Depending on the case-specific definition, these can be, for example, roads, agricultural fields and urbanized areas. The result is affected by which elements are regarded as fragmenting the landscape. Effective mesh size is useful when assessing future land use scenarios with multiple fragmenting elements included, such as roads, housing and conversion to agricultural land (Girvetz et al., 2008).

Net Landscape Ecological Potential (NLEP) & CORILIS

NLEP (Net Landscape Ecological Potential) is an indicator of ecosystem integrity developed at the European Environment Agency (EEA). Ecosystem integrity is understood as the key determinant of the potential provision of ecosystem services. In NLEP, ecosystem potential is described at the macroscale based on the following landscape characteristics (MA, 2005):

- *Vegetation potential of the territory from land cover classification datasets:* Green and non-green areas are identified with the Green Background Landscape Index (GBLI). GBLI is calculated through the aggregation of land cover classes that have been smoothened with the CORILIS methodology (see below).
- *Scientific and political value given to nature via protected sites:* Natura 2000 and other locally designated conservation areas.
- *Fragmentation by roads and railways:* Natural logarithm (ln) of the effective mesh size. The lower the effective mesh size, the higher the fragmentation.

NLEP can be implemented, for example, with the ArcGIS software (**example output map**). In a multi-temporal analysis, a decrease in the NLEP indicates degradation of the ecosystem potential, whereas an increase indicates improvement (MA, 2005).

CORILIS is a methodology for generalizing and analyzing land cover data, especially for the smoothening of the CORINE Land Cover dataset. In the context of NLEP, CORILIS is used for generating the input data layers for calculating the GBLI and assessing vegetation potential of a territory. The output is a surface with calculated intensity and probability values ranging from 0 to 100 for a given theme based on the intensity or probability calculations within a defined smoothing radius.

Morphological Spatial Pattern Analysis (MSPA)

MSPA (Morphological Spatial Pattern Analysis) is an approach for detecting and mapping corridors and physical connections between habitat patches within a forested landscape (Soille and Vogt, 2009, Vogt et al., 2007). In the output, each pixel belonging to the green structure is classified based on morphological image analysis. Nine classes can be identified including core areas, patches, transition zones, corridors, shortcuts and branches. First, a skeleton of the habitat structure is formed based on which the connecting elements are identified. With MSPA it is also possible to differentiate between relatively narrow and wide corridors through applying the method at different scales of observation.

Input data needs to be in a binary format classified into two mutually exclusive classes (e.g. protected areas or non-protected areas; or green or non-green areas). Also simulated or observed movement data can be used as an input in MSPA (see J-walk below). MSPA analysis can be applied with the Guidos software (Vogt, 2014). Guidos (Graphical User Interface for the Description of Image Objects and their Shapes) is a freeware toolbox for raster image processing and spatial pattern analysis developed at the European Commission Joint Research Center (JRC).

Landscape permeability analysis

The connectivity of protected areas can also be assessed by examining the relative ease of movement (landscape permeability, landscape transparency) or its opposite (landscape resistance) for certain species of interest. In these approaches, the landscape is usually analyzed by giving relative scores to spatial data (e.g. land cover) in terms of landscape resistance (or permeability) based on scientific literature and/or expert judgment. The resulting data can be used in determining "least-cost" corridors, that is, the optimal routes for the given species between two habitat patches (e.g. Adriaensen et al., 2003; Gurrutxaga et al., 2010; Beier et al., 2011) . It is also possible to take into account the permeability or resistance of the surrounding areas, for example, by using CORILIS smoothing of each pixel in a land cover raster (Peifer, 2009). The permeability or resistance scores may also be applied in estimating the probabilities of movement between habitat patches (see Section 2.5.2 below).

Habitat suitability and gap analysis with IDRISI Selva Land Change Modeler

IDRISI Selva is commercial software for spatial data analysis and image processing. Tools for habitat suitability and corridor mapping are included in the Land Change Modeler application of the software. According to the software website, "the Habitat Assessment panel maps areas into categories of primary and secondary habitat, primary and secondary potential corridor and unsuitable lands based on land cover and habitat suitability. The user specifies parameters such as home range size, buffer widths, and gap crossing distances within range and during dispersal." The Land Change Modeler is also available as an extension to ArcGIS 10.2 or later. The IDRISI Land Change Modeler includes interfaces to Marxan (software for conservation planning and reserve selection), and MaxEnt (software for species habitat modeling).

2.5.2 Analyzing potential connectivity

Graph-theoretical approaches

In a graph-theoretical framework, landscape is conceptualized as a network of nodes and links. Habitat patches are represented as the nodes, and movement possibilities between habitat patches are links between the nodes. The potential connectedness of the landscape elements depends on the dispersal ability of a focal species. Patches are considered connected if their properties and distance meet the given requirements, for example, a given distance threshold (Calabrese and Fagan, 2004). Two types of links exist:

- binary (a link indicates that the patches are connected or not connected)
- probabilistic (the link indicates the probability of movement between habitat patches)

Graph-theoretical approaches are useful in identifying key landscape elements for conservation decision-making (Calabrese and Fagan, 2004). For example, methods that simulate the destruction of habitat patches can be used for ranking the patches based on their contribution to the landscape-level connectivity. Similarly, the effect of the establishment of new patches on the connectivity of the network can be examined. Dispersal abilities of different species can be included in the analysis by altering the distance thresholds. In the context of boreal forests, graph-theoretical approaches have been used for studying the effectiveness of existing reserve networks in Sweden and Finland (Bergsten et al., 2013, Laita et al., 2010).

Several graph-theoretical connectivity indices exist that can be applied for studying ecological connectivity (Laita et al., 2011, Pascual-Hortal and Saura, 2006). Here, two of such indices are reviewed: 1) the Integral Index of Connectivity (IIC) and 2) Proba-

bility of Connectivity (PC), as they have been found to be informative and applicable in recent studies of landscape-scale connectivity. IIC and PC are based on the concept of landscape-scale habitat availability (reachability) within a graph-theoretical framework (Pascual-Hortal and Saura, 2006, Saura et al., 2011, Saura and Pascual-Hortal, 2007, Saura and Rubio, 2010). In this approach, connectivity is considered to occur also within a patch (intra-patch connectivity) in addition to the linking connections (inter-patch connectivity). Connectivity is measured as the total amount of reachable habitat, regardless of whether such reachable habitat is located within or in between the patches or as a combination of both intra-patch and inter-patch connectivity.

IIC is based on binary links between the nodes, whereas PC is based on probabilistic connectivity. The binary approach of IIC is useful in detecting the value of connecting elements (habitat patches or stepping stones), especially with long average inter-patch distances. This is often the case with a protected area network and especially with key woodland habitats in Scandinavia (Bergsten et al., 2013). PC measures the probability that two randomly placed individuals fall into interconnected habitat areas within the network. The probabilistic connection model implemented in PC allows for the modulation of connection strength and dispersal feasibility. Probabilistic measures favour short, direct inter-patch distances, giving more weight to links with large flow potential (Bergsten et al., 2013).

In addition to the network connectivity indices, different network centrality measures can be calculated based on the graph-representation of a landscape. Useful measures are, for example, patch importance, degree centrality and betweenness centrality, which were applied in the study of the contribution of woodland key habitats (WKH sites) to the connectivity of the whole reserve network in central Finland (Laita et al., 2010). Patch importance can be determined with node removal analysis, where each patch at a time is removed from the network and the impact of the removal on the reconstructed network is evaluated based on the resulting IIC or PC value. Degree centrality represents the number of direct neighbours and describes the importance of the patch on a local scale. Betweenness centrality is the proportion of shortest paths between all pairs of patches that connect through the node in question. Betweenness centrality is a measure of the contribution of the node to large-scale connectivity and can be useful for identifying critically important patches for landscape-scale connectivity.

Both IIC and PC metrics are incorporated into Conefor, which is freely available software for implementing graph-theoretical approaches. Required input files can be generated from vector and raster data formats in other commonly used GIS software. The software can be used non-commercially when citing the software (Saura and Torne, 2009) and the most related references (Pascual-Hortal and Saura, 2006, Saura and Pascual-Hortal, 2007, Saura and Rubio, 2010).

FunCon (individual-based simulation model for functional connectivity)

FunCon is a spatially explicit individual-based simulation model for assessing how different components of functional connectivity affect the sensitivity of a focal species to landscape structures (Pe'er et al., 2011). The components of functional connectivity that are included in the FunCon model are 1) movement timeframe (everyday home-range movement versus dispersal), 2) movement pattern (random walks versus gap crossing), and 3) response to habitat edges (gradual versus abrupt response, avoidance versus penetration). The FunCon model was originally developed for studying the abundance and distribution of birds in the Atlantic rainforest of South America.

As input data, the model requires a landscape map and species-specific input parameters on, for example, habitat requirements and behaviour at edges. The main outputs of the model are 1) abundance of species in the home-range stage, 2) functional connectivity due to home-range movements, and 3) functional connectivity due to dispersal. Outputs are provided for individuals, habitat patches and the entire landscape.

Related to Funcon, the G-RaFFe-model enables the simulation of landscape fragmentation that can be used as input in FunCon (Pe'er et al., 2013). The number of roads, size of agricultural fields, and the maximum distance in which disconnected fields can occur are taken into account in the simulation. As outputs, G-RaFFe produces map layers according to the user-defined fragmentation parameters (e.g. a landscape with 60% remaining forest cover with a small number of roads and large agricultural areas). FunCon and the G-RaFFe software can be freely used when citing the authors (Pe'er et al., 2011, Pe'er et al., 2013).

J-walk movement simulation

J-walk (Gardner and Gustafson, 2004) is a random walk algorithm for simulating dispersal within a landscape matrix with multiple habitat patches. In Vogt et al. (2009), J-walk was used for creating input movement data for morphological analysis of connectivity. J-walk simulation requires information on land cover and the probabilities of movement and mortality for each land cover class. The simulation starts with introducing an individual into the landscape. Simulation of movement continues until the individual dies or moves to another habitat patch. As a result, dispersal corridors between the habitat patches are identified. Combined with the information about habitat locations, the movement data can be used as input for further analysis, such as for MSPA (described above).

2.5.3 Analyzing actual connectivity

Surveillance data on species movement

Analyzing surveillance data on species movement is the most direct estimate of connectivity. On a landscape scale, two types of animal movement patterns should be identified: 1) frequent home-range movement and 2) less frequent long-range dispersal, which results in the relocation of the home range (Forman, 1995 in Vogt et al., 2009). There are various methods for acquiring surveillance data on species movements, for example, by tracking movement pathways or with mark-release-recapture studies (Calabrese and Fagan, 2004).

The applicability of direct measurement methods in large-scale studies is limited due to their data-intensive nature (Calabrese and Fagan, 2004). Simulations provide an alternative approach for including species data in the analysis, when direct observation of species' movement patterns is not feasible (e.g. with the J-walk algorithm described above) (Vogt et al., 2009), or if only limited data is available (e.g. the maximum-entropy approach for species habitat modeling implemented in the MaxEnt software) (Phillips et al., 2006).

2.6

Landscape prioritization from the perspective of biodiversity (Zonation)

Zonation is a software tool for conservation area prioritization developed at the University of Helsinki (Moilanen et al., 2011). The analysis is focused on evaluating the importance of different locations based on their biodiversity features such as species occurrence and habitat suitability. As a result, the tool creates a prioritization ranking for the whole landscape based on conservation value. The ranking is generated through iteratively removing the least valuable cell from the landscape. Connectivity and generalized complementarity of sites can be accounted for in the analysis. For example, the connectedness of most valuable habitats can be prioritized in the analysis and different species-specific penalties can be assigned for habitat boundaries (see detailed explanations in the **Zonation user manual**).

From the output map, different fractions of the landscape can be extracted to inform planning and decision-making. For example, the top 10% of the landscape can be investigated when the most valuable areas need to be identified for conservation, or the expansion of existing conservation areas. Locating the bottom 10% of the landscape can help in detecting the least valuable areas to be allocated for other land uses.

The prioritization method of Zonation has been applied to, for example, extending the protected area network in southern Finland (Lehtomaki et al., 2009). Zonation analyses have been used in focusing conservation efforts in the forest biodiversity programme METSO.

2.7

Summary of methods

This section reviewed methods for assessing ecosystem services and connectivity within a landscape. Details of the methods reviewed are summarized in Table 2 overleaf. The table contains a general description and technical details of the methods, for an in-depth explanation and case examples, see the references provided.

Table 2. Reviewed methods

CONNECTIVITY				
Method	**Focus**	**Software**	**Input data**	
MSPA	Structural connectivity	Guidos	Binary raster (1= objects of interest, 0= background)	
Landscape metrics	Structural connectivity	Fragstats	Various	
Landscape permea-bility	Structural con-nectivity, poten-tial connectivity (landscape permea-bility)	Calculation in GIS software	Land cover or land use data, other data on features restricting movements, e.g. road and rail networks	
Effective mesh size	Structural connec-tivity (Landscape fragmenta-tion)	Calculation in GIS soft-ware (no existing tool)	Fragmentation geometries (roads, railroad, mountain tops, etc.)	
NLEP	Structural connectivity	ArcGIS, CORILIS for input data processing	Three raster layers: 1) vegetation potential of the terrain 2) protected sites 3) fragmenting elements	
IDRISI Habitat assessment	Structural connectivity	IDRISI Selva	Raster format land cover data and habitat suitability data	
Graph-theoretical	Potential connectivity	Conefor; Conefor inputs for QGIS/ arcGIS/GUIDOS	1) text file containing a list of nodes and 2) text file containing distances between nodes (from vector or raster datasets)	
FunCon simulations	Potential connectivity	FunCon	Landscape map (raster), species-specific move-ment properties	

	Output	Notes on the viability, limitations and workload	Examples & references
	Classification of the landscape according to connectivity (9 MSPA classes)	Limitations considering input data size in Guidos (10000x10000 pixels in MS-Windows,'MSPA-tiling' for larger datasets)	European forest connectivity (Esterguil et al. 2012); Mapping landscape corridors – case in Slovakia (Vogt et al. 2007); EVITA case study in Tampere, Finland (Söderman et al., 2014)
	Proxies for biodiversity, connectivity	Limited applicability to connectivity analysis. For example, nearest-neighbour metrics have been proven to be too simplistic indicators of connectivity.	Examples in the Nordic context (Levin et al., 2008)
	Map of landscape permeability, i.e. the relative changes in the ease of movement through a landscape (species specific)	Requires expert judgment on land cover – specific resistance to the species of interest. Easy to implement in GIS.	Spatial analysis of GI of Europe (EEA, 2014); Regional connectivity in the U.S. (Beier et al., 2011); Least cost modeling in simulated and Belgian landscapes (Adriaensen et al., 2003)
	Degree of landscape fragmentation measured as the effective mesh size across the area (average accessible area)	For comparison between sub-regions within the study areas, between scenarios, studying temporal change, etc.	Degree of landscape fragmentation in Switzerland (Jaeger et al., 2008)
	Map of landscape ecological potential (index value for each pixel)	Relatively laborious compared to other reviewed methods of structural connectivity.	Landscape Ecological Potential of Europe (MA, 2005)
	Classification of the landscape into primary and secondary habitats, corridors and unsuitable areas	Requires a licence for IDRISI Selva software. A black-box tool which means that all processing steps and calculations cannot be investigated in detail.	Suggested method for assessing the ecological network in Southwest Finland (Orjala & Käyhkö 2014)
	Overall network connectivity index (IIC or PC), per patch network centrality measures	Input data can be automatically generated in external software (QGIS, ArcGIS, Guidos). There are limitations for input raster data size in Guidos.	Reachability of pine forest patches in Northern Sweden (Bergsten et al., 2013); functional reserve network in Central Finland (Laita et al., 2010); other applications: http://www.conefor.org/applications.html
	Abundance of species in the home-range stage, and functional connectivity due to home-range movements and dispersal.	Applicability in a broad scale case-study? Results may provide supporting information for using more simplistic landscape metrics.	Movement simulations for a hypothetical bird species in a fragmented landscape (Pe'er et al. 2011)

ECOSYSTEM SERVICES				
Method	Focus	Software	Input data	
GreenFrame	Ecosystem service provision potential	ArcGIS or other GIS software	Multiple raster layers (qualitative and quantitative data)	
Public Participatory GIS (PPGIS)	Demand for ecosystem services	Place-based input data is collected via interviews, deliberative workshops, Internet-based surveys or on mobile platforms. Any common GIS software or statistical software can be used for data analysis.	Digital markers (points, lines, polygons); Markings on a paper map - digitizing markings or georeferencing photographed maps; Movable markers on a paper map	
Accessibility analysis	Potential demand for ecosystem services; potential pressure of use on ecosystem services	ArcGIS or other GIS software	Road network, locational population data, target locations	
BIODIVERSITY				
Method	Focus	Software	Input data	
Zonation	Biodiversity	Zonation	Multiple raster layers	

	Output	Notes on the viability, limitations and workload	Examples & references
	Maps representing the provision potential of one or many ecosystem services	Requires the organizing of expert and local stakeholder workshops and focus groups, as well as basic statistical and GIS skills. Gathering and preparing the data for analysis can be very time consuming.	Pirkanmaa and Kanta-Häme region (Kopperoinen et al., 2014); Application of GreenFrame in analysing the green infrastructure for the regional plan of the Helsinki-Uusimaa Region (Final report of the EkoUuma project, in prep.)
	Maps representing the demand for ecosystem services	Requires knowledge on building surveys or conducting interviews or facilitating workshops, statistical knowledge on handling survey data or qualitative interview or workshop data plus basic GIS skills. Getting a statistically significant sample of data can be a problem.	Perceived residential quality in urban densification (Kyttä et al., 2013); Research priorities for PPGIS (Brown and Kyttä, 2014)
	Maps representing e.g. (a) areas achievable within specified timeframes via road networks from a certain point; (b) Number of people that are within a specified distance or a specified timeframe from each pixel; (c) Number of people within a specified buffer from a green area (or green infrastructure) in relation to the area unit of the green area.	Does not account for demand for and pressure from long-distance travel. Accessibility analysis of the road network can be heavy for the computer. Requires more than basic GIS skills unless only a basic buffer analysis is conducted.	GIS-based indicators of recreational accessibility (Skov-Petersen, 2001); Potential population pressure and accessibility of green infrastructure in the Helsinki-Uusimaa Region (Final report of the EkoUuma project, in prep.)
	Output	Notes on the viability, limitations and workload	Examples & references
	Landscape prioritization map: Conservation prioritization ranking for each pixel (0= low, 1= high)		Zonation analysis related to the forest biodiversity project METSO in Finland (see Lehtomäki et al., 2009); Case study in the Uusimaa region (Helsinki-Uusimaa regional plan project)

3 Spatial data for assessing ecosystem services, biodiversity and connectivity

3.1 Background

For spatial assessments of ecosystem services, biodiversity and connectivity, spatially explicit GIS data is needed. The data should represent different themes of the study area including information, among other things, on the protected areas network, different types of land cover and land use, hydrological conditions, culturally valuable sites, and recreational areas. Acquiring such data can be a challenging and laborious task, especially in transboundary studies where data is usually dispersed in various sources, inconsistent and produced at different levels of detail. Therefore, a review of the existing data is needed.

The most appropriate spatial data was reviewed by exploring previous and ongoing studies covering the GBF and by interviewing different experts and stakeholders. The main focus was on nationwide and cross-border datasets, but also regional and local datasets were reviewed. In order to gain detailed insight on regional-level data, a case study on the Kainuu Region in Northern Finland was carried out. Local experts and stakeholders were interviewed regarding the available datasets for the assessment of ecosystem services and connectivity of the Green Belt in general, and of the Kainuu Region in particular. It has to be acknowledged that it is not realistic to conduct an all-inclusive review of all possible existing datasets within a brief preliminary study. Nevertheless, an effort was made to cover a wide variety of different themes and datasets that are relevant to connectivity and ecosystem services supply and demand.

The results of the data review are shown in Appendix 1, including the following information: description of *theme, name of the dataset, data type, data source, data producers and contributors, spatial scale, coverage, cost and possible restrictions on data usage.* Short descriptions and the sources of the datasets reviewed are listed below under the following sections. Some of the important datasets are not available to the public, or they must be purchased or an official data request is needed. Information on possible restrictions on data availability is detailed in Appendix 1 under *possible restrictions on data usage.* The different experts and stakeholders contacted during the data review are listed in Table 4.

Data coverage poses challenges when selecting appropriate datasets for analysis. Most of the data reviewed here cover only the Finnish parts of the GBF. One of the main issues of a possible full-scale analysis of the GBF will be to find harmonized data of similar themes covering the whole study area of the GBF. During the data review the special importance of some datasets was recognized: these should be included to achieve a comprehensive and explicit analysis of the GBF.

Establishing important contacts both nationally and internationally is crucial for gaining access to important data sources. Especially cross-border contacts with Russian representatives and experts are necessary to get the best information available. Several contact details for Russian data providers and possible collaborators are listed under the section for Russian datasets.

3.2

Reviewed cross-border datasets

THEME: PROTECTED AREAS

Barents Region Protected Area Network (BPAN project)

The dataset includes information on the existing and planned protected areas in the Barents Region, and other data that has been used for analysis on the representativeness and the connectivity of the protected area network. In addition, data on unprotected high conservation value areas of Northwest Russia was produced in "Gap analysis of Northwest Russia" project. The gap analysis focused on high conservation value areas, gaps and representativeness of the protected area network in northwest Russia. Some of the data compiled in the project are unrestricted, whereas certain data have been negotiated for BPAN project use only.

- *Data source:* Finnish Environment Institute – BPAN Project
- *Data description:* For more information contact anna.kuhmonen@ymparisto.fi (Finnish Environment Institute)

Landscape planning data from Karelia (KARLANDS project)

The dataset includes information on the following forest variables of the Karelia region: silent areas, forest age, average forest height, forest volume, volume of spruce, volume of pine, volume of birch, volume of other broadleaved trees, clear cuts and fire risk areas.

- *Data source:* KARLANDS Project
- *Data description:* For more information contact timo.hokkanen@ely-keskus.fi (Centre for Economic Development, Transport and the Environment)

Protected Areas in the Euregion Geodatabase (EUREGIO–Karelia project 2000)

The Euregion–Karelia Geodatabase includes information on nature reserves and parks and on national parks (under the theme protected areas) in the Karelia region in the Finnish and Russian territories. The database contains also data on other themes, such as hydrology and the administrative structure of the region, but the data might be outdated.

- *Data source:* National Land Survey of Finland
- *Data description:* For more information contact *the Regional Council of Kainuu*

THEME: LAND COVER AND LAND USE

Barents Region land cover data from the BPAN project

The land cover data used in the BPAN project. The study utilized CORINE Land Cover data and data produced in the GAP analysis of northwest Russia that focused on high conservation value areas, and gaps and representativeness of the protected area network in northwest Russia.

- *Data source:* Finnish Environment Institute – BPAN Project
- *Data description:* For more information contact *the Finnish Environment Institute*

Hybrid Land Cover of Russia: Land cover classification 300 m

The data was produced using geographically weighted regression (GWR) and crowd-sourced validation data from Geo-Wiki to create two hybrid global land cover maps that use medium resolution land cover products as an input.

- *Data source:* International Institute for Applied System Analysis
- *Data description:* Link to article

Hybrid Land Cover of Russia: Land cover classification 1 km

The dataset includes a Russian land cover and land use dataset where data from statistics, remote sensing and in-situ observations are combined. The resulting dataset contains detailed subclasses of land cover at a 1 km resolution.

- *Data source:* International Institute for Applied System Analysis
- *Data description:* Link to article

EUREGIO–Karelia project 2000: Land cover areas including glaciers, forests and open wetlands

Includes land cover information on the Karelia area from the EUREGIO–Karelia database.

- *Data source: National Land Survey of Finland*
- *Data description:* For more information contact *the Regional Council of Kainuu*

GIT Barents

GIT Barents was an EU-funded project active between 1997 and 2008. During this project, spatial data on the Barents Region was produced covering areas of north-western Russia and the northernmost parts of Finland, Sweden and Norway. According to the project website, the following data should be available: homogenized information on administrative boundaries, transportation, hydrography, land cover and land use, settlements, elevation, protected areas and geographical names.

- *Data source:* GITBarents
- *Data description:* Link to metadata

Other land cover data

Different commercial and free land cover and land use data are available covering global and regional areas.

- *Data source:* Multiple data sources, for example, USGS

THEME: REMOTE SENSING DATA

Landsat 8 – satellite images

Landsat provides satellite images for monitoring, understanding and managing the resources needed for human sustainment such as food, water and forests. Landsat 8 measures Earth's surfaces in the visible, near-infrared, short-wave infrared and thermal infrared, with a moderate resolution of 15 to 100 meters, depending on spectral frequency.

- *Data source:* USGS
- *Data description:* Link to metadata

1 km MODIS-based Maximum Green Vegetation Fraction

These data describe the annual maximum green vegetation fraction (MGVF), and are based on 12 years (2001-2012) of Collection 5 MOD13A2 normalized difference vegetation index (NDVI) data. Each map shows MGVF for one year (as well as the average, for all years from 2001-2012), based on the annual maximum NDVI and linear mixing models that describe the green vegetation fraction (vs. non-vegetated area) for each land cover class for each year.

- *Data source:* USGS
- *Data description:* Link to metadata

Earth Observing 1 (EO-1): Hyperion sensor –satellite images

The Hyperion instrument provides a new class of Earth observation data for improved Earth surface characterization using hundreds of spectral bands with moderate resolution of 30 m. Through these spectral bands, complex land ecosystems can be imaged and accurately classified.

- *Data source:* USGS
- *Data description:* Net Primary Production: Link to article

Other commercial remote sensing data

- *Data source:* Multiple data providers with different sensor specifications

THEME: GEOLOGY AND MINING

Fennoscandian Ore Deposit Database (FODD)

The public data from the Fennoscandian Ore Deposit Database (FODD) includes data on more than 900 metal mines, unexploited deposits and significant occurrences within Fennoscandia. The data contains information on, among other things, the location, mining history, tonnage and commodity grades.

- *Data source:* Fennoscandian Ore Deposit Database
- *Data description:* Geological Survey of Finland Report (Eilu et al., 2007)

3.3

Reviewed Finnish datasets

THEME: PROTECTED AREAS

Natura 2000 sites

The Natura 2000 network ensures the conservation of biotopes and habitats of species requiring the designation of Special Areas of Conservation listed in the annexes of the Habitats Directive.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Nationally designated nature protection areas and wilderness reserves

The nature protection areas and wilderness reserves dataset (Finnish: *Luonnonsuojelu- ja erämaa-alueet*) includes nationally designated protected areas established on state-owned land in accordance with the Nature Conservation Act or Nature Conservation Decree, and areas established on private lands under a decision of the local Centre for Economic Development, Transport and the Environment. The dataset also includes extensive wilderness areas which are maintained in a natural state and are at least partially managed in a natural state.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Protected areas included in national conservation programmes

The national conservation programme dataset (Finnish: *Luonnonsuojeluohjelma-alueet)* includes the boundaries of protected areas described in the Finnish conservation programme. The dataset includes data on seven approved nature conservation programmes: national parks and strict nature reserves, mires, bird wetlands, eskers, herb-rich woodland, shores and old-growth forests.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

State-owned real estate reserved for conservation purposes, Metsähallitus

The datasets of the real estate owned by Metsähallitus that have been reserved for conservation purposes show the plot boundaries that are partly or completely located in strict nature reserves, national parks, other state-owned nature reserves, old-growth forest reserves, mire reserves, herb-rich forest reserves, protected areas established by Metsähallitus, areas reserved for protection in nature conservation programme, or wilderness areas.

- *Data source:* Metsähallitus
- *Metadata:* For more information contact Metsähallitus

Conservation areas in the national database of regional land use plans

The national database of regional land use plans (Finnish: *Valtakunnallinen maakuntakaavapaikkatietokanta*) includes information on areas reserved for conservation purposes in ratified regional land use plans.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Protected state-owned and privately owned forest patches (SAKTI database)

The dataset includes the protected state-owned and privately owned forest patches in Finland.

- *Data source:* Metsähallitus
- *Metadata:* For more information contact Metsähallitus

THEME: AREAS OF VALUABLE LANDSCAPES

Nationally valuable landscape areas in national conservation programmes

Areas in conservation programmes include the geographical boundaries of nationally valuable landscapes. First, a conservation programme and the areas included in it are delineated in a general decision. When a certain area is declared to be protected, the area is delineated at the site. The conservation programme areas and their geographical boundaries are not removed from the database after the decision declaring the site an official protected area.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Valuable landscape areas in the national database of regional land use plans

The national database of regional land use plans (Finnish: *Valtakunnallinen maakuntakaavapaikkatietokanta*) includes data on valuable landscape areas that have been designated as landscape zones in regional land use plans.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

THEME: AREAS OF CULTURAL HERITAGE

Nationally valuable built environment

The database on the nationally valuable built environment in Finland (Finnish: *Rakennettu kulttuuriympäristö 1993*) is based on the national inventory including regional and temporal diversity of built heritage and central themes in Finnish construction history.

- *Data source:* Finnish National Board of Antiquities
- *Data description* (only in Finnish): Link to metadata

Archaeological sites

The data include protected archaeological sites (Finnish: *muinaisjäännökset*) in the archaeological heritage register of the National Board of Antiquities.

- *Data source:* Finnish National Board of Antiquities
- *Data description* (only in Finnish): Link to metadata

Protected built heritage areas

Protected built heritage areas (Finnish: *Suojeltu rakennusperintö*) include significant views and buildings that have been protected under the Act on the Protection of the Built Heritage.

- *Data source:* Finnish National Board of Antiquities
- *Data description* (only in Finnish): Link to metadata

THEME: MIRES

Natural mires, drained mires and peatlands in Finland

This dataset includes a mire classification of ”undrained mires”, “drained mires” and “peatlands” (Finnish: *soiden ojitustilanne*).

- *Data source:* Finnish Environment Institute
- *Data description:* For more information contact Finnish Environment Institute

Mires in the Finnish Topographic Database

The Finnish topographic database (Finnish: *maastotietokanta*) includes data on mires and organic matter extraction areas in Finland.

- *Data source:* National Land Survey of Finland
- *Data description* (only in Finnish): Link to metadata

THEME: GEOLOGY AND MINING

Nationally valuable rocky areas

The dataset of nationally valuable rocky areas (Finnish: *Valtakunnallisesti arvokkaat kalliomuodostumat*) includes data on nationally valuable rocky outcrop areas for nature and landscape conservation. The dataset includes data on the following areas (situation on 31.12.2011) Uusimaa, Southeast Finland, Southwest Finland, Häme, Päijät-Häme, Pirkanmaa, Central Finland, North Savo, West Finland, North Ostrobothnia, Kainuu, South Savo and Northern Karelia.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Nationally valuable moraine formations

The dataset of nationally valuable moraine formations (Finnish: *Valtakunnallisesti arvokkaat moreenimuodostumat*) includes data on inventoried moraine formations in Finland. Exploitation pressures on moraine resources are intensifying because of fewer remaining sources of gravel in eskers. Beside their economic significance, moraine formations hold important ecological, environmental and landscape values.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Nationally valuable aeolian and beach formations

The dataset of nationally valuable aeolian sand and beach formations (Finnish: *Arvokkaat tuuli- ja rantakerrostumat*) is based on the final report of the joint inventory project of valuable aeolian sand and beach formations (TUURA) of the Ministry of the Environment, the Finnish Environment Institute (SYKE) and the Geological Survey of Finland (GTK). The dataset includes data on 417 aeolian sand and beach formations classified as nationally valuable.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Superficial deposits of Finland

The dataset includes data on the superficial deposits of Finland, produced in various scales. There is data on basal deposits, superficial deposits and Quaternary geological formations.

- *Data source:* Geological Survey of Finland
- *Data description:* Link to metadata

Bedrock of Finland

The dataset includes unified data on the bedrock all over Finland in various scales.

- *Data source:* Geological Survey of Finland
- *Data description:* Link to metadata

Mineral deposits

The dataset contains all mineral deposits and their occurrences in Finland.

- *Data source:* Geological Survey of Finland
- *Data description:* Link to metadata

Geological map of Finland, pre-Quaternary

The bedrock data contains, among others, bedrock observation points and drilling sites, tectonic observations, lithological primary structures and ore minerals.

- *Data source:* Geological Survey of Finland
- *Data description:* Link to metadata

Other GIS data and map services of the Geological Survey of Finland

The Geological Survey of Finland also has plenty of other data available through its online services:

- Hakku data service
- Map services
- Interface services

THEME: GROUNDWATER

Groundwater formation areas

The dataset includes those groundwater areas (Finnish: *Pohjavesialueet*) that have been assessed and classified for water supply purposes. Groundwater areas have been classified according to their usability and need for protection.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Chemical condition of groundwater areas

The dataset of groundwater areas includes data on the chemical condition of groundwater areas that have been assessed and classified for water supply purposes.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Volume of groundwater areas

The dataset of groundwater areas includes data on the yield of groundwater areas that have been assessed and classified for water supply purposes.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

THEME: SURFACE WATERS AND DRAINAGE BASINS

Water formations according to the EU Water Framework Directive (second planning period): Ecological status of water

The dataset of water formations according to the Water Framework Directive (Finnish: *Vesipuitedirektiivin mukaiset vesimuodostumat*) includes data on inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata; Directive 2000/60/EC

Hydromorphological condition of lakes and rivers

The dataset includes data on the state of waters, barriers and the structure of the water areas.

- *Data source:* Finnish Environment Institute
- *Data description:* For more information contact *Finnish Environment Institute*

Protected rapids

The dataset includes data on rapids, rivers and catchment areas protected in accordance with the Act on the Protection of Rapids (Finnish: *Koskiensuojelulailla suojellut alueet*).

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Agricultural areas with high natural values (HNV)

High nature value farmland refers to those areas in Europe where agriculture is a major land use (usually the dominant one) and where agriculture supports or is associated with either a high diversity of species and habitats or the presence of species of European conservation concern or both.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

THEME: RECREATION AREAS

Recreation areas in the national database of regional land use plans

The national database of regional land use plans (Finnish: *Valtakunnallinen maakuntakaavapaikkatietokanta*) includes data on the areas reserved for recreation purposes in ratified regional land use plans.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Recreation areas (VIRGIS)

The recreation areas dataset (Finnish: *Virkistysalueet*) is a nationwide spatial dataset (VIRGIS) including data on nature-based recreational services. These services include recreation areas and services and publicly maintained outdoor routes. The services are provided mainly by municipalities, government, local recreation associations, unions and clubs, as well as private companies. The dataset is insufficient and outdated, which restricts its use.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

Recreational routes, areas and service structures from retkikartta.fi

Retkikartta.fi contains information on recreational routes, areas and services from the whole Finland. At the moment most of the information is about areas and facilities on state-owned land.

- *Data source:* Metsähallitus
- *Data description:* Link to the service

THEME: BIOTOPES

Traditional rural biotopes

Traditional rural biotopes include meadows, pastures and grazed woodlands which were formed by traditional agricultural practices and especially by animal grazing. By definition, cultivated fields or fallows are not regarded as traditional rural biotopes.

- *Data source:* Finnish Environment Institute
- *Data description:* For more information contact *Finnish Environment Institute*

Natural habitats referred to in the EU Habitats Directive

The Habitats Directive protects nearly 200 habitats considered valuable by the European Community. Naturally, these habitats are only found in very small areas, or are in danger of disappearing within the European Community. On the other hand, they could also be excellent examples of the European Union's six biogeographical regions. Some natural habitats are priority habitats. These habitats are in immediate danger of disappearing and the EU has a particular responsibility for them. A total of 69 habitats referred to in the Habitats Directive can be found in Finland, 14 of which have a priority status.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to general description

THEME: LAND COVER AND LAND USE

CORINE Land Cover 2012/2006

The dataset provides data on land cover and land use in Finland in 2006 and 2012. The Finnish Environment Institute (SYKE) has generated the dataset, based on automated interpretation of satellite images and integration of various GIS data. It has four hierarchy levels. The first-level classes are: artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands and open bogs, water and marshes. The second level has 15 classes and the third level, 44 sub-classes. In addition, there is a fourth national class level.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

SLICES 2005

SLICES is a land cover dataset covering the territory of Finland. SLICES has been produced by combining raster datasets from different organizations. The dataset includes 50 land cover classes at the most precise level of the hierarchical classification.

- *Data source:* National Land Survey of Finland
- *Data description (only in Finnish):* Link to metadata

THEME: REMOTE SENSING DATA

Image 2012 mosaic

Image 2012 mosaic is a satellite image mosaic of 20-meter pixel size covering the territory of Finland.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to metadata

THEME: SPECIES DATA

Species from the Environmental Administration data system (TAXON)

The endangered species data system includes national and regional data on observations of endangered plant and animal species.

- *Data source:* Finnish Environment Institute
- *Data description:* For more information contact *Finnish Environment Institute*

LajiGIS database

The LajiGIS database includes species observation and mapping data. The data has been compiled from species data in the Hertta database (of the Finnish Environmental Administration) and the SutiGIS database (of Metsähallitus).

- *Data source:* Metsähallitus
- *Data description:* For more information contact *Metsähallitus*

Important bird areas (IBA)

Areas recognized as being globally important habitats for the conservation of bird populations.

- *Data source:* Finnish Environment Institute
- *Data description:* Link to Birdlife International

Important bird areas in Finland (FINIBA)

Areas recognized as being nationally important habitats for the conservation of bird populations.

- *Data source:* BirdLife Finland
- *Data description:* Link to Birdlife Finland

The Finnish Breeding Bird Atlas

The third Finnish Breeding Bird Atlas survey was conducted between 2006 and 2010. The data compiled from various sources consist of observations by more than 5,000 persons. The data contains species distributions of Finnish breeding birds in 10 km grid squares. The third survey data is open to everyone since the beginning of 2015. The data from the first (1974–1979) and the second (1986–1989) bird atlas surveys can be freely downloaded online.

- *Data source:* Finnish Breeding Bird Atlas (Valkama et al., 2011)
- *Data description:* Link to description

Large carnivore populations

Large carnivore research focuses on populations and living habits of the brown bear (*Ursus arctos*), the wolf (*Canis lupus*), the wolverine (*Gulo gulo*) and the lynx (*Lynx lynx*). The Finnish Game and Fisheries Research Institute estimates large carnivore populations primarily on the basis of observations recorded by a volunteer network. The data include types of species and time and place of the observation.

- *Data source:* Game and fisheries research
- *Data description:* For more information contact *Finnish Game and Fisheries Research Institute*

Moose population estimation

Moose research focuses on populations and living habits of moose, white-tailed deer, fallow deer and roe deer. The Finnish Game and Fisheries Research Institute estimates moose populations primarily on the basis of observations recorded by the volunteer network. The data include types of species and time and place of the observation.

- *Data source:* Game and fisheries research
- *Data description:* For more information contact *Finnish Game and Fisheries Research Institute*

Fish species in the fish register

The registry of test fishing (Finnish: *koekalastusrekisteri*) contains data on species derived from standardized test fishing in Finland.

- *Data source:* Game and fisheries research and Finnish Environment Institute
- *Data description:* For more information contact *Finnish Environment Institute*

Reindeer husbandry areas in Finland

Spatial data of the reindeer pasture areas and reindeer husbandry structures.

- *Data source:* Finnish Environment Institute
- *Data description:* For more information contact *Finnish Environment Institute*

THEME: FOREST AREAS

Valuable forest habitat according to the Finnish Forest Act (Mete sites)

The Forest Act defines habitats of special importance to forest biodiversity (Finnish: *Mete-kohteet*) – areas, the natural features of which must be conserved. These habitats are clearly delimited and generally fairly small areas in a natural or semi-natural state, including the following: the immediate surroundings of springs, brooks, rivulets constituting a permanent water flow channel, and small ponds, herb-rich and grassy hardwood-spruce swamps, ferny hardwood-spruce swamps, eutrophic paludal hardwood-spruce swamps, and eutrophic fens located to the south of the Province of Lapland, fertile patches of herb-rich forest, heathland forest islets in undrained peatlands, gorges and ravines, steep bluffs and the underlying forest, sandy soils, exposed bedrock, boulder fields, peatlands with sparse tree stand, and flood meadows which are less productive than nutrient-poor heathland forests.

- *Data source:* Finnish Forest Centre
- *Data description:* Link to metadata

Landscape ecological planning of the Finnish forest areas

The dataset includes data on the ecological, economic and sociocultural conditions. It includes different nature sites, for example, primeval forests and ecological corridors between protected areas and valuable nature sites.

- *Data source:* Metsähallitus
- *Data description:* For more information contact *Metsähallitus*

Dialogue process concerning protected forest areas in Finland

Includes data on areas inventoried under the national old-growth forest programme. The areas were not selected as protection sites but are, however, considered ecologically valuable.

- *Data source:* Metsähallitus
- *Data description:* For more information contact *Metsähallitus*

The Forest Biodiversity Programme METSO

New forest areas included in the METSO programme.

- *Data source:* Metsähallitus
- *Data description:* For more information contact *Metsähallitus*

Finnish Forest Centre's Zonation analysis of the METSO programme areas

The data includes important areas for retaining habitat quality and connectivity for multiple biodiversity features while indirectly aiming at long-term persistence of biodiversity in METSO programme areas.

- *Data source:* Finnish Forest Centre
- *Data description:* For more information contact antti.leinonen@metsakeskus.fi (Finnish Forest Centre)

Multi-source National Forest Inventory (MS-NFI)

The multi-source inventory method employs field measurements, remote sensing data and other digital data sources, such as land-use maps and elevation models. With the aid of satellite images, the forest characteristics can be estimated for areas lying between the relatively sparse network of NFI sample plots. The non-parametric k nearest neighbour estimation method is used in the image analysis.

- *Data source:* Finnish Forest Research Institute
- *Data description:* Link to metadata

State-owned nature sites worthy of protection

The dataset includes nature sites (around 500 habitat patches) on public land that have been recognized as valuable for conservation and the connectivity of existing protected areas, but are not protected by law.

- *Data source and description:* WWF Finland

THEME: ACCESSIBILITY AND POPULATION

Digiroad road network

Digiroad is a national, comprehensive database containing accurate data on the location and attributes of all roads and streets in Finland (e.g. speed limits, width of roadways, bus stops and road classification).

- *Data source:* Finnish Transport Agency Data services
- *Data description:* Finnish Transport Agency

Population grid 1 km

Statistics Finland distributes freely population data in a 1 km grid, covering all populated squares of Finland. The database contains data on total population, gender and broad age groups (0–14 years, 15–64 years, 65 years and older).

- *Data source:* Link to download (Statistics Finland)
- *Data description:* Link to description (Statistics Finland)

Statistics Finland grid database

More detailed population data can be obtained from the grid database of Statistics Finland. Acquiring a single license for the 250 m grid database costs €4,800. The database contains data on, among other things, population structure, educational structure of the population, inhabitant's and household's dispensable monetary income, and size and stage in life of households.

- *Data source:* Statistics Finland
- *Data description:* Link to description (Statistics Finland)

3.4

Reviewed Russian datasets

Environmental variables from the Hybrid Land Cover of Russia

The hybrid land cover of Russia integrates ground and remote sensing data that parameterizes Russian territory at a 1 km spatial resolution for forests. The dataset includes data on 1) net primary production of forest ecosystems, 2) soil contribution to carbon budget, 3) soil organic carbon and 4) biomass distribution.

- *Data source:* International Institute for Applied System Analysis
- *Data description:*
  - Net Primary Production: link to article
  - Soil contribution to carbon budget: link to article
  - Soil organic carbon: link to article
  - Live biomass: Contact Dimitry Schepaschenko (IIASA) for more details

Other Russian datasets

Multiple datasets of natural resources, biodiversity and specific features of territories in Western Russia are listed in Table 3 with relevant contact people. Finnish Environment Institute SYKE (Jevgeni Jakovlev in particular) has established contact with various Russian data providers.

Table 3. Contact details of Russian data providers

Data	Contact details	Institution
Geology: Bedrock, stratigraphy	Prof.Valentin Gorkovets Prof.Sergei Svetov	Institute of Geology of Karelian Research Center of Russian Academy of Sciences
Geology: Quaternary sediments	Dr.Tatyana Shelekhova	Institute of Geology of Karelian Research Center of Russian Academy of Sciences
Geology: Soils	Dr. Olga Bakhmet Dr. NatalyaFedorets	Institute of Geology of Karelian Research Center of Russian Academy of Sciences
Hydrography: Catchments	Dr. Alexander Litvinenko Dr. Maria Bogdanova	Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences
Forests: Primeval forests, Secondary forests, Protective forest along water bodies	Dr. Andrey Gromtsev	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences
Wetlands: Mires and paludified forests	Dr.Oleg Kuznetsov Dr. Stanislav Kutenkov	Institute of Biology of Karelian Research Center of Russian Academy of Sciences
Aquatic communities	Dr.Sergei Komulainen	Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences
Biogeographical zoning: Vegetation mapping	Dr. Alexander Kryshen Dr. Oleg Kuznetsov	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences, Institute of Biology of Karelian Research Center of Russian Academy of Sciences
Projects for ecotourism development	Dr. Jyri Savelyev	Institute of Economics of Karelian Research Center of Russian Academy of Sciences

Data	Contact details	Institution
Cultural heritage	Dr. Alexander Zukov	Institute of History, Languages and Literature of Karelian Research Center of Russian Academy of Sciences
Species: Fungi	Dr. Anna Ruokolainen	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences
Species: Lichens	Dr. Margarita Fadeeva	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences
Species: Vascular plants	Dr. Alexei Kravchenko Dr. Oleg Kuznetsov	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences, Institute of Biology of Karelian Research Center of Russian Academy of Sciences
Species: Birds	Dr. Nikolai Lapshin Dr. Alexander Artemyev Dr. Sergei Sazonov	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences, Institute of Biology of Karelian Research Center of Russian Academy of Sciences
Species: Algae		Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences
Species: Fish	Dr. Nikolai Ilmast	Institute of Biology of Karelian Research Center of Russian Academy of Sciences
Species: Mammals	Dr. Piotr Danilov Dr. Vladimir Belkin	Institute of Biology of Karelian Research Center of Russian Academy of Sciences
Species: Mosses	Dr. Anatoly Maximov	
Species: Insects	Dr. Alexei Polevoi Dr. Andrei Humala	

3.5

Reviewed Norwegian datasets

Different data themes in the Norwegian database

Naturbase.no provides access to data on various categories of the following themes in the Norwegian territory: protected areas, planned protected areas, recreational areas, habitat types, valuable cultural landscapes, areas of contaminated soil.

- Data source: Norwegian Environment Agency
- Data description: Link to metadata

3.6

Reviewed regional datasets – case Kainuu

Classification of the sensitive landscape areas in commercial forests

The dataset includes a classification of the visual sensitivity to changes in commercial forests. It is based on the main criteria of visibility, usage pressure, and landscape attractiveness, and includes sub-criteria. It is used to guide allocation of landscape management.

- *Data source:* Finnish Forest Research Institute
- *Data description: Contact Finnish Forest Research Institute for more details*

Kainuu regional plan

The dataset includes areas reserved for nature-based tourism and tourism development in the Kainuu regional plan.

- Data source: Regional Council of Kainuu
- Data description: Contact Regional Council of Kainuu for more details.

Outdoor map of Kainuu

The outdoor map of Kainuu provides information on, for example, various types of routes, campfire sites, accommodation, culturally interesting sites and nature protection areas in the Kainuu Region.

- Data source: infoGIS Oy
- Data description: link to service

Preliminary study of the Kainuu mires

The data includes boundaries of the Kainuu mires investigated during the preliminary studies. A separate dataset includes protected and unprotected mires (over 10 ha) in tourist attraction sites and in tourist development areas.

- Data source: Centre for Economic Development, Transport and the Environment
- Data description: Link to metadata

3.7

List of contacted people

During the review of potential datasets to use, several experts and stakeholders were contacted for consultation on the datasets and methods. For some of the persons listed in Table 4 discussions were held in person, whereas others were contacted via telephone or e-mail.

Table 4. List of different persons contacted during the data review

Name	Contact details	
Ron Store Eeva Karjalainen	ron.store@metla.fi eeva.karjalainen@metla.fi	
Sanna Jantunen	sanna.jantunen@metsa.fi	
Jyri Mikkola	jyri.mikkola@sll.fi	
Jevgeni Jakovlev	jevgeni.jakovlev@ymparisto.fi	
Tiia Kalske	fmfithk@fylkesmannen.no	
Antti Leinonen	antti.leinonen@metsakeskus.fi	
Antti Otsamo	antti.otsamo@metsa.fi	
Markku Mikkola-Roos	markku.mikkola-roos@ymparisto.fi	
Samuli Heikkinen	samuli.heikkinen@rktl.fi	
Jyrki Pusenius	jyrki.pusenius@rktl.fi	
Dimitry Schepaschenko	schepd@iiasa.ac.at	
Janne Heliölä	janne.heliola@ymparisto.fi	
Minna Kallio	minna.kallio@ymparisto.fi	
Olli Ojala	olli.ojala@ymparisto.fi	
Lasse Järvenpää	lasse.jarvenpaa@ymparisto.fi	
Suvi Hatunen	suvi.hatunen@ymparisto.fi	
Rauno Malinen	rauno.malinen@pohjois-pohjanmaa.fi	
Heidi Kaipiainen-Väre	heidi.kaipiainen@ymparisto.fi	
Kari Oinonen	kari.oinonen@ymparisto.fi	
Kerttu Härkönen	kerttu.harkonen@metsa.fi	
Maarit Vainio	maarit.vainio@ely-keskus.fi	
Martti Juntunen	martti.juntunen@kainuu.fi	
Darja Flogny	darja.flogny@metsa.fi	
Mikko Tiira	mikko.tiira@metsa.fi	
Olle Höjer	olle.hojer@naturvardsverket.se	
Eugene Lopatin	eugene.lopatin@metla.fi	
Jukka Nykänen	jukka.nykanen@gmail.com	
Timo J. Hokkanen	timo.hokkanen@ely-keskus.fi	
Anna Kuhmonen	anna.kuhmonen@ymparisto.fi	
Antti Sallinen	antti.sallinen@gmail.com	
Kaisu Aapala	kaisu.aapala@ymparisto.fi	
Päivi Korhonen	paivi.korhonen@ymparisto.fi	
Tapani Mikkola	tapani.mikkola@metsa.fi	

	Theme of contact
	Classification of the sensitive landscape areas in commercial forests
	Forest patterns (SAKTI database)
	Interview: Northern Russian GAP analyses and Barents Region Protected Areas (BPAN project)
	Interview: Russian GIS data and contacts
	Norwegian databases: Vann-net (vannmiljo.no), Naturbase.no, Nordatlas, Miljodirektoratet.no, Norge i bilder
	Finnish Forest Centre's Zonation analysis of the METSO programme areas
	Metsähallitus ecological planning of the forest areas, Dialogue process, METSO programme
	Finland's important bird areas (FINIBA)
	Large carnivore populations: Lynx, bear, wolverine and wolf observations
	Moose, white-tailed deer, fallow deer, roe deer population estimations
	Hybrid Land Cover of Russia
	High Nature Value Farmlands data
	Traditional rural biotopes
	Natural habitats referred to in the EU Habitats Directive, natural habitats under the conservation act
	Hydromorphological condition of water areas: areas where hydromorphological change is low or very low
	SLICES land cover data
	Nature, tourism and cultural attraction sights from EUREGIO-Karelia project
	Endangered species from the Environmental Administration data system (TAXON)
	Reindeer husbandry: Seasonal reindeer pasture areas
	Interview: Case Kainuu
	Interview: Case Kainuu
	Interview: Case Kainuu
	Quality-CET project
	Metsähallitus databases
	BPAN project data
	KARLANDS project data, forest connectivity analyses
	KARLANDS project database
	KARLANDS project database
	Interview: BPAN project data
	Preliminary study of the Kainuu mires
	Data from the preliminary study of the Kainuu mires
	Fish species in fish register
	Recreational routes, areas and service structures from retkikartta.fi

4 Outline and recommendations for conducting a full-scale assessment of the Green Belt of Fennoscandia

The scale of the analyses

The GBF covers an extensive area, consisting of a variety of different types of habitats, vegetation zones and ecosystems. The coastal and freshwater ecosystems that characterize the southernmost part of the GBF give way to extensive mires, forests and fell landscapes when moving northwards along the Finnish–Russian border zone. The southern parts of the GBF are more densely populated and more easily accessible from the metropolitan areas of St. Petersburg and Helsinki. Thus, there are differences between regions in the most important ecosystem services, in the demand for them, and in the potential drivers and pressures that might affect them. In addition, not all areas of the GBF have been studied in equal rigour, and the existing data are heterogeneous and have gaps concerning the ecosystem services.

Bearing the above-mentioned in mind, in order to carry out a thorough assessment of the ecosystem services and the connectivity of the protected areas, a single analysis of the whole GBF will not be sufficient. Instead, it needs to be supplemented with more detailed, regional assessments. Our suggestion is to approach the green infrastructure of the GBF on two distinct scales: 1) the full scale of the whole GBF and 2) the regional scale.

Conducting a full-scale assessment allows for a general overview of the GBF to be generated and identification of the most significant and most critical areas of connectivity. There are already existing examples of large-scale pattern-oriented analyses on the suitable habitats and landscape permeability for different forest species covering large parts of the GBF (e.g. maps produced in the BPAN project, see http://www.bpan.fi/).

Consistent full-scale analyses require harmonious large-scale data and need to be based on more simplistic assumptions than regional-scale analyses. This limits the relevance and usability of the results for planning and decision-making on the regional scale. Conducting more detailed analyses on the regional scale enables better utilization of available regional data and taking differences in regional characteristics into account. We recommend dividing the GBF into four to six regions that are analyzed separately. After all regions have been analyzed, a synthesis can be drawn from the separate regional assessments. This approach would in fact result in two full-scale analyses on the GBF: a comprehensive, more general 'top-down' analysis, and a 'bottom-up' synthesis of more detailed regional analyses. Instead of producing redundant results, a multi-scale approach would bring added value and robustness into the assessment.

Remarks on the available data

One of the focal aims of this preliminary report was to shed light on the existing GIS data that could be utilized in assessing the ecosystem services and connectivity of the Green Belt of Fennoscandia. We focused our review on trans-border and national-scale datasets, with a case study from Kainuu to give examples of existing data that have been produced also on a sub-national scale. With regard to national-scale data, we focused mainly on Finnish datasets for two reasons: 1) Finnish datasets – or at least their documentation – can be relatively easily accessed. The Finnish data reviewed here cover various relevant themes and serve as examples of the types of data to look for from other areas of the GBF. 2) As we came to find out during the review, in order to even acquire information on certain foreign datasets, it would have been advantageous to have established personal contacts with the correct people. Within the limits of the project, we made an effort to overcome this by interviewing experts that are already connected to Russian authorities and research institutes.

When interviewing local stakeholders and experts, different observations came up concerning cross-border and national spatial data produced by different quarters. It is good to acknowledge that many of the existing datasets are only available through co-operation (i.e. involving the data producer as a project partner and allocating project funding to the partner in question), or they must be purchased. In some cases the existing datasets may not be available at all due to restrictions. Detailed information on the possible restrictions of data usage under different themes can be found in Appendix 1.

Reviewing and actually acquiring and compiling the data are time consuming because data is usually dispersed in various sources and/or it may need to be pre-processed, e.g. by merging multiple different datasets. Thus, it is recommended to use existing harmonized data, to spare processing time. Furthermore, if the data has already been used in previous research projects, the possible restrictions and problems in its use are usually known.

During the data review, certain cross-border and nationwide datasets were recognized as especially important. These data are discussed below. Spatial data produced in the GAP analysis of Northwest Russia (link to publication) and later updated in the BPAN project (link to project) provide the most spatially explicit and harmonized data of the Russian land cover and high conservation value areas that are compatible with data under the same themes in Finland and Norway. This data was requested and it should be available for use but it requires agreement with the data producers and contributors.

Some of the most important nationwide datasets covering Finland are freely available from the whole country. The Multi-source National Forest Inventory (MS-NFI) 2009 provides information on Finnish forest characteristics. It can be used, for example, in assessing the volume, age structure, species distribution and dominant tree species of forest patches. Another important nationwide dataset is the CORINE Land Cover that provides detailed information on Finnish land cover and land use in 2012 using four different hierarchy levels (Link to CORINE Land Cover description).

Based on expert interviews, the data on landscape ecological planning of the Finnish forest areas from Metsähallitus was recognized as being especially important for the analysis as it includes relevant information, for example, on primeval forests and ecological corridors between protected areas and valuable nature sites. Despite a request from the Finnish Environment Institute (in November 2014), Metsähallitus did not grant permission to use the ecological planning data (nor the data from their Zonation analyses or the data from the dialogue process between Metsähallitus and nature conservation organizations) for the purposes of this study. In order to get permission to use these data, a formal data request, signed by a highly authoritative officer, would be required.

Of course, it is also possible to produce new data, for example, by interpreting remote sensing data. Using remote sensing data has proven to be especially useful and cost-effective in large and remote areas, where other data is scarce or missing. However, producing such data naturally requires resources and expertise on remote sensing.

As already mentioned, we also made an effort to find out the proper contact information for the persons in charge of potential useable Russian datasets. A summary of such contact persons is presented in Table 3. As it was not possible to compile an all-encompassing list of these contact persons, we recommend co-operating with experts who already have connections to Russian authorities and research institutes.

Recommendations for the analysis methodology

For conducting a full-scale analysis of the connectivity of the GBF, we recommend pattern-oriented approaches, such as Morphological Spatial Pattern Analysis, and mapping of suitable habitats and landscape permeability. These approaches can be used to produce general estimates of the connectivity of the GBF, utilizing, for example, land cover or habitat data. The definition of potential habitats and the level of permeability (i.e. the ease or difficulty of species movement) in different land cover types have to be done carefully – and separately for each species or genus of interest. Also the effect of water surfaces and rivers on the dispersal ability for different species needs to be taken into account.

In regional assessments of connectivity, the use of graph-theoretic approaches is also recommended. This allows the quantification of the importance of different habitat patches and corridors in relation to the overall connectedness of the regional ecological network. In addition to identifying and recognizing the most critical features of the network in the current situation, also the effects of potential changes in the network can be simulated. The nodes (habitats) of the network can be determined based on species distribution data (if available), or, for example, on land cover. The existence (binary approach) or the probability (probabilistic approach) of the links between the patches may be determined, for example, on the basis of distance between patches. Also the land cover and possible barriers, such as large roads or steep topography, may be taken into account, but this requires more processing and careful expert judgment.

In conclusion, no single analysis can capture all aspects of the connectivity in the GBF. First, the species and genera of interest need to be defined. In the full-scale assessment of the GBF, we recommend assessing the connectivity at least from the perspectives of large forest mammals with high dispersal ability and migratory birds. On the regional scale, the most crucial species to consider depend on the region.

The diverse collection of reviewed GIS-based analysis methods for assessing the connectivity may convey an illusion of false certainty. The assessment must not be a mere exercise of data analysis, however. Ecological expertise on ecology and comprehension of the characteristics of different parts of the GBF is crucial, both in parameterizing the analyses and in interpreting the results.

For assessing the provision of ecosystem services, we recommend using a semi-quantitative matrix approach, such as GreenFrame, for the following reasons: 1) it allows integrating existing 'hard' quantitative spatial data on, for example, provisioning services such as timber volumes and groundwater yield into the analysis whenever available, 2) regarding other ecosystem services, a wide variety of thematic data can be combined with expert judgment in order to provide an overview of the spatial variation of the ecosystem services provision. We recommend assessing the ecosystem services of the whole GBF using the 'bottom-up' approach, constituting an overall picture of the GBF by synthetizing regional-scale assessments. We feel that conducting a single full-scale assessment of the ecosystem services using uniform

specifications will most likely produce results that are too general to be relevant for developing the GBF. There are considerable regional differences in the physical characteristics, ecosystems, and ecosystem services in the GBF.

As contemplated earlier in Section 2.3, mapping the spatial variation in the demand is neither equally applicable nor equally relevant for all ecosystem services. In the context of the GBF, cultural ecosystem services – such as recreational use of nature, aesthetics and cultural heritage, and educational values – are very essential both for the local population and as attractions for nature tourism. Cultural ecosystem services are not easily exported – they need to be "consumed" (experienced) at the site (although one can argue that the actual benefits may be felt afterwards at another location). The local or regional demand for cultural ecosystem services can be estimated using, for example, public participatory GIS surveys (PPGIS) and analyses on potential demand by combining data on accessibility and population distribution.

The demand for cultural ecosystem services from the perspective of nature-based tourism cannot rely solely on the accessibility and population distribution – nature tourists may find remote locations more appealing than nearby locations. Although tourists have individual preferences, they tend to seek locations with good recreational and accommodation facilities. The actual, realized level of 'consumption' of these cultural ecosystem services may be assessed on the basis of, for example, visitor surveillance data of national parks. These figures may reveal that there is either unrealized potential in some areas or unsustainable overexploitation in other areas, but they cannot be used to investigate the demand for cultural ecosystem services outside the limited boundaries of the national parks.

We recommend that the demand for cultural ecosystem services in the GBF are assessed regionally using a combination of methods: participatory methods (such as PPGIS surveys) can be used to gain insight on the locations that regional people use and perceive as important (which is context- and culture-dependent). This investigation can be complemented by conducting a GIS-based analysis of the potential demand using accessibility analysis combined with population distribution data. The demand from the nature-based tourism perspective can be approximated using visitor surveillance data and the location of suitable facilities, such as hotels, restaurants, and visitor and nature centres. In addition, this section could include deliberative workshops with regional stakeholders, focusing on their experiences of the demand for nature-based tourism, both realized and unrealized.

Relevant stakeholders and partners to include

It is evident that in order to carry out a comprehensive assessment of the GBF, a multilateral and diverse consortium of partners is required. In order to acquire certain existing datasets, formal agreements and/or actual co-operation in the project is required. Besides data issues, there is a wide assemblage of public and private organizations that have expertise on the ecosystems, species and biodiversity of the whole GBF or certain parts of it. Based on our experiences in the project, we recommend considering co-operation with at least the following organizations:

Bioforsk Svanhovd
Directorate of Regional Protected Areas of Karelia
ELY Centres (Centres for Economic Development, Transport and the Environment)[1]
Finnish Association for Nature Conservation (SLL)
Finnish Environment Institute (SYKE)
Finnish Forest Centre
Finnish Nature League (Luonto-Liitto)
Ministry of the Environment, Finland

[1] The ELY Centres closest to the GBF are Lapland, North Ostrobothnia, Kainuu, North Karelia, South Savo, Southeast Finland

Geological Survey of Finland
Government of Karelia
Government of the Leningrad Region
Kalevalsky National Park
Karelian Research Centre of the Russian Academy of Sciences
Kivach State Nature Reserve
Kostomukshsky State Nature Reserve
Metsähallitus, Forestry
Metsähallitus, Parks & Wildlife Finland
Murmansk Regional Government
Natural Resources Institute Finland (LUKE)[2]
Nordland Research Institute (NIFU)
Norwegian Directorate for Nature Management
Norwegian Environment Agency
Ministry of Climate and Environment, Norway
Office of the Finnmark County Governor
Paanajärvi National Park
Pasvik Reserve
Regional Councils[3] and municipalities of the GBF
Russian Forest Research Institute
Russian Institute of Biology
Russian Institute of Economics
Russian Institute of Geology
Russian Institute of Northern Water Problems
The Ministry of Ecology and Natural Resources of the Russian Federation
University of Eastern Finland
University of Helsinki
University of Lapland
University of Oulu
WWF Finland
WWF Russia
WWF Norway

Outline of different stages of the assessment and estimated timetable

Here, we present a suggestive outline of the different components and resources required for conducting a full-scale assessment of the Green Belt of Fennoscandia. Altogether, a thorough and consistent assessment will require a large-scale project with a broad consortium of partner organizations. It is also necessary to engage a committed network of scientific and regional experts and a diversity of other stakeholders that are not necessarily partners in the project for two reasons: 1) data cooperation and 2) utilizing their expert knowledge required at different stages of the assessment.

Compiling and harmonizing the data will be among the most crucial, time-consuming and laborious tasks. Although this preliminary report serves the purpose of identifying and assessing the existing datasets, it has to be acknowledged that not all existing data could be scrutinized within the constricted limits of this project – this concerns especially data from the Norwegian and Russian parts of the GBF. Earlier experiences (e.g. in the BPAN project) have shown that the process of data compilation from Russia may take from several months to a year due to bureaucratic formalities.

[2] Comprising the former MTT Agrifood Research Finland, the Finnish Forest Research Institute (Metla), the Finnish Game and Fisheries Research Institute (RKTL) and the statistical services of the Information Centre of the Ministry of Agriculture and Forestry (Tike), as of 1 January 2015

[3] Regional Council of Lapland, Council of Oulu Region, Regional Council of Kainuu, Regional Council of North Karelia, Regional Council of South Karelia, South Savo Regional Council, Regional Council of Kymenlaakso

Expert and stakeholder workshops are necessary for parameterizing the analyses and interpreting and validating the results. The amount of required workshops depends on the selected methodology and the number of separate regions to be assessed. For each region, we recommend organizing four joint workshops for experts and stakeholders: 1) a workshop for discussing the regional data, most essential ecosystems, ecosystem services, habitats, species and other regional characteristics to take into account, 2) a scoring workshop for the parameterization of the ecosystem services analyses, 3) a workshop for the parameterization of the connectivity analyses, and 4) viewing, validating and critically assessing the preliminary results of the analyses. In order to secure proper attendance at these workshops, we recommend reserving adequate funding for covering the travel expenses of the participants in the project budget.

We also recommend establishing a decent online platform for the project for two purposes: 1) communication with stakeholders and the wider public (extranet) and 2) facilitation of the project work (intranet). Providing timely, meaningful and comprehensible information on the aims, progress and results of the assessment gives incentive for stakeholders to commit to the project. Providing an easy-to-use, stable and secure platform for project partners facilitates data exchange and more efficient project management and coordination. The online platform could also include a map interface to a continuously updated database, where the stakeholders and wider public could input, for example, important locations, routes and other features from the perspective of ecosystem services supply and demand, based on their experience and expertise.

WP 0A: Project coordination and management

Duration: months 01–24 (throughout the project)
Estimated resources: 3–4 man months

WP 0B: Communication and reporting

This work package includes establishing and maintaining the project extranet and intranet online platform, preparing necessary communications materials for the workshops, and reporting on the project.
Duration: months 01–24 (throughout the project)
Estimated resources: 3–5 man months

WP 1: Compiling the data

This work package includes compiling and harmonizing the required data for the analyses, for each region. Regional co-operation is highly important in compiling the data. Therefore, the first regional workshop (organized jointly with WPs 3 and 4) of each region should be held at an early stage of the project and concern the available regional data among other issues.
Duration: months 01–12
Estimated resources: 6–8 man months

WP 2: Full-scale analysis of the connectivity

This work package includes conducting a full-scale analysis of the connectivity of the whole GBF using, for example, Morphological Spatial Pattern Analysis and landscape permeability analyses. For the sake of robustness, various parameterizations and focus species are recommended.

Duration: months 13–14
Estimated resources: 2–4 man months

WP 3: Regional analyses on the connectivity

This work package includes conducting regional analyses on the connectivity of the GBF, using, for example, a combination of graph-theoretic approaches and Morphological Spatial Pattern Analysis. For each region, a few species and/or genera of interest are selected for the assessment. The selected species can vary between regions, but at least one common parameterization is used for all regions (consistent with the full-scale analysis of the connectivity) to ensure comparability and meaningful synthesis of the regions. A series of regional expert and stakeholder workshops are organized jointly with WPs 1 and 4. Before conducting the analyses, all regional workshops – except the one for validating the results – need to be held. This is necessary for going through the results of the workshops and synthetizing them into coherent parameterization and specifications for the regional analyses.
Duration: months 01–24
Estimated resources: 12 man months

WP 4: Regional analyses on the ecosystem services

This work package includes conducting regional analyses on the supply and demand of the ecosystem services, using, for example, a combination of quantitative data, matrix-based methods, PPGIS methods and other GIS analyses on potential demand. Matrix-based methods are used for assessing the supply of those ecosystem services that cannot be covered with quantitative data. In ecosystem services analyses, not only the biophysical but also the socio-cultural aspects need careful consideration. Therefore, the expert and stakeholder input from the regional workshops (organized jointly with WPs 1 and 3) are especially essential.
Duration: months 01–24
Estimated resources: 12–18 man months

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APPENDIX

The reviewed datasets

Coverage	Theme	Data	Data type	Data source	
Cross-border datasets	Protected areas	”Data on existing, planned protected areas and high conservation values in the Barents Region (BPAN project)”	Vector	Finnish Environment Institute	
		Nature reserves/parks, national parks of Karelia region (EUREGIO-Karelia project 2000)	Vector	National Land Survey of Finland	
	Land Cover and Land Use	Barents Region Land Cover data (used in BPAN project)	Raster	Finnish Environment Institute	
		”Hybrid Land Cover of Russia: Land cover classification 300 m resolution”	Raster	International Institute for Applied System Analysis	
		”Hybrid Land Cover of Russia: Land cover classification 1 km resolution”	Raster	International Institute for Applied System Analysis	
		”EUREGIO-Karelia project 2000: Land cover areas including glaciers, forests and open wetlands”	Vector	National Land Survey of Finland	
		GIT Barents: Spatial data of the Barents Region	Vector	National land survey of Finland	
		”Other (commercial and free) land cover data e.g. Global Land 1 km AVHRR data, GTOPO30 Digital Elevation Model”	”Raster/ Vector”	Multiple data providers	
	Forest areas	KARLANDS: Quiet areas	Vector	NLS, SYKE/Corine and Karlands; made using spatial criteria offered by HiKuMa project	
		KARLANDS: Forest age	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
		KARLANDS: Forest average length	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
		KARLANDS: Forest volume	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
		KARLANDS: Volume spruce	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
		KARLANDS: Volume pine	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
		KARLANDS: Volume birch	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
		KARLANDS: Volume other broadleafs	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	

Data producers and contributors	Spatial scale	Coverage	Cost	Restrictions for use
Finnish Environment Institute, the Barents EuroArtic Region, Ministry of the Environment, World Wildlife Fund, Nordic Council of Ministers, Norwegian Directorate for Nature Managment, Svedish Environmental Protection Agency	Varies regionally	”Barents Region: Northern Finland, Norway and Russia”	Free of charge	Official request for the data is needed from the partners
National Land Survey of Finland, Parties of Barents GDB 2000	1: 250 000	Karelia region	Free of charge	Data exist, but owner unclear
Finnish Environment Institute, The Barents Euro Artic Region, Ministry of the Environment, World Wildlife Fund, Nordic Council of Ministers, Norwegian Directorate for Nature Managment, Svedish Environmental Protection Agency	Varies regionally: Compatible with Finnish Corine Land Cover 2006	”Barents area: Northern Finland, Norway and Russia”	Free of charge	Official request for the data is needed from the partners
International Institute for Applied System Analysis	300 m	”Russia, part of Finland, Northern Norway”	Free of charge	Free use licence
International Institute for Applied System Analysis	1 km	Russia	Free of charge	Free use licence
”National Land Survey of Finland, Parties of Barents GDB 2000”	1: 250 000	Karelia region	Free of charge	Data exist, but owner unclear
National Land Survey of Finland, Norwegian Mapping and Cadastre Authority, National Land Survey of Sweden, Federal Service of Geodesy and Cartography of Russia, European Union		North-western Russia and the northernmost parts of Finland, Sweden and Norway.	Free of charge	Data available according to the website
Multiple data producers and contributors	Multiple scales	”Global/ regional”	”Commercial/free of charge”	Varies according to datasets
NLS, SYKE/Corine and Karlands; made using spatial criteria offered by HiKuMa project		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Free use licence
KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only

Coverage	Theme	Data	Data type	Data source	
Cross-border datasets		KARLANDS: Clearcuts	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
		KARLANDS: Fire risk areas	Raster	KARLANDS project. Map service: http://karlands.maps.arcgis.com	
	Remote Sensing	Landsat 8 -satellite images	Raster	USGS	
		1 km MODIS-based Maximum Green Vegetation Fraction	Raster	USGS	
		EO-1: Hyperion sensor -satellite images (hyperspectral data)	Raster	USGS	
		Other (commercial) remote sensing data, e.g. SPOT images, QuickBird	Raster	Multiple data providers	
	Geology and mining	Fennoscandian Ore Deposit Database (FODD): Metallogenic areas of the Fennoscandian shield, metallic mineral deposits of the Fennoscandian shield, industrial mineral deposits of the Fennoscandian shield	Raster	Fennoscandian Ore Deposit Database FODD: http://geomaps2.gtk.fi/website/fodd/viewer.htm	
Finnish datasets	Protected areas	Natura 2000 sites	Vector	Finnish Environment Institute	
		Nationally designated nature protected areas and wilderness reserves	Vector	Finnish Environment Institute	
		”Protected areas included in national conservation programmes”	Vector	Finnish Environment Institute	
		State-owned real estate reserved for conservation purposes	Vector	”Metsähallitus ”	
		Conservation areas in national database of regional land use plans	Vector	Finnish Environment Institute	
		Protected state-owned and privately owned forest patches (SAKTI database)	Vector	Metsähallitus	
	Areas of valuable landscapes	Nationally valuable landscape areas in national conservation programmes	Vector	Finnish Environment Institute	
		Valuable landscape areas in the national database of regional land use plans	Vector	Finnish Environment Institute	
	Areas of cultural heritage	Nationally valuable built environment	Vector	Finnish National Board of Antiquities	
		Relics	Vector	Finnish National Board of Antiquities	
		Conserved built heritage areas	Vector	Finnish National Board of Antiquities	
	Mires	Natural mires, drained mires and peatlands in Finland	Raster	Finnish Environment Institute	
		Mires in the Finnish topographic database	Vector	National Land Survey of Finland	

	Data producers and contributors	Spatial scale	Coverage	Cost	Restrictions for use
	KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
	KARLANDS project partners		North Karelia and Kainuu (or part of them), Mujejärvi and Kostamus RUS)	Free of charge	Map service is public, data available for partners only
	USGS/NASA	15 - 100m	Global	Free of charge	Free use licence
	USGS	1 km	Global	Free of charge	Free use licence
	USGS	30 m	Global (may require possible data acquisitions requests)	Free of charge	Free use licence
	Multiple data producers and contributors	Multiple scales	”Global/ regional”	Commercial	Varies
	Geological Survey of Finland, Geological Survey of Sweden, Geological Survey of Norway, The Federal Agency of Use of Mineral Resources of the Ministry of Natural Resources of the Russian Federation	1: 2 000 000	Fennoscandian shield	Free	Free for non-profit purposes
	Finnish Environment Institute, Former Finnish Local Environmental Administrations	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Centres for Economic Development, Transport and the Environment, Former Finnish Local Environmental Administrations, Metsähallitus	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Centres for Economic Development, Transport and the Environment, Former Finnish Local Environmental Administrations, Finnish Transport Agency, Ministry of the Environment	1 : 20 000	Finland	Free of charge	Free use license
	Metsähallitus, National Land Survey of Finland		Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	Finnish Environment Institute, Regional Councils, Ministry of the Environment	1 : 250 000	Finland	Free of charge	Free use -license
	Metsähallitus		Finland	Free of charge	Data available for research in the Finnish Environmental Administration
	Finnish Environment Institute, Former Finnish Local Environmental Administrations, Centres for Economic Development, Transport and the Environment, Ministry of the Environment	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Regional Councils, Ministry of the Environment	1 : 250 000	Finland	Free of charge	Free use license
	Finnish National Board of Antiquities	1 : 20 000	Finland	Free of charge	Free use license
	Finnish National Board of Antiquities	1 : 20 000	Finland	Free of charge	Free use license
	Finnish National Board of Antiquities	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, National Land Survey of Finland	25 m	Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	National Land Survey of Finland	1 : 5 000	Finland	Free of charge	Free use license

Coverage	Theme	Data	Data type	Data source	
Finnish datasets	Geology and mining	Nationally valuable rocky areas	Vector	Finnish Environment Institute	
		Nationally valuable moraine formations	Vector	Finnish Environment Institute	
		Nationally valuable aeolian and beach formations	Vector	Finnish Environment Institute	
		Superficial deposits of Finland	Vector	Geological Survey of Finland	
		Bedrock of Finland	Vector / raster	Geological Survey of Finland	
		Mineral deposits	Vector	Geological Survey of Finland	
		Geological map of Finland, pre-Quaternary	Vector / raster	Geological Survey of Finland	
		+ Other GIS data by Geological Survey of Finland, see Hakku data service: http://hakku.gtk.fi/en/locations/search; Map services: http://en.gtk.fi/informationservices/map_services/; Interface services: http://en.gtk.fi/informationservices/map_services/interfaceservices.html			
	Groundwater	Groundwater formation areas	Vector	Finnish Environment Institute	
		Chemical condition of groundwater areas	Vector	Finnish Environment Institute	
		Volume of the groundwater areas	Vector	Finnish Environment Institute	
	Surface water and drainage basins	Water formations according to the Water Framework Directive (2nd planning period): Ekological condition of water	Vector	Finnish Environment Institute	
		Hydromorphological condition of lakes and rivers: areas where hydromorphological change is low or very low	Vector	Finnish Environment Institute	
		Protected rapids	Vector	Finnish Environment Institute	
	Agricultural areas with high nature values	Areas with high nature values (HNV)	Vector	Finnish Environment Institute	
	Recreation areas	Recreation areas in the national database of regional land use plans	Vector	Finnish Environment Institute	
		Recreation areas (VIRGIS)	Vector	Finnish Environment Institute	
		Routes, areas and service structures from Retkikartta.fi	Vector	Metsähallitus	
	Biotopes	Traditional rural biotopes	Vector	Finnish Environment Institute	
		Natural habitats referred to in the EU Habitats Directive	Raster	Finnish Environment Institute	

	Data producers and contributors	Spatial scale	Coverage	Cost	Restrictions for use
	Finnish Environment Institute	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Geological Survey of Finland	1 : 20 000	Finland	Free of charge	Free use license
	Geological Survey of Finland, Agrifood Research Finland, National Land Survey of Finland, Finnish Forest Research Institute	1: 20 000, 1: 50 000, 1: 200 000, 1: 1 000 000	Finland	Free of charge	Free use licence
	Geological Survey of Finland, Agrifood Research Finland, National Land Survey of Finland, Finnish Forest Research Institute	1: 200 000, 1: 1 000 000, 1: 5 000 000	Finland	Free of charge	Free use licence
	Geological Survey of Finland		Finland	Free of charge	Public license
	Geological Survey of Finland	1: 100 000	Finland (not entirely)	Free of charge	Open license
	Finnish Environment Institute, Centres for Economic Development, Transport and the Environment	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Centres for Economic Development, Transport and the Environment	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Centres for Economic Development, Transport and the Environment	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Centres for Economic Development, Transport and the Environment	1 : 20 000 / 1: 250 000	Finland	Free of charge	Free use license
	Finnish Environment Institute	1 : 20 000 / 1: 250 000	Finland	Free of charge	Free use license
	Finnish Environment Institute	1 : 20 000	Finland	Free of charge	Free use license
	Finnish Environment Institute, Centres for Economic Development, Transport and the Environment		Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	”Finnish Environment Institute, Regional Councils, Ministry of the Environment”	1 : 20 000 / 1: 250 000	Finland	Free of charge	Free use license
	”Finnish Environment Institute, University of Jyväskylä, Municipalities of Finland, Metsähallitus, Ministry of Education and Culture, Recreation Associations”	1 : 20 000	Finland	Free of charge	Free use license
	Metsähallitus		Finland	Subject to a charge	Extraction costs
	Finnish Environment Institute	1 : 20 000	Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	”Finnish Environment Institute, Metsähallitus”	10 km	Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration

Coverage	Theme	Data	Data type	Data source	
Finnish datasets	Land cover and land use	Corine Land Cover 2012	Raster	Finnish Environment Institute	
		Corine Land Cover 2006, Corine Land Cover 2000	Raster	Finnish Environment Institute	
		SLICES 2005	Vector	National Land Survey of Finland	
	Remote Sensing	IMAGE 2012 mosaic	Raster	Finnish Environment Institute	
	Species	”Species from the Environmental Administration data system (TAXON)”	Vector	Finnish Environment Institute	
		Species observations and mapping data (LajiGis database)	Vector	Metsähallitus	
		Nationally important bird areas (IBA)	Vector	Finnish Environment Institute	
		Finland’s important bird areas (FINIBA)	Vector	BirdLife Finland	
		The First and Second Finnish Breeding Bird Atlases	Grid as CSV file / API Interface	Finnish museum of Natural History	
		The Third Finnish Breeding Bird Atlas	Vector / CSV	Finnish Museum of Natural History	
		”Large carnivore populations: lynx, bear, wolverine and wolf observations”	Vector	Finnish Game and Fisheries Research Institute	
		”Moose, white-tailed deer, fallow deer, roe deer population estimations”	Vector	Finnish Game and Fisheries Research Institute	
		Fish species in the fish register	Vector	Finnish Environment Institute	
		”Reindeer husbandry: seasonal reindeer pasture areas ”	Vector	Finnish Environment Institute	
	Forest areas	Valuable forest habitat according to the Finnish Forest Act (Mete sites)	Vector	Finnish Forest Centre	
		Ecological planning of Finnish forest areas		Metsähallitus	
		Data from the dialogue process concerning protected forest areas in Finland		Metsähallitus	
		Forest Biodiversity programme METSO		Metsähallitus	

	Data producers and contributors	Spatial scale	Coverage	Cost	Restrictions for use
	Finnish Environment Institute, Finnish Forest Research Institute, Agency for Rural Affairs, Finnish Transport Agency, Population Register Centre, National Land Survey of Finland: Topographic database 05/2012)	20 m	Finland	Free of charge	Free use licence
	Finnish Environment Institute, Finnish Forest Research Institute, Agency for Rural Affairs, Finnish Transport Agency, Population Register Centre, National Land Survey of Finland: Topographic database 05/2012)	25 m	Finland	Free of charge	Free use licence
	National Land Survey of Finland	1: 50 000	Finland	Free of charge	Free use licence
	Finnish Environment Institute	20 m	Finland	Free of charge	Free use licence
	”Finnish Environment Institute, Centres for Economic Development, Transport and the Environment, Metsähallitus”		Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	Metsähallitus, Centres for Economic Development, Transport and the Environment		Finland	Free of charge	Data available for research. Database ready in 2015
	Finnish Environment Institute, Metsähallitus, Ministry of the Environment, Former Finnish local Environmental Administrations, BirdLife Finland ry	1 : 100 000	Finland	Free of charge	Free use licence
	Finnish Environment Institute, Metsähallitus, Ministry of the Environment, Former Finnish local Environmental Administrations, BirdLife Finland ry		Finland	Free of charge	Free use licence
	Several sources, Over 5000 observers: see http://atlas3.lintuatlas.fi/background and http://atlas3.lintuatlas.fi/taustaa/havainnoijat	10 km grid	Finland	Free of charge	Creative Commons Licence
		10 km grid	Finland	Free of charge	Data will be opened for everybody in the beginning of 2015
	Finnish Game and Fisheries Research Institute	Point data	Finland	”Data extraction cost €115/h + VAT”	Needs to be purchased
	Finnish Game and Fisheries Research Institute	Point data	Finland	Subject to a charge	Needs to be purchased
	Finnish Environment Institute, Game and Fisheries Research Institute, Centres for Economic Development, Transport and the Environment	Point data	Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	”Finnish Environment Institute, Game and Fisheries Research Institute, Regional Council of Lapland, Ministry of the Environment, Lapland’s Centre for Economic Development, Transport and the Environment, Finnish Reindeer Herding Association, Sámi Education Institute, Finnish Forest Research Institute, Lapland University of Applied Sciences, Metsähallitus”		Northern Finland	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	Finnish Forest Centre		Finland	Subject to a charge	Needs to be purchased
	Metsähallitus		Finland		Permission to use not granted
	Metsähallitus, Finnish Association for Nature Conservation, World Wildlife Fund Finland		Finland		Permission to use not granted
	Metsähallitus, Ministry of the Environment, Ministry of Agriculture and Forestry		Finland		Permission to use not granted

Coverage	Theme	Data	Data type	Data source	
Finnish datasets		Finnish Forest Centre's Zonation analysis from the METSO programme	Raster	Finnish Forest Centre	
		Multi-source National Forest Inventory (MS-NFI) 2009	Raster	Finnish Forest Research Institute	
		State-owned nature sites worthy of protection	Vector	World Wild Life Fund Finland	
	Accessibility and population	Digiroad road network	Vector	Finnish Transport Agency	
		Population grid 1 km	Vector grid	Statistics Finland	
		Statistics Finland grid database	Vector grid	Statistics Finland	
Russian datasets	Environmental variables from the Hybrid Land Cover of Russia	Net primary production of forest ecosystems in Russia	Raster	Internationa Institute for Applied System Analysis	
		Soil contribution of carbon budget of forests	Raster	International Institute for Applied System Analysis	
		Soil organic carbon	Raster	International Institute for Applied System Analysis	
		Live biomass of forests	Raster	International Institute for Applied System Analysis	
	"Other multiple datasets of natural resources, biodiversity and specific features of territories in Western Russia"	Geology: bedrock, stratigraphy, Quarternary sediments	Vector	Institute of Geology of Karelian Research Center of Russian Academy of Sciences	
		Geology: soils	Vector	Institute of Geology of Karelian Research Center of Russian Academy of Sciences	
		Hydrography: catchments	Vector	"Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences"	
		"Forests: primeval forests, secondary forests, protective forest along water bodies"	Vector	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences	
		Wetlands: mires and paludified forests	Vector	Institute of Biology of Karelian Research Center of Russian Academy of Sciences	
		Aquatic communitites	Vector	"Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences"	
		Biogeographical zoning: vegetation mapping	Vector	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences, Institute of Biology of Karelian Research Center of Russian Academy of Sciences	
		Ecotourism development areas	Vector	"Institute of Economics of Karelian Research Center of Russian Academy of Sciences"	
		Areas with culutral heritage	Vector	Institute of History, Languages and Literature of Karelian Research Center of Russian Academy of Sciences	

	Data producers and contributors	Spatial scale	Coverage	Cost	Restrictions for use
	Finnish Forest Centre, Ministry of Agriculture and Forestry, Ministry of the Environment, Finnish Environment Institute, University of Helsinki, Metsähallitus, TAPIO	100 m	”Different areas in Finland”	Free of charge	Data available for research. Official Request for the data is needed
	Finnish Forest Research Institute	20 m	Finland	Free of charge	Free use licence
	”World Wild Life Fund Finland, Finnish Nature League, Finnish Association for Nature Conservation, GreenPeace, Birdlife ry”		”Finland: South from Pello-Suomussalmi”	Free of charge	Free use licence
	Finnish Transport Agency	1:5 000 – 1:10 000	Finland	Free of charge	Finnish Transport Agency’s open data licence
	Statistics Finland	1 km	Finland (populated squares)	Free of charge	Free use licence
	Statistics Finland	250 m / 1 km / 5 km	Finland	1 licence for 250 m grid data: €4 800	Licence subject to charge
	International Institute for Applied System Analysis	1 km	Russia	Free of charge	Free use licence
	International Institute for Applied System Analysis	1 km	Russia	Free of charge	Free use licence
	International Institute for Applied System Analysis	1 km	Russia	Free of charge	Free use licence
	International Institute for Applied System Analysis	1 km	Russia	Free of charge	Free use licence
	Institute of Geology of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Institute of Geology of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Institute of Biology of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	”Forest Research Institute of Karelian Research Center of Russian Academy of Sciences, Institute of Biology of Karelian Research Center of Russian Academy of Sciences”		Western Russia		Costs or restrictions might limit data usage
	Institute of Economics of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Institute of History, Languages and Literature of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage

Coverage	Theme	Data	Data type	Data source	
Russian datasets		”Species: fungi, lichens, vascular plants, birds”	Vector	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences	
		Species: algae	Vector	”Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences”	
		Species: fish, mammals	Vector	Institute of Biology of Karelian Research Center of Russian Academy of Sciences	
		Species: mosses	Vector		
		Species: insects	Vector		
Norwegian dataset	Norwegian database	Protected areas			
		Planned protected areas			
		Recreational areas			
		Habitat types			
		Valuable cultural landscapes			
		Areas of contaminated soil			
Regional datasets-case Kainuu	Forest areas	”Classification of sensitive landscape areas in commercial forests”	Vector	Finnish Forest Research Institute	
	Tourism	Kainuu regional plan: nature-based tourism areas and development areas	Vector	Kainuu Regional Council	
	Recreation	Outdoor map of Kainuu	Vector	Infogis Oy	
	Mires	Investigated mires in the preliminary study of the Kainuu mires	Vector	Centre for Economic Development, Transport and the Environment for Kainuu	
		Preliminary study of the Kainuu mires: protected and unprotected mires (over 10 ha) in tourist attraction sites and developing areas	Vector	Centre for Economic Development, Transport and the Environment for Kainuu	

	Data producers and contributors	Spatial scale	Coverage	Cost	Restrictions for use
	Forest Research Institute of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Institute of Northern Water Problems of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
	Institute of Biology of Karelian Research Center of Russian Academy of Sciences		Western Russia		Costs or restrictions might limit data usage
			Western Russia		Costs or restrictions might limit data usage
			Western Russia		Costs or restrictions might limit data usage
			Norway		Available according to the website
			Norway		Available according to the website
			Norway		Available according to the website
			Norway		Available according to the website
			Norway		Available according to the website
			Norway		Available according to the website
	Finnish Forest Research Institute, Finnish Environment Institute, University of Oulu, Forestry Development Centre TAPIO, Ministry of Agriculture and Forestry, Metsähallitus, Kainuu Forest Centre, ProAgria Kainuu, Aalto University, Openspace Research Center		Municipalities of Posio, Kuusamo, Taivalkoski, Suomussalmi, Puolanka, Hyrynsalmi, Ristijärvi, Paltamo, Kuhmo and Sotkamo	Free of charge	Free use license
	Kainuu Regional Council		Kainuu region	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	”Kainuu Environmental Administration, Kainuu municipalities, Kainuu Regional Council”	1: 20 000	Kainuu region	€85 + VAT	
	”Centre for Economic Development, Transport and the Environment for Kainuu”		Kainuu region	Free of charge	Restrictions when using outside of the Finnish Environmental Administration
	”Centre for Economic Development, Transport and the Environment for Kainuu”		Kainuu region	Free of charge	Restrictions when using outside of the Finnish Environmental Administration

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<tr><td>Title of publication</td><td colspan="3">ESGreenBelt – A preliminary study on spatial data and analysis methods for assessing the ecosystem services and connectivity of the protected areas network of the Green Belt of Fennoscandia</td></tr>
<tr><td>Publication series and number</td><td colspan="3">Reports of the Ministry of the Environment 14en | 2015</td></tr>
<tr><td>Abstract</td><td colspan="3">The Green Belt of Fennoscandia forms an ecological network that spans from the Barents Sea all the way to the Baltic Sea. It is a part of the European Green Belt which runs through Europe, starting from the Barents Region and ending in the Balkans. The main body of the Green Belt of Fennoscandia consists of existing and planned protected areas near the shared borders of Finland, Russia and Norway.

The green structure between these protected areas also plays a crucial role in the conservation of biodiversity. In addition to environmental values, the environment of the Green Belt of Fennoscandia provides a variety of ecosystem services which are notable on a local, regional and Europe-wide scale. Supplementing the current scientific knowledge base with information on the region's connectivity and ecosystem services would facilitate the inclusion of these perspectives in the development of the Green Belt of Fennoscandia into a model area for international cross-border nature conservation cooperation.

This preliminary study reviews a number of existing spatial data materials and analysis methods for assessing the Green Belt from the perspectives of the connectivity of the protected areas network and the supply of and demand for ecosystem services. In addition to this, the study provides recommendations regarding the use of materials and methods, and outlines the contents and structure of a potential study spanning the entire region, as well as an assessment of its realisation schedule.

There are a variety of methods for assessing connectivity and ecosystem services. Based on this study, we recommend that the Green Belt should be approached on two different scales: assessments of the general characteristics of the entire Belt should be supplemented with more specific regional assessments. The different parts of the Green Belt differ from one another as regards, for example, vegetation, ecosystems, living environments, population, accessibility, infrastructure and operators. As such, there are also regional differences in the most significant local ecosystem services, their demand and the pressures for change that affect them. We also recommend the use of several different and complementary analysis methods, as none of the analysis methods reviewed alone covers all of the important perspectives related to connectivity and ecosystem services.

A great deal of spatial data suitable for use in assessments has been produced about the Green Belt area, but there are problems regarding the accessibility, uniformity, accuracy and regional coverage of these materials. Because of this, the collection and standardisation of materials requires a great deal of work before an overall assessment of the Green Belt can be carried out. It is particularly difficult to find uniform materials that cover all three nations' areas of the entire Green Belt. The limited regional coverage of the materials also calls for complementary assessments carried out on different scales.

An overall assessment of the Green Belt of Fennoscandia area would require a diverse union of different project partners. Access to some materials requires formal agreements and/or actual project cooperation. For cross-border cooperation, we recommend the utilisation of existing personal relationships and contacts between researchers and authorities. In addition to researchers and authorities, there are a large number of private and public operators who possess valuable expertise on the ecosystems, species and biodiversity of the Green Belt, spanning either the entire Green Belt or specific parts thereof.</td></tr>
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KUVAILULEHTI

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<tr><td>Tekijä(t)</td><td colspan="4">Pekka Itkonen, Arto Viinikka, Vuokko Heikinheimo ja Leena Kopperoinen</td></tr>
<tr><td>Julkaisun nimi</td><td colspan="4">Esiselvitys Fennoskandian vihreän vyöhykkeen ekosysteemipalveluiden ja suojelualueiden kytkeytyneisyyden arviointiin soveltuvista paikkatietoaineistoista ja menetelmistä</td></tr>
<tr><td>Julkaisusarjan nimi ja numero</td><td colspan="4">Ympäristöministeriön raportteja 14en | 2015</td></tr>
<tr><td>Tiivistelmä</td><td colspan="4">Fennoskandian vihreä vyöhyke muodostaa Barentsinmereltä Itämerelle asti ulottuvan ekologisen verkoston. Se on osa Euroopan vihreää vyöhykettä, joka kulkee Barentsin alueelta Euroopan läpi Balkanille. Fennoskandian vihreän vyöhykkeen rungon muodostavat jo olemassa olevat ja suunnitellut suojelualueet Suomen, Venäjän ja Norjan yhteisten rajojen tuntumassa.

Myös suojelualueiden välisellä viherrakenteella on tärkeä osansa luonnon monimuotoisuuden turvaamisessa. Luontoarvojen lisäksi Fennoskandian vihreän vyöhykkeen luonto tarjoaa useita eri ekosysteemipalveluita, joilla on merkitystä paikallisessa, alueellisessa ja koko Euroopan mittakaavassa. Jos nykyistä tieteellistä tietopohjaa täydennetään alueen kytkeytyneisyyttä ja ekosysteemipalveluita koskevalla tiedolla, voidaan nämä näkökulmat huomioida entistä paremmin kehitettäessä Fennoskandian vihreästä vyöhykkeestä kansainvälistä rajat ylittävän luonnonsuojeluyhteistyön mallialuetta.

Tässä esiselvityksessä luotiin katsaus tiettyihin olemassa oleviin paikkatietoaineistoihin ja analyysimenetelmiin, joilla vihreää vyöhykettä voitaisiin arvioida suojelualueverkoston kytkeytyneisyyden ja ekosysteemipalveluiden tarjonnan ja kysynnän näkökulmista. Lisäksi tehtiin suosituksia aineistojen ja menetelmien käyttöön liittyen sekä luonnosteltiin mahdolliselle koko vyöhykettä koskevalle selvitykselle sisältö, rakenne ja arvio toteuttamisaikataulusta.

Kytkeytyneisyyden ja ekosysteemipalveluiden arviointiin on olemassa useita erilaisia menetelmiä. Selvityksen perusteella suosittelemme lähestymään vihreää vyöhykettä kahdessa eri mittakaavassa: koko vyöhykkeen yleispiirteistä arvioita tulisi täydentää tarkemmilla alueellisilla arvioilla. Vihreän vyöhykkeen eri osat ovat keskenään erilaisia muun muassa kasvillisuuden, ekosysteemien, elinympäristöjen, väestön, saavutettavuuden, infrastruktuurin sekä toimijoiden osalta. Näin ollen alueellisia eroja on myös paikallisesti merkittävimmissä ekosysteemipalveluissa, niiden kysynnässä ja niihin vaikuttavissa muutospaineissa. Suosittelemme myös käyttämään useita eri analyysimenetelmiä tukemaan toisiaan, sillä mikään arvioitu analyysimenetelmä ei yksinään kata kaikkia tärkeitä kytkeytyneisyyteen ja ekosysteemiapalveluihin liittyviä näkökulmia.

Vihreän vyöhykkeen alueelta on tuotettu paljon arviointiin soveltuvaa paikkatietoaineistoa, mutta aineistojen saatavuudessa, yhdenmukaisuudessa, tarkkuudesssa ja alueellisessa kattavuudessa on ongelmia. Tästä johtuen on tehtävä paljon työtä aineistojen kokoamiseksi ja yhdenmukaistamiseksi, jotta alueelta voitaisiin tehdä yhtenäinen arvio. Erityisesti yhdenmukaisia, kolmen valtion alueelta koko vihreän vyöhykkeen kattavia ainestoja on vaikea löytää. Myös aineistojen suppea alueellinen kattavuus puhuu toisiaan täydentävien eri mittakaavaisten tarkastelujen puolesta.

Koko Fennoskandian vihreän vyöhykkeen alueelta tehtävä arvio vaatisi monipuolisen erilaisten hankekumppanien yhteenliittymän. Joidenkin aineistojen saaminen edellyttää muodollisia sopimuksia jat/tai tosiasiallista hankeyhteistyötä. Rajat ylittävässä yhteistyössä suosittelemme hyödyntämään jo olemassa olevia tutkijoiden ja viranomaisten välisiä keskinäisiä henkilösuhteita ja kontakteja. Tutkijoiden ja viranomaisten lisäksi on olemassa suuri määrä yksityisiä ja julkisia toimijoita, joilla on arvokasta asiantuntemusta vihreän vyöhykkeen ekosysteemeistä, lajeista ja luonnon monimuotoisuudesta, koskien koko vihreää vyöhykettä tai tiettyjä osia siitä.</td></tr>
<tr><td>Asiasanat</td><td colspan="4">Fennoskandian vihreä vyöhyke, ekosysteemipalvelut, paikkatieto</td></tr>
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www.ym.fi/julkaisut</td></tr>
<tr><td>Julkaisun kustantaja</td><td colspan="4">Ympäristöministeriö</td></tr>
<tr><td>Painopaikka ja -aika</td><td colspan="4">Helsinki 2015</td></tr>
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The Green Belt of Fennoscandia forms an ecological network that spans from the Barents Sea all the way to the Baltic Sea. It is a part of the European Green Belt which runs through Europe, starting from the Barents Region and ending in the Balkans. The main body of the Green Belt of Fennoscandia consists of existing and planned protected areas near the shared borders of Finland, Russia and Norway.

The green structure between these protected areas also plays a crucial role in the conservation of biodiversity. In addition to environmental values, the environment of the Green Belt of Fennoscandia provides a variety of ecosystem services, which are notable on a local, regional and Europe-wide scale. Supplementing the current scientific knowledge base with information on the region's connectivity and ecosystem services would facilitate the inclusion of these perspectives in the development of the Green Belt of Fennoscandia into a model area for international cross-border nature conservation cooperation.

This preliminary study reviews a number of existing spatial data materials and analysis methods for assessing the Green Belt from the perspectives of the connectivity of the protected areas network and the supply of and demand for ecosystem services. In addition to this, the study provides recommendations regarding the use of materials and methods, and outlines the contents and structure of a potential study spanning the entire region, as well as an assessment of its realisation schedule.

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