Faculty of Life Science

Department for Nature Conservation, Vegetation- and Landscape Ecology

Project name: TransEcoNet

"Transnational ecological networks"

This project is implemented through the CENTRAL EUROPE Programme and co-financed by the ERDF

WP5

Action 5.5.4

Output XV - May 2012

Ecosystem services

CORE OUTPUT

ECOSYSTEM SERVICES

IMPLEMENTATION OF THE CONCEPT OF ECOSYSTEM SERVICES IN PROTECTED AND NON-PROTECTED TRANSBOUNDARY REGIONS

Authors:

Sylvi Bianchin[2], Anna Hermann[1], Christa Hainz-Renetzeder[1], Éva Konkoly-Gyuró[4], Markus Hollaus[3], Michael Kuttner[1], Werner Mücke[3], Marco Neubert[2], Norbert Pfeifer[3], Hana Skokanová[5], Ágnes Tirászi[4], Sonja Völler[1], Thomas Wrbka[1], Tamara Zhuber[1], Katharina Zmelik[1] (authors are listed alphabetically)

[1]*PP05 – Dept. of Conservation Biology, Landscape- and Vegetation Ecology, University of Vienna, Vienna, Austria*

[2]*PP02 – Leibniz Institute of Ecological and Regional Development (IOER), Dresden/Germany*

[3]*PP04 – Dept. of Geodesy and Geoinformation, Vienna University of Technology*

[4]*PP09 – University of West Hungary, Department of Surveying and Remote Sensing, Sopron/Hungary*

[5]*PP12 – Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Pub. Res. Inst., Brno*

With contributions of:

PP06 – Austrian League for Nature Conservation Burgenland

PP07 - University of Jan Evangelista Purkyně in Ústí nad Labem, Faculty of the Environment, Ústí nad Labem/Czech Republic

University of Natural Resources and Life Sciences, Vienna, Department of Landscape, Spatial and Infrastructure Sciences, Institute of Landscape Development, Recreation and Conservation Planning

TABLE OF CONTENTS

1 Abstract 6

2 Ecosystem services – case studies 8
2.1 Abstract: Ecosystem services – case studies 9
2.2 Landscape services in the investigation area of the Project region Central South 11
2.2.1 Introduction 11
2.2.2 Investigation area Neusiedler See/Fertő 16
2.2.3 Concept of actual service assessment 17
2.2.3.1 Habitat and regional approach: *Provision, Habitat, Regulation*, *Carrier* (partly) 19
2.2.3.1.1 Sampling and identification of representative validation areas 19
2.2.3.1.2 Service assessment 23
2.2.3.2 Socio-cultural approach: *Information* services and touristic services 26
2.2.3.2.1 Socio-cultural approach on ‘aesthetic information’, ‘cultural and artistic information’, ‘spiritual and historic information’, ‘science and education’ 27
2.2.3.2.2 Socio-cultural approach: Touristic services 37
2.2.3.3 Upscaling of Landscape Service Values from single landscape elements to LFT 47
2.2.4 Results - Actual landscape service provision 49
2.2.4.1 Socio-cultural approach 49
2.2.4.2 Habitat approach 50
2.2.4.3 Spiderweb diagrams of each Landform 53
2.2.4.4 Critical view and conclusions on our methods 57
2.3 Landscape services in four investigation areas in the Project region Central North 59
2.3.1 Introduction 59
2.3.2 Methodology 59
2.3.3 Results 60
2.3.3.1 Regulation services 60
2.3.3.1.1 Climate regulation 60
2.3.3.1.2 Disturbance prevention 63
2.3.3.1.3 Water regulation 65
2.3.3.1.4 Water supply 67
2.3.3.1.5 Soil retention 69
2.3.3.1.6 Soil formation 71
2.3.3.1.7 Nutrient regulation 73
2.3.3.1.8 Pollination 75
2.3.3.2 Habitat services 77
2.3.3.2.1 Refugium service 77
2.3.3.2.2 Nursery service 79
2.3.3.3 Provision services 81
2.3.3.3.1 Food 81
2.3.3.3.2 Raw materials 83
2.3.3.3.3 Genetic resources 85
2.3.3.3.4 Medicinal resources 87
2.3.3.4 Information services 89
2.3.3.4.1 Science and education 89
2.3.3.5 Carrier services 91
2.3.3.5.1 Habitation 91
2.3.3.5.2 Cultivation 93
2.3.3.5.3 Waste disposal 95
2.3.3.5.4 Transportation 97
2.3.3.6 Summary of service assessment 99
2.4 Landscape services in the investigation area of the Northern Project region 101

2.4.1 Investigation area ... 101
2.4.2 Data and data preparation ... 103
2.4.3 Methodology ... 111
2.4.3.1.1 Results ... 114

3 Catalogue of planning measures ... 120
3.1 Introduction ... 121
3.2 Catalogue of planning measures for BR Neusiedler See ... 122

4 Structural framework of planning measures ... 125
4.1 Abstract: Structural framework of planning measures ... 126
4.2 Introduction ... 127
4.2.1 Problem identification ... 127
4.2.2 Research questions ... 128
4.3 Material and Methods ... 129
4.3.1 UNESCO's Man and the Biosphere Programme: description of Seville strategy ... 129
4.3.2 Seville conform Leitbild creation ... 129
4.4 Results ... 133
4.4.1 Actual services ... 133
4.4.2 Potential Seville conform services ... 133
4.4.2.1 Core area of the BR ... 133
4.4.2.2 Buffer and Transition zone of the BR ... 134
4.4.2.2.1 Stakeholder participation process: Information and Carrier Services ... 134
4.4.2.2.2 Combined results of stakeholder participation and expert evaluation ... 137
4.4.3 Communication ... 140
4.4.3.1 Information workshops in Illmitz 2009 and 2011 ... 140
4.4.3.2 Communication with decision makers ... 143
4.5 Conclusions ... 144
4.5.1 Discussion and recommendations for Biosphere Reserve Neusiedler See ... 144
4.5.1.1 General feedback on the label “Biosphere Reserve” ... 144
4.5.1.2 Project team´s opinion (based on our results) ... 145
4.5.1.3 Outsiders view (reflection on the newspapers) ... 145
4.5.1.4 Possibilities of Cooperation ... 145
4.5.1.5 Recommendations for Biosphere Reserve „Neusiedler See“ ... 146
4.5.2 The ecosystem service concept as a structural framework of planning measures ... 146
4.5.2.1 Critical view on the stakeholder implementation process ... 146
4.5.2.2 General recommendations for structural framework of planning measures ... 147

5 Assessing the biodiversity of ecological networks with airborne laser scanning ... 148
5.1 Introduction ... 149
5.2 Description of the study area and data ... 149
5.2.1 Study area ... 149
5.2.2 Field data ... 150
5.2.3 ALS data ... 150
5.2.3.1 Full-waveform ALS ... 150
5.2.3.2 Data acquisition and quality check ... 150
5.2.4 Basic digital height models ... 150
5.3 Methods ... 151
5.3.1 Derivation of a building and a vegetation mask ... 151
5.3.2 Segmentation of vegetated areas ... 151
5.3.3 Derivation of 3D landscape metrics ... 151
5.3.3.1 Surface-to-volume ratio ... 151
5.3.3.2 Vegetation layer structure ... 152
5.3.4 Delineation of landscape elements ... 152

5.4 Results 152
5.4.1 Building and vegetation mask.. 152
5.4.2 Segmentation of vegetated areas.. 153
5.4.3 Surface-to-volume ratio.. 153
5.4.4 Vegetation layer structure.. 154
5.4.5 Comparison of biotope delineation based on aerial photography and ALS.................. 155
5.5 Conclusion 157
5.6 Acknowledgements 157

6 References 158

1 Abstract

Introduction: Nowadays European cultural landscapes are characterised by a high level of anthropogenic fragmentation and habitat loss which are known as major reasons for the decline of biodiversity in industrialised countries. Countering this development by enhancing connectivity requires an evaluation of the status quo and trends of ecological valuable landscapes. One promising possibility to provide the knowledge basis for sustainable development and management of transnational ecological networks can be the concept of ecosystem functions, goods and services. This scientific concept has experienced increasing attention in the last years as it provides the means of documenting and communicating the importance and benefits of ecosystems and landscape for human society as well as offers promising possibilities for participatory concepts. The present study on ecosystem services and related structural frameworks & planning measures has been carried out within the CENTRAL EUROPE Project TransEcoNet aiming at a comprehensive inventory and the protection of ecological networks in 4 transboundary project regions within Central Europe.

Objectives of this study are:

- to **implement the concept of ecosystem services in selected transboundary areas** along the ecological networks of the project region on different spatial scales.
- to **develop a catalogue of planning measures** for the case study Biosphere Reserve Neusiedler See basing on the general guidelines of a strategy and action plan for sustainable management and providing results that can be implemented in regional and landscape planning processes.
- to **create a structural framework for planning measures** for the case study Biosphere Reserve "Neusiedler See" by **applying a participatory concept** of ecosystem services integrating local and regional stakeholder's knowledge and demands. Analyses are aiming at the identification, measuring and communication of the ecological and socio-cultural values of the region for the implementation of a redesigned Biosphere Reserve following Seville standards.
- to test the **innovative method of airborne laser scanning for assessing diversity of habitats** in ecological networks of the investigation area Neusiedler See/Fertő.

Methods: In our project the classification of landscape services and functions are mainly based on de Groot (2006). As local people define their environment more as a 'landscape' than as an 'ecosystem' we preferred the term 'landscape services' as a specification of ecosystem services.

Landscape services assessment: The approach has been carried out in the Northern Project Region (Focal area: Elbe Sandstone Mountains D/CZ), Central Project Region North and the Central Project Region South (Focal area: Neusiedler See /Fertő A/H). Within the first stage of this study landscape services were grouped into five adapted main categories: *Regulation, Habitat, Provision, Information* and *Carrier* services (including 21 sub-services). We developed a methodological framework for assessing and mapping landscape services based on spatial information as well as field data. In order to accomplish a comprehensive analysis, different levels of service assessment considering location and spatial extent were distinguished within the different investigation areas. The habitat approach focused on the assessment of landscape services of *Regulation, Habitat* and *Provision* directly at the landscape element scale. For the socio-cultural approach focusing on *Information* services and tourism facilities landscape metrics, biophysical and socio-economic landscape components were used to describe the capacity to provide services at the level of Landscape Character Types.

Catalogue of planning measures: Analyses of this action have been carried out in the Central Project Region South (Focal area: Neusiedler See /Fertő A/H). The catalogue of planning measures bases on the general guidelines of a strategy and action plan for sustainable management of ecological networks (see Action 5.4.3) of the TransEcoNet project. This part of the study consists of the application of this action plan to the case study Biosphere Reserve Neusiedler See by integrating all related project results.

Structural framework of planning measures: This study has been carried out in the Central Project Region South. The investigation area is consisting of the current Biosphere Reserve (BR) Neusiedler See and its surrounding landscapes. The process of integrating the concept of landscape services into landscape planning is based on a structural framework developed by the project partners. Results on the actual state of landscape service provision of above-mentioned studies are providing the basis for a participatory process for sustainable development of the region integrating knowledge of local experts and stakeholders from spatial planning, water management, agriculture, nature conservation and tourism.

Airborne laser scanning: Complementary to other methods of landscape assessment applied in this project the method of airborne laser scanning (ALS) has been carried out in a number of local study sites in the investigation area Neusiedler See /Fertő. In this study the 3D information and penetration capability of ALS is tested for the derivation of novel landscape metrics supporting habitat and landscape assessment.

Results and conclusions:

Landscape services assessment: For the *Project region Central South* the resulting main service values have been visualised in spiderweb diagrams describing the allocation and trade-offs in landscape service provision on Landform level. So landscape service values analysed in the habitat approach can be detected on biotope type level whereas services of the socio-cultural approach are shown on the level of Landscape Character Types. In the *Project region Central North* and *Northern Project region* the spatial distribution and area proportions of the different service values in the investigation areas are described by spatial maps and block diagrams. The aggregation of the main landscape services have been visualised in spiderweb diagrams. Relationships between landscape services and mean functionalities of landscape elements were statistically analysed.

In this study we aimed at assessing a wide range of services to provide a good overview of the benefits people derive from landscapes. In general our analysis showed clearly visible differences in landscape service provision within the investigation areas. Displaying the benefits that landscapes provide for sustaining life our analysis can be used as knowledge basis in landscape planning decision processes and for nature conservation issues. In this respect detailed application and analysis also brought up constructive criticism and knowledge gaps.

Catalogue of planning measures: The generated action plan provides a catalogue of planning measures for sustainable implementation and management of ecological networks & nature conservation projects on the basis of the case study BR Neusiedler See. The visualised catalogue for the BR describes contents and linkages of analysed process steps consisting of legal & administrative frameworks and policies, Citizen Science Interface /Participation and a Status Review & Assessment. A list of recommendations for BR Neusiedler See resulting from Action 5.5.3 is integrated into the action plan.

Structural framework of planning measures: Combined results on landscape services from expert's analyses and stakeholders input are displayed in spiderweb diagrams and are describing differences between the actual and a sustainable Seville-conform landscape service provision. In detail, our results showed different potential and actual landscape services in the individual Landform Types. It can be said that this evaluation has been a first step of stakeholders' knowledge implementation into this structural framework for the BR Neusiedler See and also the first interaction concerning the issue of landscape service provision between project partners and stakeholders. Therefore, points of criticism and experiences from the workshop should be integrated in further analyses.

Airborne laser scanning - an innovative method for habitat assessment: The presented study shows the potential of ALS applications in landscape assessment. The ALS method provides 3D information on the vegetation (e.g. structure of vegetation layer, the compactness of a particular landscape elements), which is of great significance and not derivable with conventional methods based on orthophoto analysis and manual field surveys alone. ALS is capable of delivering additional information for the assessment of landscape elements, which can further be used in the evaluation process and for the derivation of landscape functionality indices.

2 Ecosystem services – case studies

Action 5.5.1

LANDSCAPE SERVICES IN THE INVESTIGATION AREA OF THE PROJECT REGION CENTRAL SOUTH

PP05 – Dept. of Conservation Biology, Landscape- and Vegetation Ecology, University of Vienna, Vienna, Austria

PP09 – Institute of Forest resource Management and Rural Development, The University of West Hungary, Sopron/Hungary

LANDSCAPE SERVICES IN FOUR INVESTIGATION AREAS IN THE PROJECT REGION CENTRAL NORTH

PP12 – Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Pub. Res. Inst., Brno

LANDSCAPE SERVICES IN THE INVESTIGATION AREA OF THE NORTHERN PROJECT REGION

PP2 – Leibniz Institute of Ecological and Regional Development (IOER), Dresden

With contributions of:

PP06 – Austrian League for Nature Conservation Burgenland
PP07 - University of Jan Evangelista Purkyně in Ústí nad Labem, Faculty of the Environment, Ústí nad Labem/Czech Republic
University of Natural Resources and Life Sciences, Vienna, Department of Landscape, Spatial and Infrastructure Sciences, Institute of Landscape Development, Recreation and Conservation Planning

2.1 Abstract: Ecosystem services – case studies

Introduction: Nowadays European cultural landscapes are characterised by a high level of anthropogenic fragmentation and habitat loss which are known as major reasons for the decline of biodiversity in industrialised countries. Countering this development by enhancing connectivity requires an evaluation of the status quo and trends of ecological valuable landscapes. One promising possibility to provide the knowledge basis to meet the needs of a sustainable development and management of transnational ecological networks can be the concept of ecosystem functions, goods and services. This scientific concept has experienced increasing attention in the last years as it provides the means of documenting the importance and benefits of ecosystems and landscape for human society. As local people define their environment more as a 'landscape' than as an 'ecosystem' we preferred the term 'landscape services' as a specification of ecosystem services.

Objectives: The main objective of this action is to implement the concept of ecosystem services in selected transboundary areas along the ecological networks of the project region on different spatial scales. The investigation of landscape services provide regional stakeholders with valuable information on the service provision of transnational ecological networks and can therefore be used as a decision tool in landscape planning processes.

Methods: In our project the classification of landscape services are mainly based on de Groot (2006) and landscape services were grouped into five adapted main categories: *Regulation*, *Habitat, Provision, Information* and *Carrier* services (including 21 sub-services). Within this project we developed a methodological framework for assessing and mapping landscape services based on spatial information as well as field data. In order to accomplish a comprehensive analysis, different levels of service assessment considering location and spatial extent were distinguished within the different investigation areas. The habitat approach focused on the assessment of landscape services of *Regulation, Habitat* and *Provision* directly at the landscape element scale. The capacity values of biotope types to provide services were set up by expert knowledge and linked to the landscape elements of the investigation areas. Within the project region Central South these data were extended by habitat´s specific attributes, so called qualifiers coming from a field survey. For the socio-cultural approach focusing on *Information* services and tourism facilities landscape metrics, biophysical and socio-economic landscape components were used to describe the capacity of landscapes to provide services at the level of Landscape Character Types. In further steps data were aggregated to the main service categories and extrapolated to different spatial levels within the investigation areas.

Results:

Project region Central South: The resulting main service values have been visualised in spiderweb diagrams describing the allocation and trade-offs in landscape service provision on Landform level. For detailed information the individual sub-services have been displayed on the particular assessment levels. So landscape service values analysed in the habitat approach (e.g. water regulation) can be detected on biotope type level whereas services of the socio-cultural approach (e.g. recreation) are shown on the level of Landscape Character Types (e.g. Foothills and basins with historic towns and periurban areas).

Project region Central North: Resulting maps and block diagrams show the spatial distributions and area proportion of the different sub-service values in the investigation areas. Further relationships between landscape services and mean functionalities of landscape elements calculated in the WP 5.1 were analysed in Kruskal-Wallis tests and made visible in box-and-whisker diagrams.

Northern Project region: Results of landscape services are displayed in maps illustrating the distribution of the different main landscape services in the investigation area. Block diagrams show the values of the main functions within each investigation cell. The aggregation of the main landscape services for the whole investigation area is visualised in a spiderweb diagram.

Conclusions: In our study we aimed at assessing a wide range of services to provide a good overview of the benefits people derive from landscapes. In general our analysis showed clearly visible differences in landscape service provisions within the investigation areas. Making landscape services spatially explicit and combining empirical data with spatial information presents an innovative approach to landscape research in the field of visualising and quantifying landscape services. Displaying the benefits that landscapes provide for sustaining life our analysis can therefore be used as knowledge basis in landscape planning decision processes and for nature conservation issues. In this respect detailed application and analysis also brought up constructive criticism and knowledge gaps. Especially incomplete data and availability on different spatial levels is still a limiting factor for the assessment of landscape service provision. Therefore detailed evaluation of data and further research on the application of the ecosystem services concept in regard to different cultural landscapes and European ecological networks is required.

2.2 Landscape services in the investigation area of the Project region Central South

Authors:

Anna Hermann, Michael Kuttner, Christa Hainz-Renetzeder, Thomas Wrbka, Tamara Zhuber, Katharina Zmelik (authors are listed alphabetically)
PP05 – Dept. of Conservation Biology, Landscape- and Vegetation Ecology, University of Vienna, Austria

Éva Konkoly-Gyuró, Ágnes Tirászi
PP09 – Institute of Forest resource Management and Rural Development, The University of West Hungary, Sopron/Hungary

2.2.1 Introduction

An ecosystem may be considered as a unit within which an assemblage of living organisms interacts with each other and with its chemical and physical environment. Human beings benefit from these processes or structures within ecosystems that give rise to a range of goods and services called *'ecosystem services'* (MEA, 2005). Haines-Young and Potschin (2010) provided an assessment framework for linking ecosystems to human well-being, which has been used in several projects, for instance, the TEEB project (TEEB, 2010) (Figure 1). The proposed diagram makes a distinction between ecological processes and functions as well as the provided services and the outputs considered for humans as benefits. Although the general structure of the suggested framework is widely agreed upon, the distinction between the terms *'function'*, *'service'* and '*benefit'* is still under discussion (see Hermann et al., 2011). Another approach is to define functions, services and benefits at landscape scale to integrate the concept into land management decisions (Bastian & Schreiber, 1999; de Groot et al., 2010; Willemen et al., 2010). As local people define their environment more as a 'landscape' than as an 'ecosystem' the term 'landscape services' is preferred as a specification (rather than an alternative) of ecosystem services (Termorshuizen & Opdam, 2009).

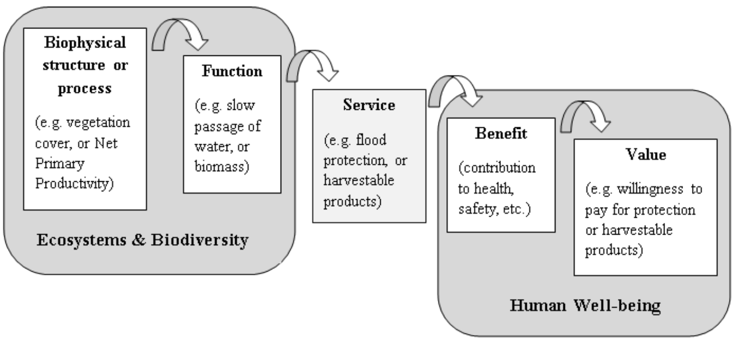


Figure 1: Framework for linking Ecosystems & Biodiversity to Human Well-being (after Haines-Young and Potschin, 2010).

In **our project** we will refer to the concept of **landscape functions**, which can be defined as the

"capacity of ecosystems to provide goods and services that satisfy human needs, directly and indirectly" (de Groot, 1992).

We do not focus on single ecosystems, but we take the entire landscape into account. Most landscapes provide a multitude of functions and are subject to many possible land uses. The function analysis translates the ecological complexity into a limited number of landscape functions at the landscape element or biotope scale, which, in turn, provide a range of goods and services at landscape scale (Figure 2, Figure 3).

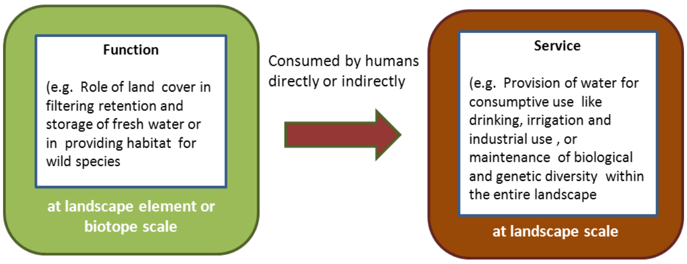


Figure 2: The concept of landscape function and service used in TransEcoNet

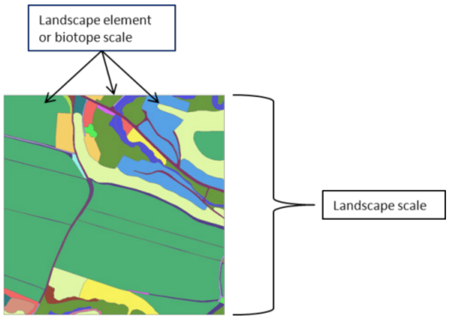


Figure 3: Landscape element or biotope scale vs. landscape scale

Landscape services are, in our definition,

"all goods and services that landscapes provide for sustaining life. It includes potentials, materials and processes of nature (e.g. raw materials, biomass, biodiversity etc.) and services of cultural elements and constructions that come into being through human creation (e.g. buildings, settlements, infrastructure etc.)."

(Definition formulated by Éva Konkoly-Gyuró (PP09) for the TransEcoNet project).

Although the debate of the distinction between 'function', 'service' and 'benefit' and how to put the concepts into practice, is still going on (Hermann et al., 2011), a wide range of authors has attempted to provide a systematic typology and comprehensive framework for integrated assessment and valuation of ecosystem goods and services (see Daily, 1997; de Groot et al., 2002; MEA, 2005; de Groot, 2006; Boyd & Banzhaf, 2007; Fisher & Turner, 2008). The Millennium Ecosystem Assessment (MEA, 2003) provided a simple typology of services that has been widely taken up in the international research and policy literature (TEEB, 2010). However, due to the fact that ecosystem services and functions can be defined in different ways depending on scale and perspective (Daily, 1997) and because of the different aims of assessments, other more extensive and detailed categorisations have been developed (e.g. Bastian, 1997; Perez-Soba et al., 2008; Bakkera and Veldkamp, 2008; Verburg et al., 2009).

In **our project** the classification of landscape services is mainly based on de Groot (2006) and has been adapted to our research issues. Landscape services are grouped into five primary categories:

1. *Regulation services*

These services relate to the capacity of cultural landscapes to regulate essential ecological processes and life support systems through biogeochemical cycles. They maintain a 'healthy' ecosystem at different scale levels and provide important pre-conditions for all other services. Whereas a range of *Regulation* services exist, our project only incorporates those that provide direct and indirect services to humans (such as maintenance of clean water, soil and prevention of soil erosion).

2. *Habitat services*

Natural as well as cultural landscapes provide refuge and reproduction habitats to wild plants and animals and thereby contribute to the maintenance of biodiversity (e.g. genetic diversity as evolutionary potential). The availability or condition of this service depends on the physical components of the ecological niche. As the requirements differ for different species groups they can be defined in terms of the carrying capacity and spatial needs (minimum critical biotope size) of the natural biotope type.

3. *Provision services*

Photosynthesis and nutrient uptake by autotrophic organisms convert energy, carbon dioxide, water and nutrients into a wide range of living biomass. This biomass in turn can be used by humans as food (concerning edible wild plants and animals), raw materials, energy resources and/or genetic resources.

4. *Information services*

Due to their individual characteristics, natural as well as cultural landscapes provide opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experiences.

5. *Carrier services*

These services only refer to cultural landscapes. As most human activities (e.g. cultivation, habitation, and transportation) require a suitable substrate (soil) or medium (water), the use of these services implies the conversion of the natural system into an either semi-natural or artificial system.

Table 1 gives an overview of the services applied in our project. The first column provides a list of the main services and their sub-services and the second column describes the services in detail. The third column sets examples of specific services consumed at the landscape scale.

Table 1: Services of cultural landscapes used in the project TransEcoNet (mainly adapted from de Groot et al. 2002 and de Groot, 2006); services with * are defined in detail below.

Services	Definition	Services (examples)
***Regulation* services**		
Local climate regulation	Influence of biotope type on local climate (mainly buffer function)	Maintenance of a favourable local climate (e.g. temp., moisture etc.) for e.g. human habitation, health, cultivation
Disturbance prevention	Influence of landscape structure on environmental disturbances	Storm protection and/or flood prevention (e.g. flood detention basin, shelter belt)
Water regulation	Role of biotope type in regulating runoff and river discharge	Drainage and natural irrigation
Water supply	Filtering, retention and storage of fresh water	Provision of water for consumptive use (e.g. drinking, irrigation and industrial use)
Soil retention	Role of vegetation root matrix and soil biota in soil retention	Maintenance of arable land; prevention of damage from erosion/siltation
Soil formation	Weathering of rock, accumulation of organic matter	Maintenance of natural productive soils
Nutrient regulation	Role of biota in storage (buffer) and recycling of nutrients (e.g. N, P and S)	Maintenance of healthy and productive ecosystems
Pollination	Role of biota in movement of floral gametes (is there any suitable habitat available for pollinators?)	Pollination of wild plant species and crops

***Habitat* services**		
Refugium service	Suitable living space for wild plants and animals	Maintenance of biodiversity, in particular
* Nursery service	Suitable reproduction habitat	Maintenance of commercially harvested species
***Provision* services**		
Food	Conversion of solar energy into wild edible plants and animals	Maintenance of edible wild plants and fungi (not cultivated), game and fish
Raw materials	Conversion of solar energy into biomass	Material for human constructions (building and manufacturing), like lumber, fuel and energy wood
Genetic resources	Genetic material and evolution in wild plants and animals	Improve crop resistance to pathogens and pests and maintenance of old cultivated plants
Medicinal resources	Variety in chemical substances in natural biota	Drugs and pharmaceuticals
***Information* services**		
Aesthetic information	Attractive landscape features	Enjoyment of scenery (scenic roads, housing etc.
Recreation	Variety in landscapes with (potential) re-creational uses	Travel to natural ecosystems for eco-tourism and (re-creational) nature study
Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architect, advertising, etc.
Spiritual and historic information	Variety in natural features with spiritual	Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features)
Science and education	Variety in nature with scientific and educational value	Use of nature for scientific research
***Carrier* services**		
Habitation	Providing suitable space for human living	Living space (ranging from small settlements to urban areas)
* Cultivation	Providing suitable substrate for cultivation (actual available)	Cultivated food and fodder
Energy conversion	Providing suitable substrate or medium for energy conversion	Energy facilities (solar, wind and water)
Mining	Providing suitable substrate for mining	Minerals, oil, gold
* Waste disposal	Providing suitable substrate for waste disposal	Space for solid waste disposal
Transportation	Providing suitable substrate or medium for transportation	Transportation by land and (water)
Tourism facilities	Providing space and facilities for human activities related to tourism and recreation	Tourism and leisure activities (e.g. outdoor sports)

* Cultivation

The ‘cultivation’ service provides food and raw materials from cultivated land and aquaculture, especially cultivated plants and domesticated animals.

* Nursery service

The ‘nursery’ service provides habitats for juveniles of certain species as it is a suitable reproduction-habitat, e.g. for the maintenance of commercially harvested species. Many ecosystems provide nursery areas to species which, as adults, are harvested elsewhere for either subsistence or commercial purposes (de Groot et al. 2002).

* Waste disposal

This service provides space for whether potential or real solid waste disposal (de Groot, 2006). It is important that the area provides a permanent store of the waste for the duration of its biological and chemical activity.

2.2.2 *Investigation area Neusiedler See/Fertő*

The investigation area is situated on both sides of the border between Hungary and Austria. Altogether an area of 2 015 km² is covered (1 120.8 km² Austrian part and 894.2 km² Hungarian part). The trans-frontier region of the Neusiedler See is part of the Small Hungarian Plain in Central Europe representing the westernmost extension of the Pannonian Basin. It is dominated by the Neusiedler See which lies in a flat basin bordered to the west by uplands. The southern Hungarian part (Fertő) is mainly lowland with gentle hills on the western side. The northern part which belongs to Austria has contrasting western and eastern sides: the former is formed by the pronounced slope zone of a low mountain ridge, whereas the latter, the Seewinkel, represents the lowest land in Austria. In 2001, the whole region Neusiedler See/Fertő was designated an UNESCO World Heritage Site.

The region is characterised by a hot, dry Pannonian climate with an annual precipitation of 700-800 mm and an annual mean temperature of >9°C. In a relatively small area, plants and animals with Alpine, Asiatic and Mediterranean affinities, as well as northern species, are present, resulting in high species diversity. Although its origin can be traced to tectonic movements in the mid-Tertiary, the final shape of the landscape relates to the late Quaternary, when Tertiary sediments were partly covered by glacial clay, sand and loess deposits during glacial periods.

Today two main economy sectors dominate the area: on the one hand intensive agriculture particularly crop-growing, wine growing and greenhouse-vegetable gardening and on the other hand, especially around the lake and focused on rather small places, tourism. The Neusiedler See is one of the most popular tourist destinations in the eastern part of Austria. In the last decades the typical lake tourism changed to a more diversified tourism based on nature, the national park, cycling and other sports activities, cultural traditions and events.

Nowadays the main problem is the growing conflict between these two utilisation claims caused by increasing demand for land for their uses, additionally interfering with nature conservation issues.

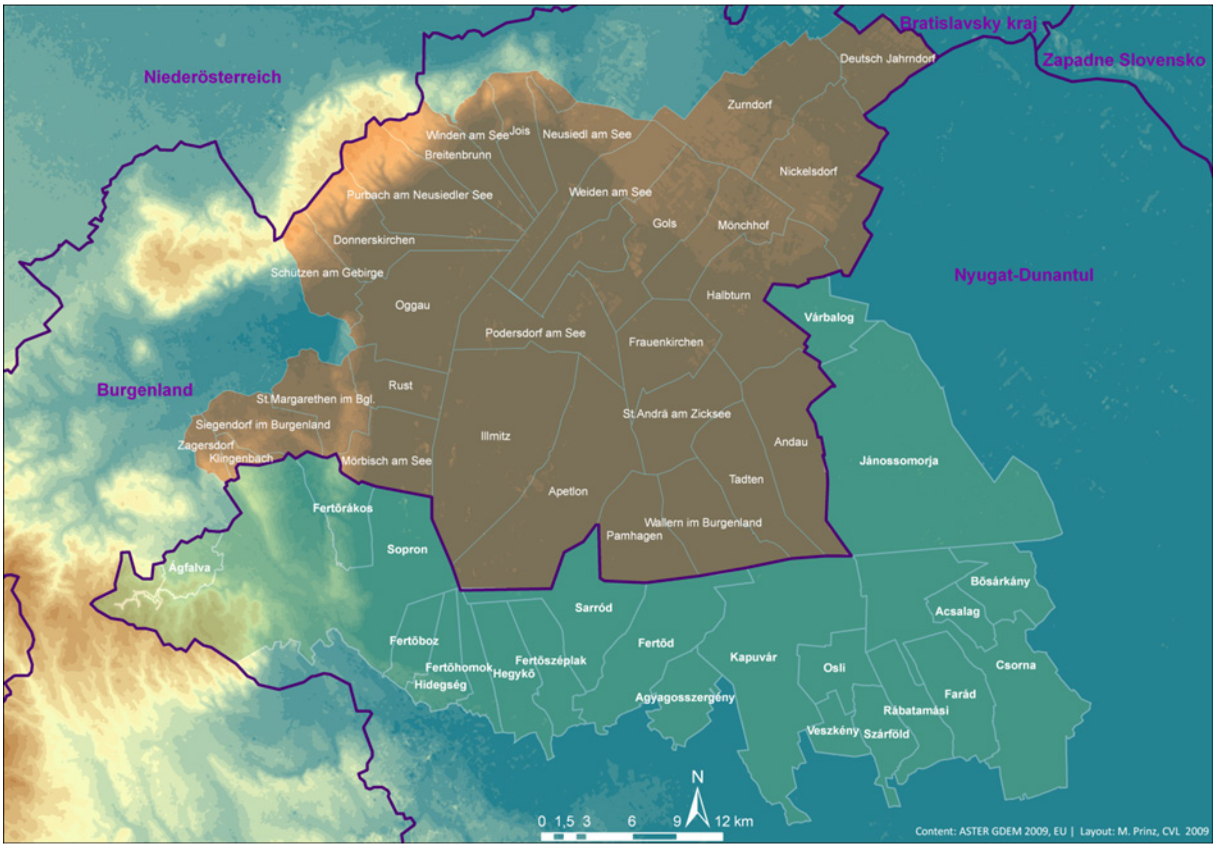


Figure 4: Map of the Austrian and Hungarian investigation area, names of municipalities indicated in white

2.2.3 *Concept of actual service assessment*

The methodological framework is based on the availability of data for the location of the selected landscape services. Driven by the link between landscape services and mappable landscape features two different levels of functional assessment considering location and spatial scale are distinguished (Figure 5):

a. Habitat and regional approach

Landscape services are directly assessed at the landscape element scale. Each service can be related to a specific habitat (biotope type) within the landscape.

b. Socio-cultural approach

For those services that occur at a broader scale than the landscape element level, additional indicators have to be defined.

These two levels of landscape service assessment form the basis of our different service mapping approaches.

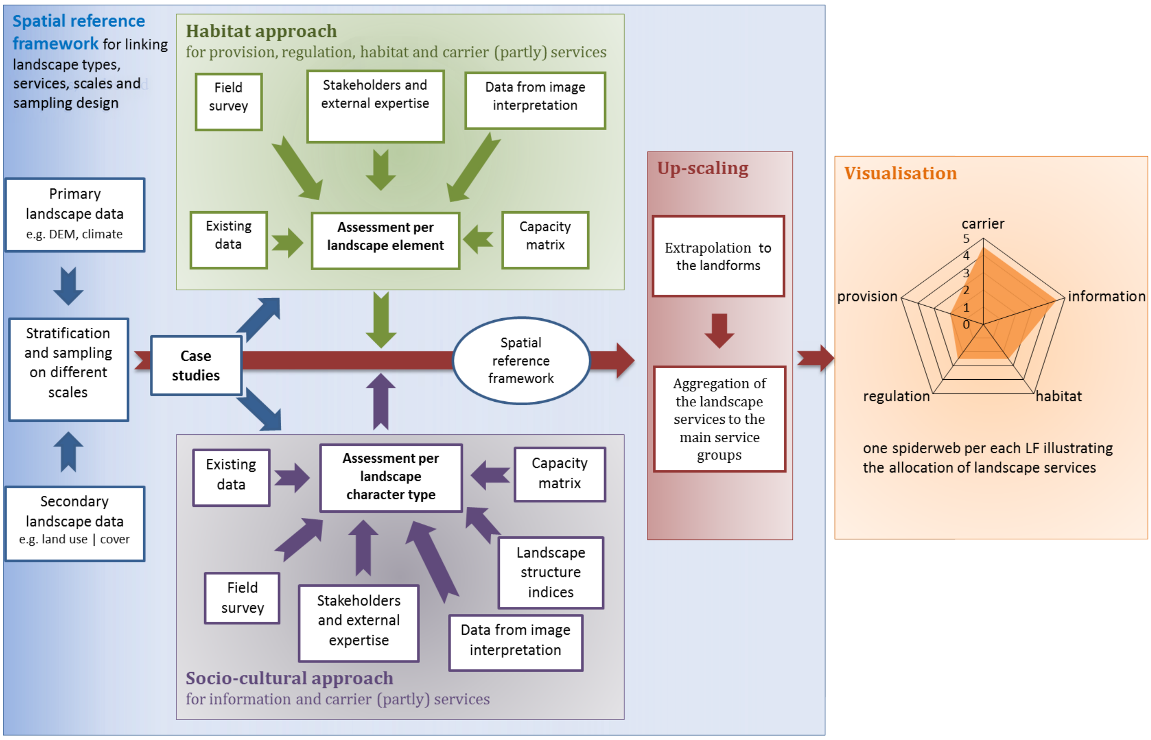


Figure 5: Methodological approach for the assessment of landscape services

For the service evaluation, we defined homogenous spatial units within the project region. Thus, the investigation area was divided into seven Landform Types (LFT) representing the main geomorphological features of the study area: 'Lake basin' (LFT 1), 'Marshlands' (LFT 2), 'River floodplains' (LFT 3), 'Low lying terraces' (LFT 4), 'Elevated terraces' (LFT 5), 'Hilly areas and hill ranges' (LFT 7) and 'Low and middle range mountains' (LFT 8) (see Figure 8) and 14 Landscape Character Types (LCT) illustrating a combination of relief, dominant land cover and land use intensity in the landscapes (Konkoly-Gyuró et al., 2010; after Swanwick, 2002, see Table 2, Figure 6).

Table 2: Landscape Character Types

CODE	super category	Landscape Character Types
1	***Deep, water dominated lowlands***	
1a		Lake basin, with low intensity human use, dominated by reed and wetland
1b		Lake basin, with various intensity of human use, dominated by open water
1c		Satellite lake basins, with low intensity human use, dominated by grassland and divers agriculture
1d		Marshland with low intensity human use, dominated by a mosaic of forest, grasslands and water
2	***Reclaimed marshland, reclaimed lake basin and terrace flatlands***	
2a		Reclaimed marshland and lake basin with low or medium intensity human use, arable- and grassland dominance
2b		Flatland with medium or high intensity human use and dominant homogenous arable land cover
2c		Slightly undulating flatland with medium or high intensity human use and dominant vineyard cover
2d		Slightly undulating flatland with medium or high intensity of human use and heterogeneous land cover
3	***Hill range and low mountains***	
3a		Hill range and foothills with medium intensity human use and heterogeneous land cover
3b		Hill range and foothill with medium or intensive human use and vineyard dominance
3c		Low mountains and foothills with low intensity human use, covered by closed forests
3d		Foothills and basins with historic towns and periurban areas
3e		Foothills and basins with low or medium intensity human use, mainly arable- and grassland dominance

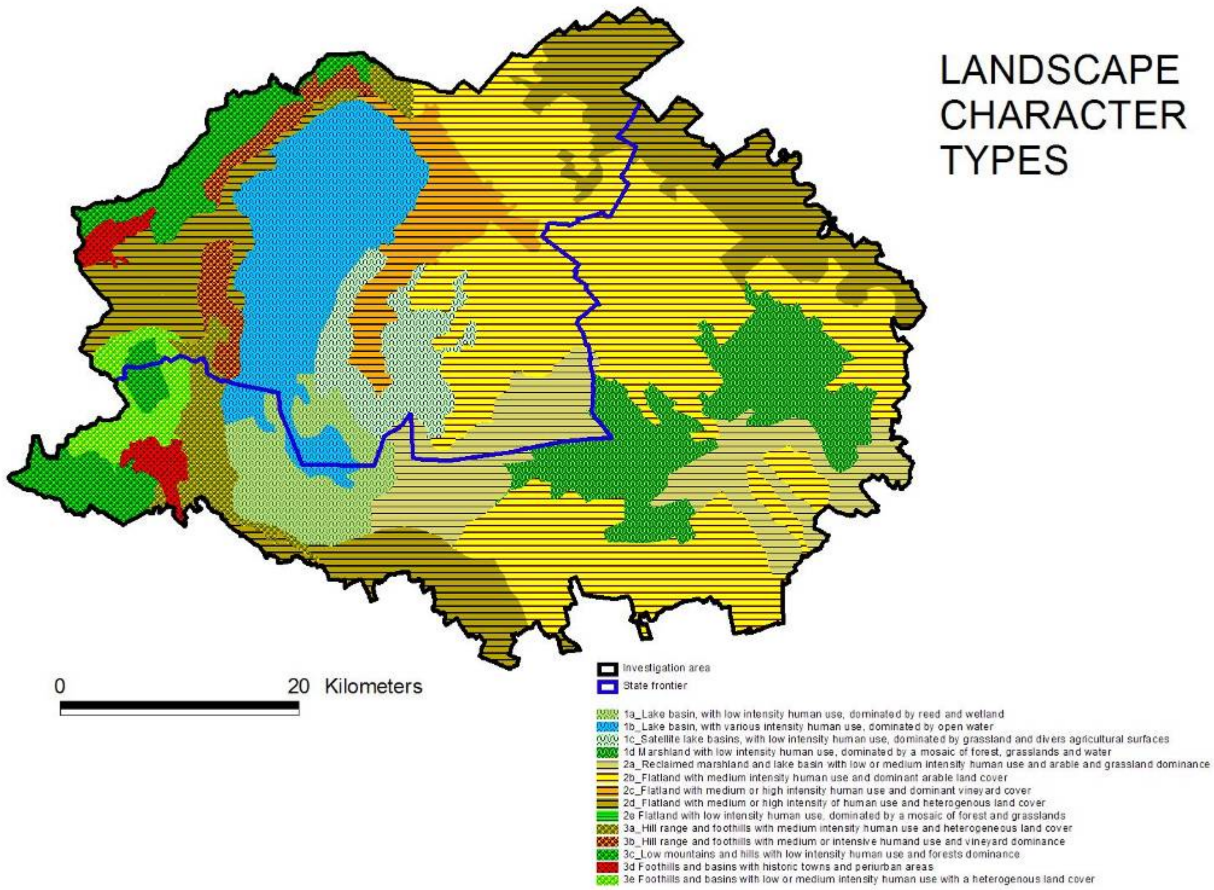


Figure 6: Landscape Character Types in the investigation area

2.2.3.1 Habitat and regional approach: ***Provision, Habitat, Regulation*, *Carrier*** (partly)

The habitat approach (Haines-Young & Potschin, 2008; Burkhard et al., 2009) is based on the use of a matrix of habitats and their related functions. As data availability for specific function indicators (e.g. yield kg per hectare and year for production function or biodiversity index value for an ecological function) is limited or often not comparable or transferable to various areas and scales, the habitat approach provides a good opportunity to map landscape services. A clear advantage of using habitats as a framework to represent the output of landscape services is that distinct ecological units could be considered as 'bundles' of services that they deliver. It is generally known that most ecosystems are multifunctional, as structures and processes within them are capable of generating a wide range of different services (de Groot, 2006). In our project we provide a new advanced assessment strategy for landscape service provision at the landscape scale. It offers great potential to combine expert judgements with semi-quantitative data derived from field data. As spatial reference unit we applied biotope types (land use/cover classes LUC).

2.2.3.1.1 Sampling and identification of representative validation areas

For a statistically correct analysis of data (calculation and comparison), a minimum amount of samples is necessary. Sampling can be either done by a pure random selection or by defining strata which give the basic set of elements which are equally likely to be chosen. At least three samples per category (i.e. stratum) should be selected for minimising variations within a single dataset. So, the first step is the definition of the basic set and the strata which are defining them.

At first, the whole investigation area is overlaid by a regular raster dividing the surface into squares. We used the official European Grid system (Inspire, 2009), based upon the ETRS89 Lambert Azimuthal Equal Area coordinate reference system and which has its centre of the projection at the point 52º N, 10º E and false northing: Y0 = 3.210,000 m, false easting: X0 = 4.321,000 m. In the present study, we used a basic grid-size of 1x1 km with a refinement to 500x500 m (Figure 7).

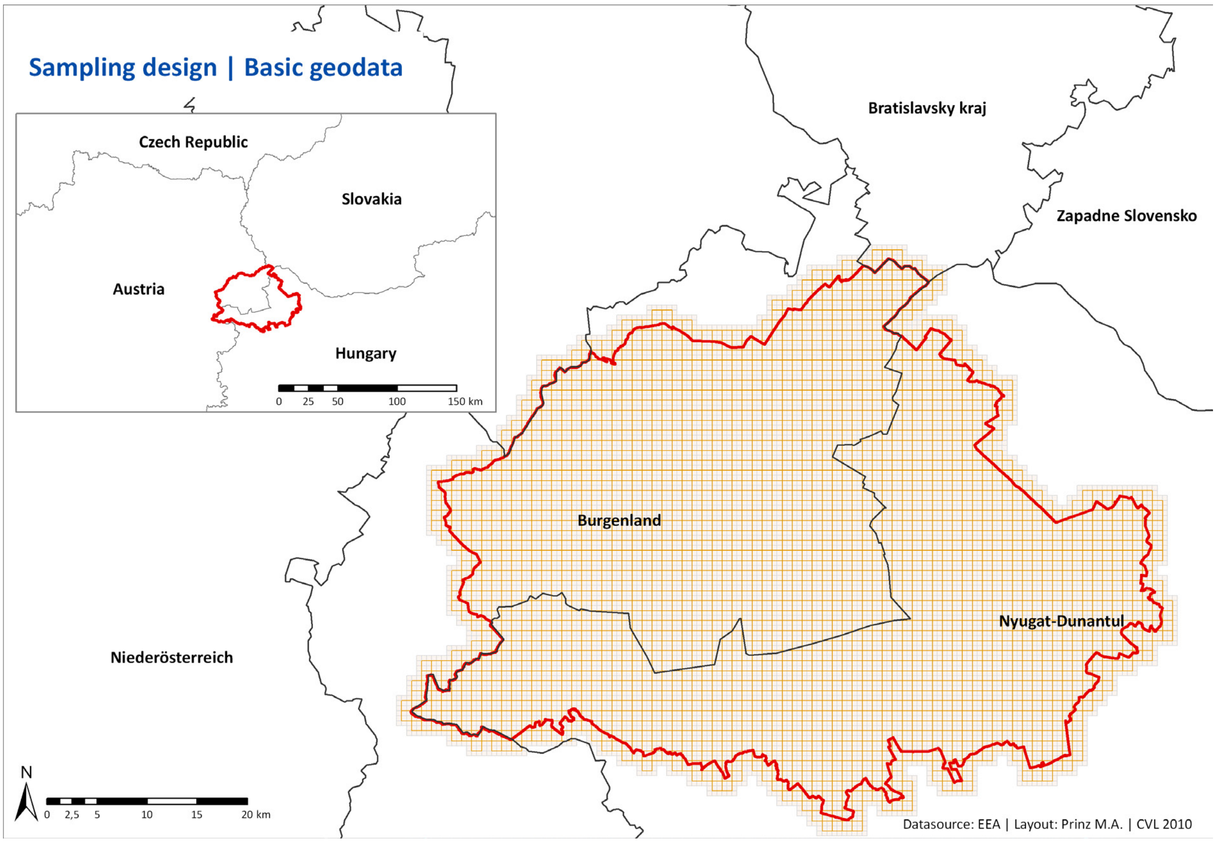


Figure 7: Basic set of raster cells (1x1 km) in the TransEcoNet project region which serves as basis for the selection of sample sites.

In the next step, we overlaid the raster with the geodata information in order to refine the strata:

- Highest level of the Landscape Character Types (Konkoly-Gyuró et al., 2010)
- Location of the Neusiedler See and not accessible areas such as the reed belt
- Extent and location of shallow lakes
- Location of artificial surfaces
- Location of protected areas

In the subsequent stage, a rule-set for the selection of grid-cells was built defining how the attributes of these geodata contribute to the designation of the individual grid-cells to the basic set of the stratification categories:

→ *Selection because of attributes:*

- Selection of grid-cells overlapping more than 99 % within the core area
- Selection of grid-cells overlapping not more than 1 % with not accessible areas (Neusiedler See, large reed belts, steep areas)
- Selection of grid-cells dedicated to one single Landscape Character Type with more than 99 % of the cell-area
- Selection of grid-cells with less than 30 % covered with shallow lakes
- Selection of grid-cells with less than 10 % artificial surface (Basedata: CORINE land cover 2006 (EEA 2006))
- Selection of grid-cells dedicated to a protected/not protected area with more than 75 % of the cell-area

→ *Selection because of spatial position (taking the surrounding 500x500 m squares into account):*

– Selection of grid-cells distant more than 500 m within the core-area-border

– Selection of grid-cells distant more than 400 m within a landscape character-type-border

→ *Random selection of remaining grid-cells:*

– Selection of four grid-cells for each combination of LCT and protected/not protected area

→ *Final selection of three grid-cells depending on optimal land cover/use, available secondary data (e.g concerning agriculture) and/or accessibility*

With each selection rule, the number of potentially selectable grid cells decreased, beginning with >2000 potential sample sites and leaving only 857 remaining grid cells as a basic set for the random sampling per stratum.

The selection of four grid-cells for each combination of LCT and protected/not protected area including the surrounding eight 500 x 500 m grid cells resulted in 54 sample sites (of 56 possible - for LCT '8' and protection status 'unprotected' only 2 grid cells are possible; LCT '6' is not in the wider investigation area – therefore 6*4*2+1*4+1*2 = 54) 1 km² cells (Table 3). 34 sample sites are located in Austria, 20 in Hungary (Figure 8).

Three out of the four sample sites per category were finally chosen for further analysis and field work. The remaining sample sites act as a reserve if any circumstances may hinder the investigation of the selected sites. Therefore, 13 grid cells will not be used for further analysis.

Table 3: Randomly selected grid cells which resulted from the application of the rule set on all possible 1km² sites of the wider investigation area.

ID	cellNr	P/U	LCT	ID	cellNr	P/U	LCT
1	725	1	1	28	258	1	8
2	972	1	1	29	1009	2	1
3	806	1	1	30	927	2	1
4	895	1	1	31	1008	2	1
5	2151	1	2	32	970	2	1
6	1070	1	2	33	1354	2	2
7	1465	1	2	34	1165	2	2
8	1416	1	2	35	2280	2	2
9	1644	1	3	36	1457	2	2
10	1496	1	3	37	1735	2	3
11	1685	1	3	38	2104	2	3
12	1686	1	3	39	1543	2	3
13	1884	1	4	40	1551	2	3
14	1992	1	4	41	1888	2	4
15	770	1	4	42	1425	2	4
16	1670	1	4	43	980	2	4
17	1388	1	5	44	1682	2	4
18	1199	1	5	45	1437	2	5
19	1200	1	5	46	1384	2	5
20	1246	1	5	47	1485	2	5
21	295	1	7	48	1034	2	5
22	270	1	7	49	124	2	7
23	119	1	7	50	206	2	7
24	263	1	7	51	171	2	7
25	16	1	8	52	201	2	7
26	86	1	8	53	194	2	8
27	29	1	8	54	26	2	8

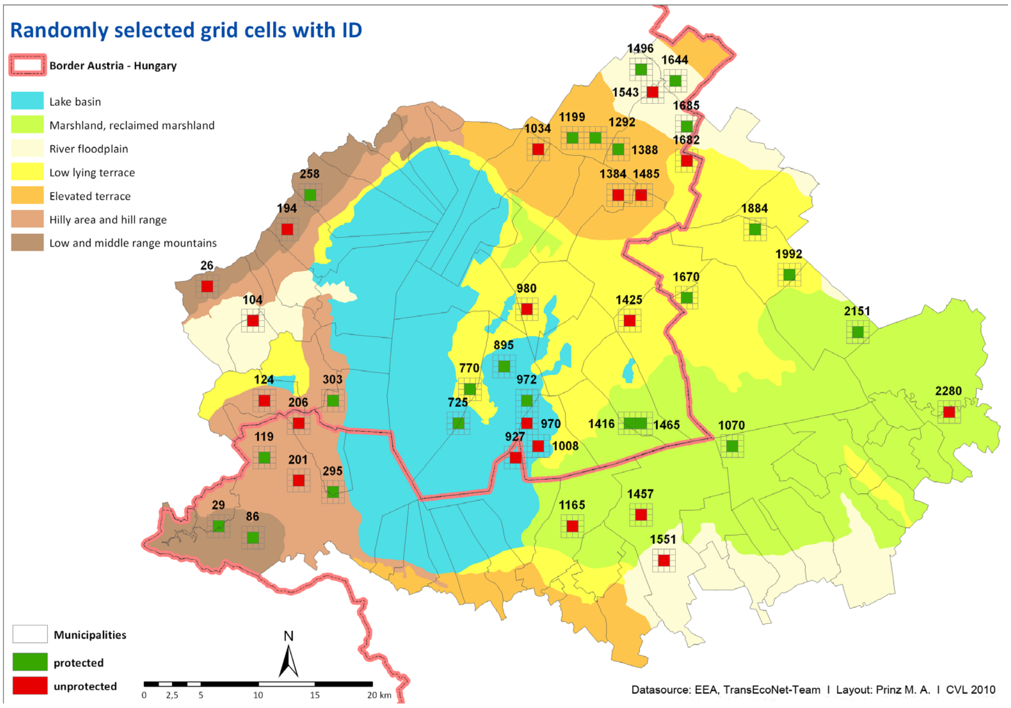


Figure 8: Selected grid cells for further investigation

2.2.3.1.2 Service assessment

During field survey each landscape element was assigned a biotope type. Then the biotope types were linked by expert knowledge with the different biotope types´ capacities to provide various landscape services. Therefore, a capacity matrix was created. The so called Biotope Type Service Value (BIS) was extended in a second step by 'qualifiers' that came from field work. The resulting Landscape Element Service Values (LESV) were extrapolated to the different Landforms, where the individual landscape service values were aggregated to the main service groups, the so called service group values (Figure 9). Below, the individual steps are described in detail (Table 4 - Table 8).

In a first step, biotope types were linked by expert knowledge about the different biotope types´ capacities to provide various landscape services. Therefore, a capacity matrix was created (see Table 4 as an excerpt). Whereas on the x-axis selected landscape sub-services as described in Table 1 (excluding the *Information* services) are placed, on the y-axis the 181 LUCs are placed. At the intersections, different biotope types´ capacities to provide landscape sub-services were assigned. The so-called Biotope Type Service Value (BIS) ranges from 0 to 5. The higher the value, the higher the general relationship between biotope type and service:

0 = no relevant link between LUC and specific service, 1 = low relevant link, 2 = relevant link, 3 = medium relevant link, 4 = high relevant link, 5 = very high relevant link (adapted from Burkhard et al., 2009).

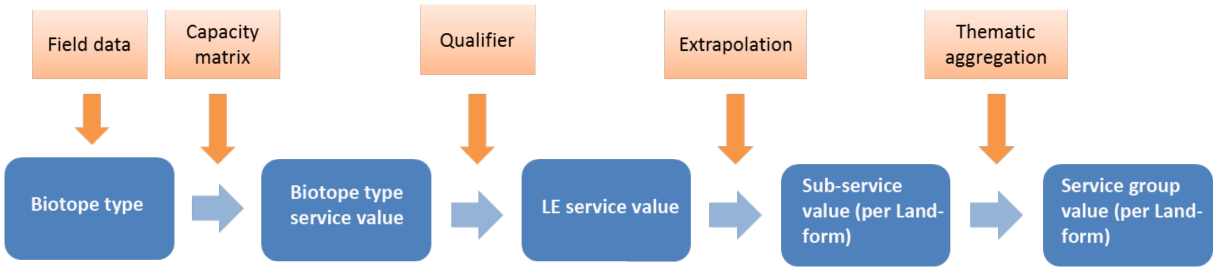


Figure 9: Assessment of the *Regulation, Habitat, Provision* and *Carrier* (partly) services applying the habitat approach; LE: Landscape element

Table 4: Excerpt of the capacity matrix for the assessment of the different links between the biotope types and the related services. The individual services were assessed on a scale consisting of: 0 = no relevant link between LUC and specific service, 1 = low relevant link, 2 = relevant link, 3 = medium relevant link, 4 = high relevant link, 5 = very high relevant link.

	Climate regulation	Disturbance prevention	Pollination	Refugium service	Soil formation
Grain fields extensive	0	1	2	2	3
Forage crops	0	2	3	1	3
Root crop extensive	0	1	2	1	3
Root crop intensive	0	0	1	1	2
Mixed green forests	5	5	2	5	5
Wet woodlands	5	5	2	5	5
Old fallow land with tall herbs	0	3	2	2	4
Village paved	4	1	0	0	0

The BIS values derive from first expert evaluations and are extended in a second step by semi-quantitative data gained from field work. Including habitat heterogeneities into the assessment methodology allows us to draw local as well as regional specific conclusions.

During field mapping specific qualifiers concerning biotope structure, management, pressure and valuable attributes were assigned to each landscape element (biotope) within the investigation area. Each of these qualifiers has either a positive (1) or a negative (-1) or no influence (0) on the provision of a service (Table 5).

Table 5: example of the qualifier matrix; the relationship between qualifiers and sub-services; (-)1 = negative influence, 0 =no influence, 1 = positive influence.

Qualifier	Climate regulation	Disturbance prevention	Pollination	Refugium service	Soil formation
Destruction of LE (all types)	-1	-1	-1	-1	-1
Construction work (all types)	-1	-1	0	-1	0
Path- and road construction	-1	-1	0	-1	0
Fragmentation	-1	-1	0	-1	0
Debris and dump deposition	0	0	0	-1	0
Sand / gravel banks	0	1	0	1	0
Organic deposits (hay, brushwood)	0	0	0	0	1
Dwarf shrubs	0	0	1	0	0
Submerse vegetation	0	0	0	1	0
Floating leaf vegetation	0	0	0	1	0
Structural diversity	0	0	0	1	0
Old growth stand worth preserving	0	0	0	1	0
Traditional land use type worth preserving	0	0	0	1	0
Natural relief form worth preserving	0	1	0	0	0

Table 6: Schematic BIS table; relationship between LEL (landscape element, biotope) within the investigation area and sub-services

BIS			
	sub-service 1	*sub-service 2*	*sub-service 3*
LEL 1	4	1	2
LEL 2	0	1	2
LEL 3	1	2	1
LEL 4	1	3	1
LEL 5	3	5	3
LEL x	4	2	3

Table 7: Schematic QUAL table; the qualifiers for one LEL are summed up for each sub-service. Therefore each LEL gets one QUAL value for each sub-service

QUAL			
	sub-service 1	*sub-service 2*	*sub-service 3*
LEL 1	-1	0	0
LEL 2	1	0	0
LEL 3	0	1	0
LEL 4	-1	1	1
LEL 5	-1	0	1
LEL x	1	1	-1

Table 8: Calculation table for one sub-service within the investigation area; for each LEL, the BIS and QUAL values are summed up, weighted by area and finally categorised within the range 0-5 resulting in the Landscape Element Service Value (LESV).

	BIS	QUAL	BIS+QUAL	(BIS+QUAL) * area	(BIS+QUAL) * area	LESV -categorised (0-5)
LEL 1	4	-1	3	3*0.01	0.03	3
LEL 2	4	1	5	5* 0.15	0.75	5
LEL 3	1	0	1	1*0.02	0.02	2
LEL 4	1	-1	0	0*0.35	0	0
LEL 5	3	-1	2	2*0.004	0.008	1
LEL x	4	1	5	5*0.01	0.05	4

The BIS value can now be either increased or decreased or remain constant by integrating the mapped qualifiers into the assessment calculations and results in a Qualifier Value (QUAL). As the area of a landscape element has also an impact on the provision of a service (e.g. a large forested area has more impact on climate regulation than a small one), additional area-weighting is integrated into the assessment (Table 8), except for 'transportation', 'habitation', 'energy conversion' and 'waste disposal' services. Regarding 'waste disposal', area-weighting was not appropriate because direct relationships between areal share and functional capacity could not be outlined. In terms of 'transportation', 'habitation' and 'energy conversion' services the nested sampling design in the frame of TransEcoNet did not seem to be representative to outline the actual state of these services in a comprehensive way. To overcome these inconsistencies a regional approach to measure these services has been carried out.

Regional GIS-based assessment of landscape services

Those landscape services that are directly observable from the land cover, or are clearly identifiable by spatial indicators independent from spatial scales were calculated for the whole LFTs, therefore, there was no need to apply a sampling design.

Ad *Carrier* Service: <u>Transportation</u>

To measure the actual state of 'transportation' within the project region, absolute run lengths of transportation networks were separately calculated for all 7 Landform Types (LFTs). Main and side roads, as well as railroad tracks were integrated into the assessment. Due to traffic densities, the lengths of the main roads were double-weighted. Resulting track lengths were divided by total areas, again separately for each LFT, resulting in areal density values of the transportation network. It was assumed that at present state the potential of transportation facilities is not fully exploited in any of the seven LFTs. In order to fit the outcomes of the 'transportation' service assessment to the generally applied categorisation system for ecosystem service evaluation, equally distributed percentile-values were deduced for this designated service using SPSS 16. Following the aforementioned considerations re-categorised values finally ranged from [0;4].

Ad *Carrier* Service: <u>Habitation</u>

To comprehensively include settlement areas and other man-made facilities such as industrial and commercial sites, sport and leisure facilities into the assessment CLC 2006 (EEA 2006) was taken as source layer.

Areal proportions of the predefined classes were again separately calculated for all LFTs by multiplying class areal shares with class specific BIS-values, which served as weighting factors. The resulting interim outcomes were consequently divided by the total areal values of each LFT to finally reach comparable results for the integration into the overall ecosystem service evaluation.

Ad *Carrier* Service: <u>Energy Conversion</u>

The ‘energy conversion’ service considers facilities for the conversion of wind energy into electricity. Again, to obtain a most meaningful result for the entire investigation area, a regional assessment to measure the actual state of wind energy conversion was conducted. On the basis of a map sheet (Regionales Rahmenkonzept für Windenergieanlagen), provided by the ‘GIS Koordinationsstelle, Raumordnung Burgenland’ all actual locations of wind power stations within the investigation area were detected. Unfortunately this base layer was only available for Austria. On the Hungarian side of the study region wind power stations were mapped after visual interpretation of the latest aerial imagery available. All wind power stations on the Austrian as well as on the Hungarian side were concentrated in LFT 5 only. In analogy to previously outlined steps for the assessment of ‘habitation’ and ‘transportation’ services the areal proportion of wind park stations was calculated for LFT 5. In order to deduce the landscape´s potential for the establishment of wind parks and to measure its relationship to the present situation all suitable zones for designated wind parks were identified as well, again relating to the map sheet mentioned above. The proportion of already built wind parks and suitable sites outlined in the spatial planning concept was also calculated afterwards and resulting values were re-categorised under the assumption that all recent and suitable sites together are representing the landscape´s potential regarding the ‘energy conversion’ service.

2.2.3.2 Socio-cultural approach: *Information* services and touristic services

The landscape perspective is important for those services, where single biotope types and/or landscape elements do not have an indicator value as such, but their extent, magnitude or sum within the whole landscape provides the indicator value. This is generally the case for the *Information* service, where only the picture as a whole is of a certain value to society and allows for differentiation among the individual landscapes. An example for this is recreational infrastructure: the bicycle paths have a touristic/recreational value but the indicator for the service can be expressed only as the length of the bicycle paths in kilometres per landscape type.

Evaluated services:

- *Information* services: aesthetical information, cultural and artistic information, spiritual and historic information, science and education, recreation
- *Carrier* services: tourism facilities

Chapter 2.2.3.2.1 describes the assessment of landscape services concerning aesthetical, cultural and artistic information, spiritual and historic information as well as science and education. In chapter 2.2.3.2.2 a special focus is given to the two services ‘recreation’ and ‘tourism facilities’ in order to account for the high touristic relevance of the region Neusiedler See/Fertő. The use of the detailed knowledge on tourism derived from former projects and within TransEcoNet enables us to analyse these two services in depth with a good fundamental knowledge.

The Socio-cultural approach is analysed by Landscape Character Types LCT (Konkoly-Gyuró et al., 2010; after Swanwick, 2002, see Table 2 and Figure 6). Different regions belonging to the same LCT are called Landscape Character Type Areas (LCTA). For these LCTAs data was evaluated and aggregated to service provision values on LCT level. Finally, results were transformed into Landform Types for comparison of all approaches and common analysis.

2.2.3.2.1 Socio-cultural approach on 'aesthetic information', 'cultural and artistic information', 'spiritual and historic information', 'science and education'

Because of the fact that the assessment works on a different spatial unit and scale, the general workflow needs an independent adaptation and works in a different way than the habitat perspective. In principle, the workflow consists of six consecutive steps:

i. Indicator development

Indicators have been developed for each component of the *Information* service (aesthetical information, cultural and artistic information, spiritual and historic information, science and education, recreation). Selection has been made according to available data in Austria and Hungary.

There are three main types of indicators: indicators of the spatial landscape elements (polygons), e.g. land cover types and indicators of the linear (lines), e.g. edge density, and punctual (points) landscape elements, e.g. density of cultural elements.

The most important data for indicator development was the following: topographic and tourist maps, data base on landscape values, satellite images from the study area. Available data has been digitalised in ArcGIS 9.3.

ii. Service Weight (SW)

SW values for landscape elements show the significance of the indicators – related to spatial (SWs), linear (SWl) or punctual elements (SWp) – in each sub-service. SW values were defined by expert judgement for each land cover class and linear or punctual landscape element occurring in the sample area. Values range from 0 to 5. The value 0 means no relevance, the value 5 means high significance.

iii. Indicator value (IV)

Indicator values were calculated per each Landscape Character Type and for each sub-service. IVs for spatial elements were calculated as the area and proportion of certain land cover classes in the Landscape Character Type (%). Indicator values for linear and point elements show the presence and the density of landscape elements (km/km^2, piece/km^2). The density of visually relevant edges has been calculated for forests (any forest edge), waters (any water edge) and vineyards (any vineyard edge) in each Landscape Character Type (km/km^2).

iv. Indicator service value (ISV)

ISVLCT1,2…=SVsubservice1,2… *IV1,2…

E.g. in case of two indicators (IV1 and 2) in one Landscape Character Type the calculation is the following:

ISVLCT1_sub1=SVsubservice1*IV1

ISVLCT1_sub1=SVsubservice1*IV2

ISVLCT1_sub2=SVsubservice2*IV1

ISVLCT1_sub2=SVsubservice2*IV2

…..continue until subservice x

ISVs were calculated in case of all indicators for all sub-services in each Landscape Character Type.

v. Normalised Indicator Service Value (NISV)

ISV values are highly diverse in measures and units. In order to get comparable data a normalisation is needed. Normalised values range from 0-5. Normalised Indicator Service Values show the relevance of the indicators for the given landscape services per Landscape Character Type. After having defined the classes for each series from 0-5 thus creating the normalised values, the sum and the mean of the NISV per Landscape Character Type were calculated. Sum and the mean of the NISVs have been calculated separately for the three kinds of indicators, thus the result will not depend on the number of indicators associated to spatial, linear or point type landscape elements:

NISVS_subservice1-x = ΣNISVS

NISVL_subservice1-x = ΣNISVL

NISVP_subservice1-x = ΣNISVP

vi. Landscape service value (LSV)

Landscape service values have been defined for each Landscape Character Type. LSVs are derived from the addition of the mean NISV of the three indicator types (spatial, linear, points) for each sub-services (Figure 10).

LSV LCT1,2... = ΣmeanNISVs_subservices1-x + ΣmeanNISVl subservices1-x + ΣmeanNISVP subservices1-x

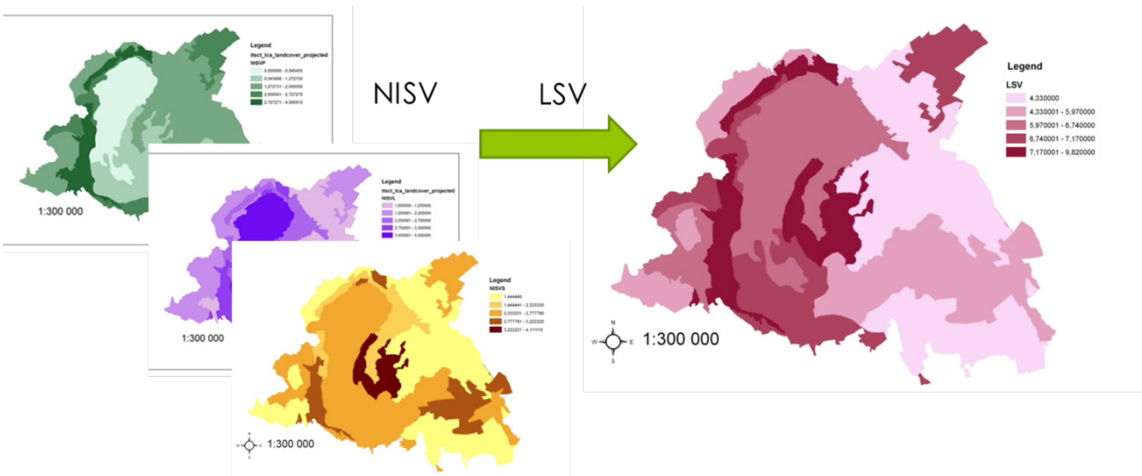


Figure 10: Relation of NISV and LSV

vii. Normalisation and transforming results into Landform Types

Landscape service values have been normalised (values [0;5]) in order to show the importance of *Information* services and their relation to other services. Subsequently, we integrated all different LCT related values for the *Information* service into one series of spiderweb diagrams. The idea behind is not to lose any relevant information of the single LCTs but to integrate all values into LFT assessment. To achieve this, we took the area-weighted means of the values for *Carrier* and *Information* services.

Ad Differences between Landscape Character Types and Landforms

Due to the fact that the socio-cultural approach works with different indicators at a different spatial scale, these results could be integrated into the spatial reference framework with clear links between the scales (Figure 11).

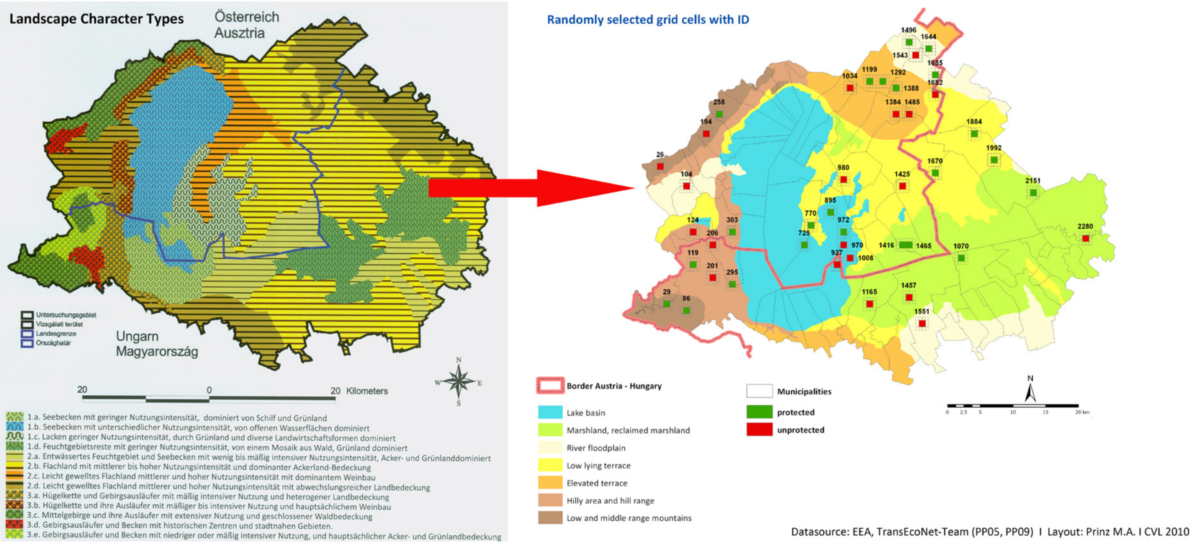


Figure 11: Relation of Landscape Character Types and Landform Types

Indicators and their significance

Three main types of indicators have been developed for each component of the *Information* service (S1: aesthetical information, S2: cultural and artistic information, S3: spiritual and historic information, S4: science and education, S5: recreation). Table 9 shows the list of developed indicators and the significance of the indicators defined by Service Weight values ([0;5]).

Table 9: Selected indicators, Service Weights and data sources related to spatial (SWs), linear (SWl) or punctual elements (SWp) in each sub-service.

	Indicator groups	Indicators	S1	S2	S3	S4	S5	Data source
Point elements	Density of sacral buildings							
		churches	5	5	5	3	4	topographic (1) and tourist maps (2), landscape values data base (3)
		chapels	4	4	4	2	3	
		crucifixes	3	4	4	1	1	
		statues (sacral/non sacral)	3	4	4	2	1	
		cemetries	4	4	5	1	1	topographic map
	Density of non-sacral buildings							
		castles	5	5	5	4	5	tourist map
		vinehouse, cave	4	4	3	3	5	tourist map, expert knowledge
		look out tower	5	2	2	4	5	tourist map
		archaelogical sites	3	5	5	5	3	landscape values database
		museums	3	5	5	5	4	tourist map
		study trails	4	2	2	5	4	tourist map
		research (visitor) centers	3	2	2	5	4	expert knowledge
Linear elements	Visually relevant edges							
		any forest edge	5	4	1	2	5	satellite image
		any water edge	5	4	1	2	5	
		any vineyard (permanent crop) edge	5	4	2	1	5	
Areal elements	Land cover							
		water bodies	5	3	4	5	5	satellite image
		wetlands	4	3	5	5	2	
		forests	5	4	3	5	4	
		natural grassland	4	3	5	5	4	
		arable land	2	2	2	2	1	
		permanent crops	3	2	2	2	3	
		pastures	4	3	3	3	3	
		heterogenous agriculture	4	4	3	3	3	
		scrubs	2	2	2	2	1	

Legend	
S1	Aestetic information
S2	Cultural and artistic information
S3	Spiritual and historic information
S4	Science and education
S5	Recreation

References:

(1) Fertő, Lajta-hegység, Hanság. Turista-, kerékpáros és szabadidőtérkép. Wanderkarte mit Rad und Freizeitthematik. 1:80 000, Szarvas Kiadó

(2) Collection of Landscape values TEKA http://tajertektar.hu/hu/kereso. Institute of Geodesy, Cartography and Remote Sensing

(3) Topographic maps 1:100 000 EOV (Uniform National Projection).

Ad Visually relevant edges

The edges were derived by the classification of a RapidEye-satellite image by the process of Object-based Image Analysis (OBIA). This procedure provides a new bridge between theoretical concepts (Wu & Loucks 1995; Poole, 2002) applied in multi-scaled landscape analysis, remote sensing methods and GIS (Burnett & Blaschke, 2003; Blaschke, 2010). It consists of the following steps (Burnett & Blaschke, 2003; Benz et al., 2004):

- Multi-resolution segmentation of remote sensing imagery, which enables the delineation of image objects simultaneously on different scales;

- Image objects, linked through a hierarchical object network, where each image object is described by its object features (spectral values, shape and texture), by neighbour and hierarchy-related features;

- Classification of the image objects based upon their feature space. Different supervised classification strategies can be combined within rule-based procedures to create a semantic classification system to represent real world objects.

We applied OBIA using the commercial software eCognition Developer 8 (Definiens AG, 2009a, b) where a two level hierarchy was defined: The lowest level was used to define a fuzzy classification system, which then was used to create a semantic classification at the highest level.

For the segmentation, we used the Maximum Likelihood method with 20 classes in order to derive feasible segments of the satellite image (Figure 12). Afterwards, we used the CORINE dataset to rescale the 10 CORINE classes of the first hierarchical level with a fuzzy majority filter to fit the segments of the satellite image (Figure 13). Finally, this could be exported as a shape file and further processed in ArcGIS for the calculation of the Edge density for the visually relevant edges.

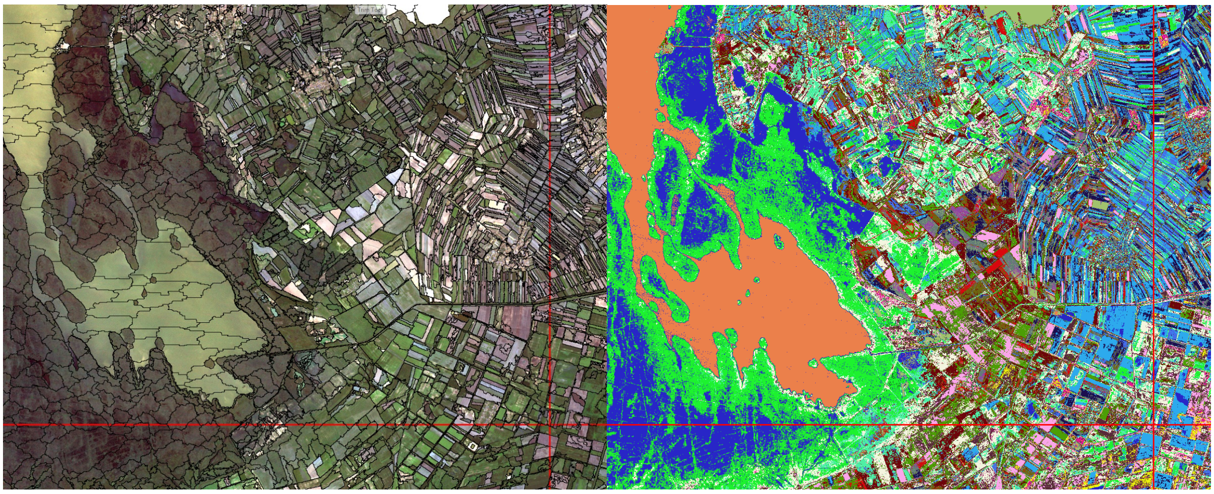


Figure 12: Maximum likelihood classification resulted in segments of the satellite image which were classified into 20 preliminary classes.

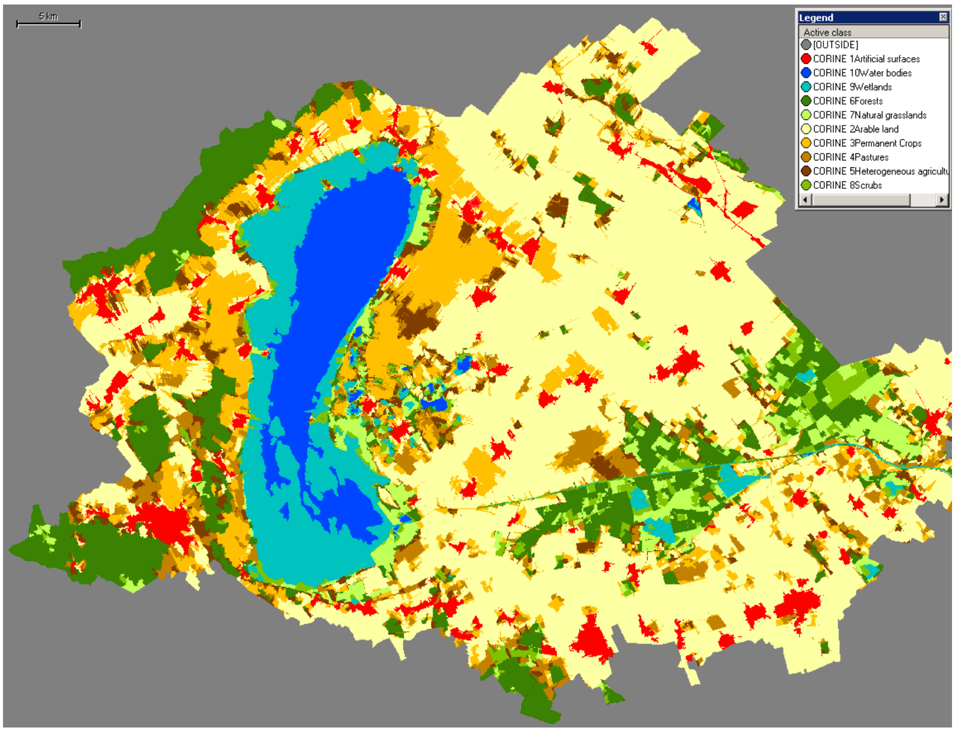


Figure 13: Final classified satellite image for the 10 CORINE categories of the first hierarchical level.

Normalised Indicator Service Values (NISV)

Normalised Indicator Service Values show the relevance of the three kinds of indicators (NISV (P), NISV (L), NISV (S)) for the given landscape services per Landscape Character Types.

Normalised Indicator Service Values of point elements are the highest in 3a, 3b, 3d Landscape Character Types. In the 3a character type the high values due to the high density of – look-out towers, castles, and also the high density of sacral buildings. In the Landscape Character Type 3b, archaeological sites and museums also have higher importance. In 3d there is a very high density of sacral elements, in addition the presence of landscape values related to viticulture results in the highest NISV values.

There is a relative low density of point elements in 1a-1d Landscape Character Types, due to the naturalness and the designation of these areas (see Table 10, Figure 14, Figure 15).

Table 10: NISV (P) values in each Landscape Character Type

NISV(P)														
		1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	3e
NISV1	churches	1	1	1	0	2	3	4	4	4	4	2	5	3
NISV2	chapels	1	1	2	0	1	2	3	3	4	5	2	5	4
NISV3	crucifixes	1	1	1	0	2	3	4	4	3	5	2	4	2
NISV4	statues (sacral+non-sacral)	0	0	0	0	1	2	0	2	4	2	2	5	2
NISV5	cemeteries	1	1	1	0	1	2	4	4	4	5	1	5	3
NISV6	castles	0	0	0	0	0	3	0	4	5	0	0	0	0
NISV7	vinehouse, cave, Heuriger	0	0	0	0	0	1	3	2	4	4	3	5	0
NISV8	look-out towers	2	1	5	0	2	0	2	2	5	4	3	4	0
NISV9	archaelogical sites	0	0	0	0	0	1	0	2	3	4	4	5	3
NISV10	museums	0	0	0	0	0	1	2	3	2	4	3	5	4
NISV12	research (visitor) centers	3	1	4	0	1	0	0	0	0	0	0	2	0
	sum	9	6	14	0	10	18	22	30	38	37	22	45	21
	mean	**0,818**	**0,545**	**1,273**	**0**	**0,909**	**1,636**	**2**	**2,727**	**3,455**	**3,364**	**2**	**4,091**	**1,909**

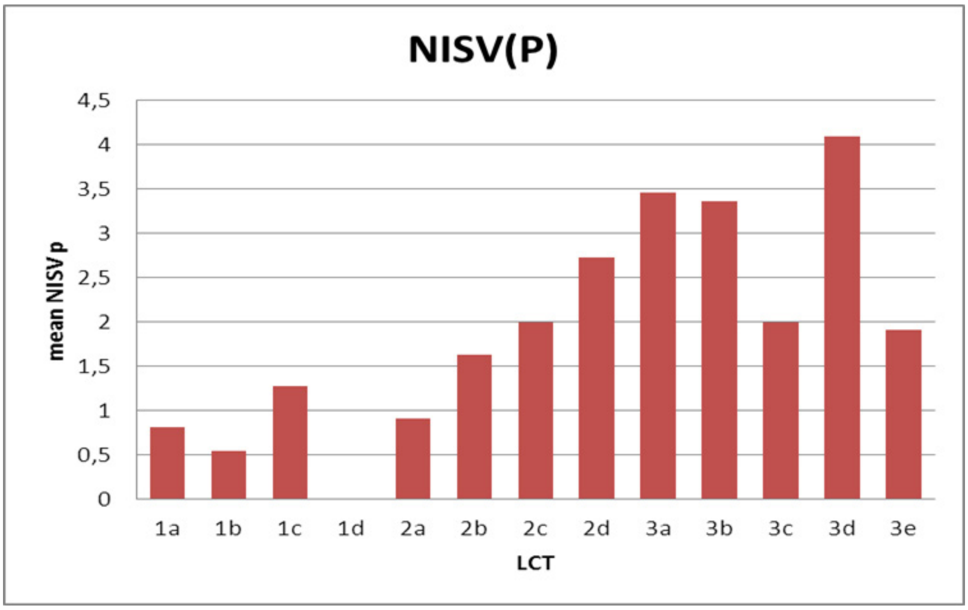


Figure 14: NISV (P) values in each Landscape Character Type

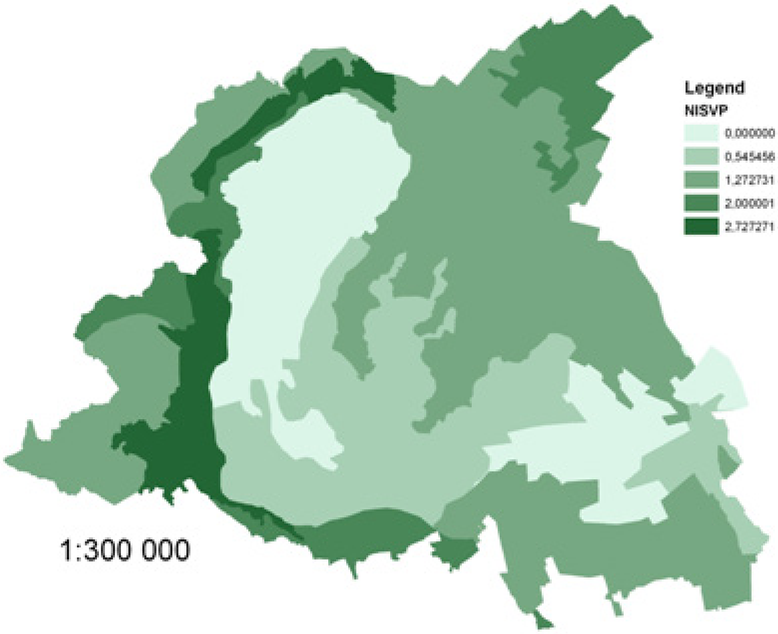


Figure 15: Normalised Indicator Service Values of point elements in the region Neusiedler See/Fertő

Normalised Indicator Service Values of linear elements are derived from visually relevant edges in landscape (aesthetical service) and study trails (science and education service). The highest Normalised Indicator Values are found in the ‘Lake basin’ (1a, 1b, 1c LCT-s) and in the ‘Hill range and foothills of low mountains’ (3a, 3b LCT-s) (see Table 11, Figure 16, and Figure 17).

Table 11: NISV (L) values in each Landscape Character Type

$NISV_{(L)}$		1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	3e
NISV11	study trails	5	0	0	0	0	0	0	0	3	0	4	0	0
NISV22	Any water edge	5	5	5	4	3	2	3	1	2	3	0	0	1
NISV23	Any permanent crop	1	5	4	2	3	2	5	4	4	5	1	3	4
NISV24	Any forest edge	3	5	4	5	2	1	2	3	4	3	4	1	3
	sum	14	15	13	11	8	5	10	8	13	11	9	4	8
	mean	**3,500**	**3,750**	**3,250**	**2,750**	**2,000**	**1,250**	**2,500**	**2,000**	**3,250**	**2,750**	**2,250**	**1,000**	**2,000**

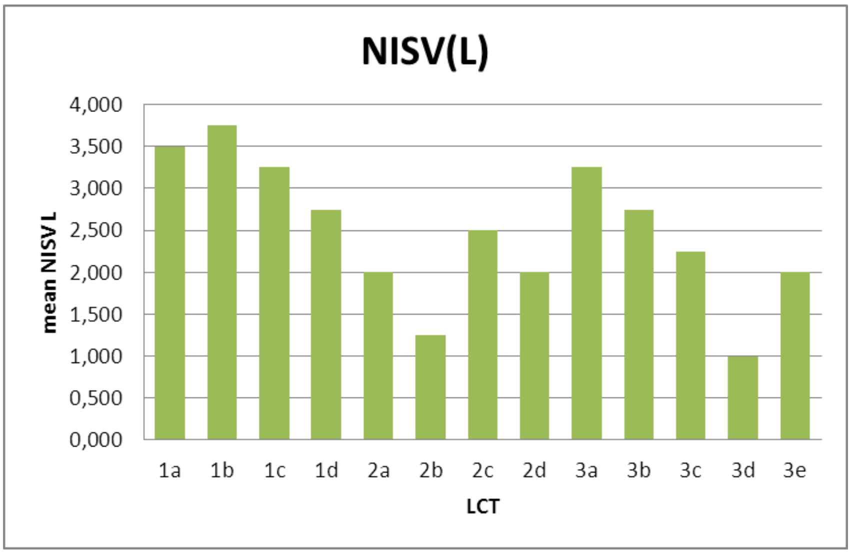


Figure 16: NISV (L) values in each Landscape Character Type

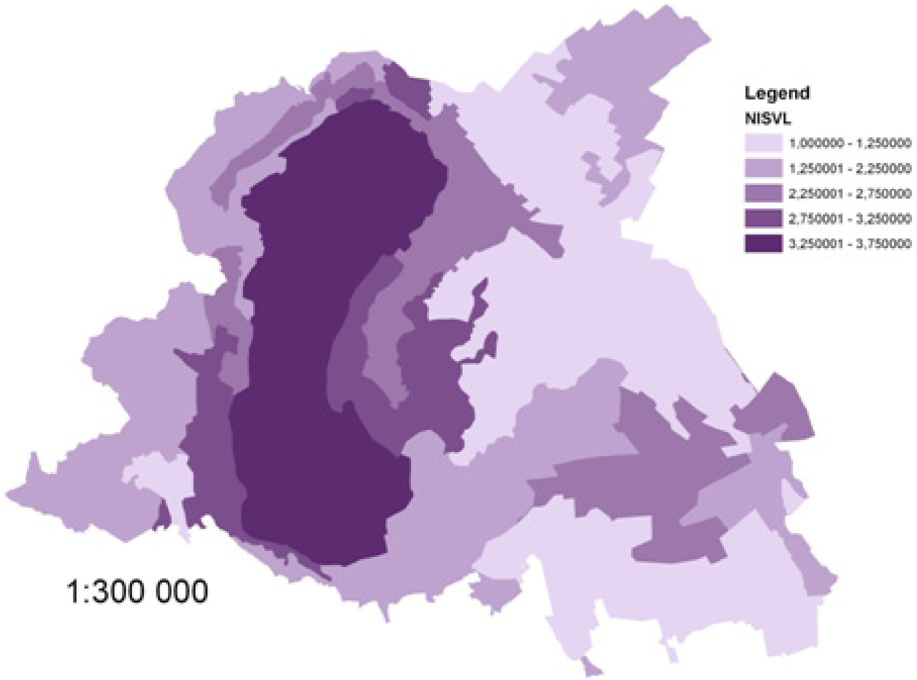


Figure 17: Normalised Indicator Service Values of linear elements in the region Neusiedler See/ Fertő

Normalised Indicator Service Values of spatial elements are derived from the area of each land cover class in the Landscape Character Types. Table 12, Figure 18 and Figure 19 below show the results of the NISV (S) values in each Landscape Character Type.

Table 12: NISV (S) values in each Landscape Character Type

NISV$_{(S)}$		1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	3e
NISV13	Water bodies	3	5	4	2	0	0	0	0	0	0	0	0	0
NISV14	Wetlands	5	5	4	4	2	1	3	1	2	2	0	0	1
NISV15	Forests	3	1	4	5	3	1	1	4	5	2	1	1	3
NISV16	Natural grasslands	5	4	5	5	2	1	2	1	3	1	4	0	1
NISV17	Arable land	1	1	3	2	5	5	2	4	3	3	1	3	4
NISV18	Permanent crops	1	1	4	2	3	2	5	4	4	5	1	3	4
NISV19	Pastures	1	1	4	2	4	1	2	3	4	3	1	3	5
NISV20	Heterogenous agricu	2	1	5	2	2	1	4	4	5	4	3	3	5
NISV21	Scrubs	3	3	4	5	2	1	1	1	2	1	2	0	2
	sum	24	22	37	29	23	13	20	22	28	21	13	13	25
	mean	**2,667**	**2,444**	**4,111**	**3,222**	**2,556**	**1,444**	**2,222**	**2,444**	**3,111**	**2,333**	**1,444**	**1,444**	**2,778**

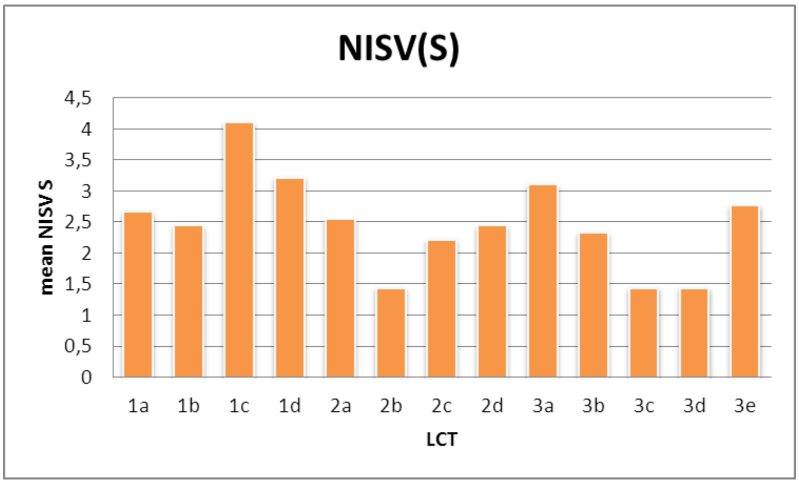


Figure 18: NISV (S) values in each Landscape Character Type

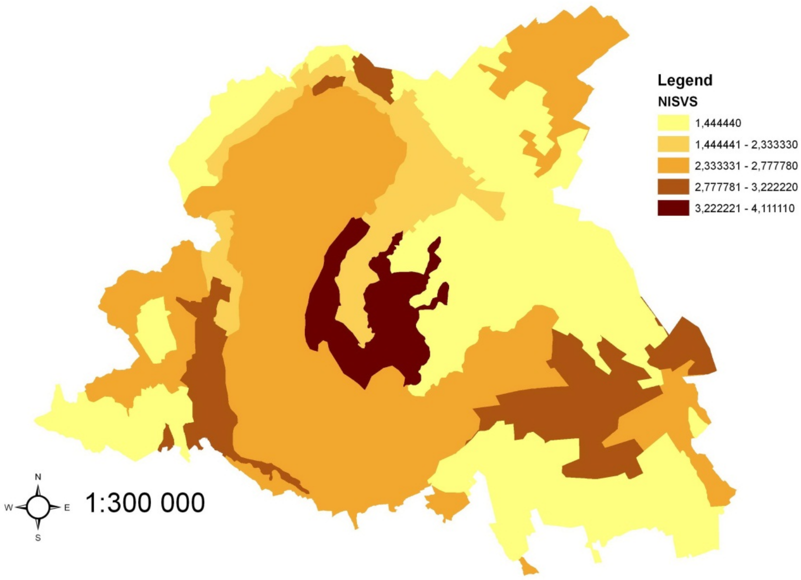


Figure 19: Normalised Indicator Service Values of spatial elements in the region Neusiedler See/Fertő

Landscape Service Value LSV

LSVs are derived from the addition of the mean NISV of the three indicator types (spatial, linear, points) for each sub-service. The highest values are found in 3a, 3b, and 1c Landscape Character Types (see Figure 20). It means that 'Hill ranges and foothills of low mountains' with medium or intensive human use dominated by a mosaic of forests, grasslands and water surfaces or vineyard dominance have higher *Information* services. Relatively high *Information* service values occurred also in low intensity human use areas, as remnants of marshlands dominated by a mosaic of forest, grasslands and water surfaces (Figure 21, Table 13).

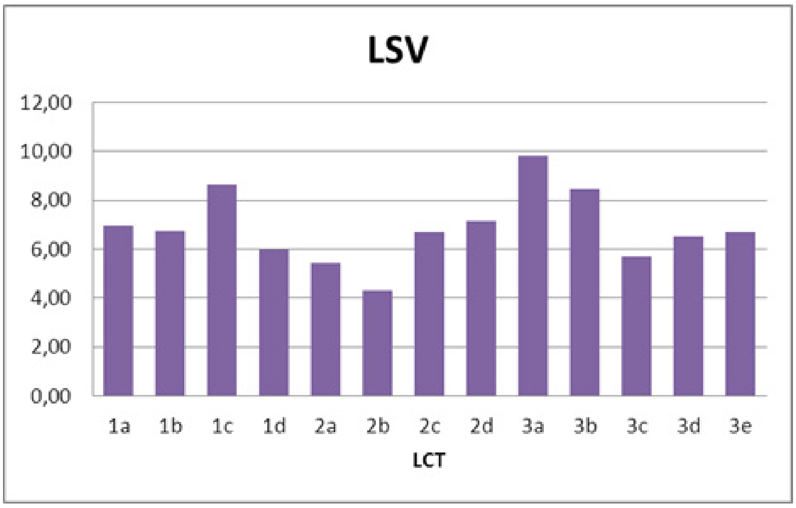


Figure 20: Distribution of Landscape Service Values in the Landscape Character Types

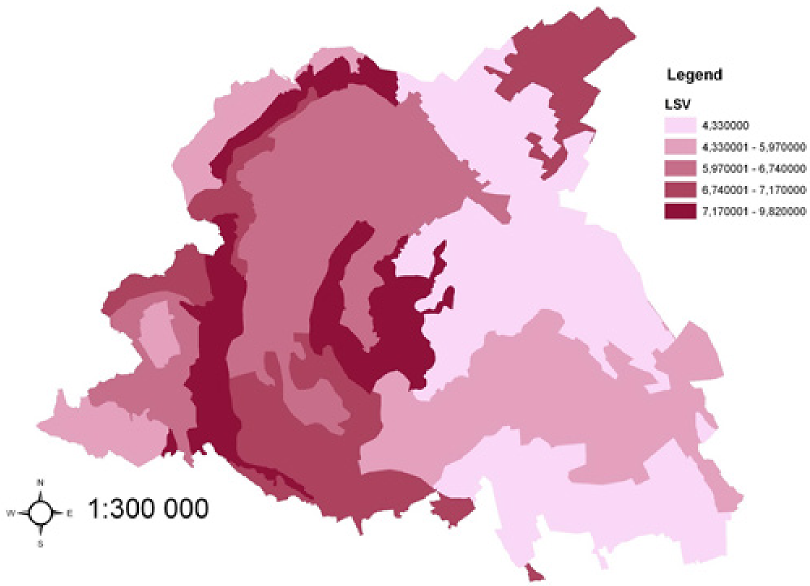


Figure 21: Distribution of Landscape Service Values in the Landscape Character Types

Table 13: Distribution of Landscape Service Values in the Landscape Character Types

	Landscape characer types												
	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	3e
LSV	6,98	6,74	8,63	5,97	5,46	4,33	6,72	7,17	9,82	8,45	5,69	6,54	6,69

2.2.3.2.2 Socio-cultural approach: Touristic services

This approach on touristic services includes landscape services on ‘recreation’ (*Information*) and ‘touristic facilities’ (*Carrier*). The requirements of tourism and recreational use in regard to the landscape can be very different. Tourists, day trippers and local recreationists have different interests and activities, and so do their requirements concerning landscape, climate and infrastructure as well as expectations. Beside these demand-related requirements of cultural landscape, touristic infrastructure and accessibility also the strategies and economic objectives of tourist companies influence the touristic requirements on the landscape services in the region.

Terms and valuation approaches of recreational potential, suitability and value

The valuation of the landscape for tourism and recreational use is connected with very different terms and concepts, among others ‘recreational potential’, ‘recreational suitability’ and ‘recreational value’ of landscape. Various criteria and appraisal procedures on different spatial levels were developed especially from the 1970ies to the early 1990ies (e.g. Kiemstedt et al., 1975; Pötke, 1979; Harfst, 1980; Barsch & Saupe, 1994). They can be divided into general methods and activity-specific methods which are based upon the different interests and needs of recreational user groups or types. Current works about recreational potential or suitability are mostly related to GIS-based planning of tourism or recreational use such as within regional plans, landscape plans or management plans of protected areas (e.g. Bundesamt für Bauwesen und Raumordnung 2005; Engels, 2008; Walz & Berger, 2004, Landeshauptstadt Dresden (Umweltatlas) 2007, Zweckverband Großraum Braunschweig, 2008a, b).

Apart from undefined or synonymous use, ‘recreational potential’ is more focused on natural and landscape attributes while ‘recreational suitability' includes other aspects like tourist facilities, accessibility and disturbing factors. Sometimes criteria of recreational potential are regarded as natural factors of recreational suitability. Recreational potential represents a nature science or user perspective based upon the classical criteria of Kiemstedt et al (1975) und Marks et al. (1992): Landform configuration, vegetation and land use, edge of woods and waters. The main indicators are naturalness, unique character and diversity, whereas most attention is given to the assessment of landscape diversity. Recreational suitability is mainly a planning category which is used on all levels of spatial and landscape planning. On the basis of recreational suitability, recreational areas were identified and recommendations for the development were given. Moreover, it is assumed that the existing areas of tourism are suitable for recreation. The recreational value results from more complex methods of valuation. From the different valuation approaches and methods for the recreational potential of landscape, a couple of main indicators can be obtained (see Table 14).

Table 14: Main criteria and indicators of the recreational potential of landscape (depending on spatial planning level)

Main criteria	Criteria / Indicators
Landscape Diversity	Diversity of Landform configuration: e.g. slope gradient, altitude difference, narrow valleys Diversity of land use: classification of land use, proximity to water, small landscape units, glades Linear landscape elements: edge of woods and water bodies (length), line of trees, hedge, flowing waters, riparian woodland Point-shaped landscape elements: single trees, groves, small biotopes (waters, hedge)
Naturalness	Land use: percentage of unbuilt areas, hemerobic levels, edge of woods and water bodies, inhomogeneity, character and intensity of anthropogenic impact, Landscape Fragmentation: fragmentation stage as measurement of naturalness / non-naturalness
Woods	percentage of woods, percentage of deciduous woods, percentage of coniferous forests
Waters	presence of waters, lakes/artificial lakes (percentage of area), rivers/canals, brooks/ditches (number), water quality assessment, depth of a body of water, quality of the edge of a body of water
Panorama	panorama views, clear views
Climate	climatic altitude, mean temperature of the year, yearly rainfall, bioclimate
Unique character	unique selling proposition (tourism)
Scenery (visual)	quality of scenery, preferred landscape elements

Source: own compilation after Grabaum et al., 2005; Walz & Berger, 2004; Kiemstedt et al., 1975, Barsch & Saupe, 1994, Greif et al., 2002; Mönecke & Wasem, 2005, Bundesamt für Bauwesen und Raumordnung, 2005; Landeshauptstadt Dresden (Umweltatlas) 2007

In the 1970ies Kiemstedt et al. (1975) already developed an extensive catalogue of indicators for the recreational suitability of different complexes of recreational activities: recreation in summer at the water (bathing/swimming, playing, camping, fishing), recreation in summer on the water (boating, sailing, boat trips), recreation in summer bonded to area (walking/hiking, playing, cycling, nature observation, sightseeing, climbing) and recreation in winter (skiing, sledding, hiking, skating). The relevance of indicators was valuated into different categories: necessary landscape or infrastructural requirements for this recreational activity (minimum entitlement), improving criteria (quality grade), indifferent criteria without any impact on the recreational activity, restrictive criteria (disturbing factors). Apart from the landscape, towns and villages were evaluated (accommodation, touristic facilities, sights, climatic altitude and infrastructure).

In the landscape planning of the Frankfurt Rhein-Main Conurbation Planning Association another approach for the assessment of recreational suitability is used (Landschaftsplan des Umlandverbands Frankfurt, 2000). The valuation of selected scenery types (e.g. field long-range, field small-scale structured, valley small-scale structured, vineyard, river/pond/artificial lake, urban park, constructed area) based upon the local expertise of landscape and land use planer. The landscape suitability is valuated for three kinds of recreation: (1) hiking, walking, cycling, landscape experience, (2) water oriented recreation like playing at the water, swimming, boating, fishing as well as perceptions and experiences of water during walking, hiking and cycling, (3) nature observation – flora and fauna. Finally different landscapes units of the region were evaluated (e.g. Hoher Taunus, Vortaunus, core of urban agglomeration Frankfurt-Offenbach) and recommendations from the view point of recreational suitability are given. In contrast the landscape valuation of the city of Dresden is related to three main motives for recreation: (1) experiences of semi-natural landscapes (little disturbance and few stress factors), (2) experience of rural cultural landscape, sustainable economic activities and healthier environment and (3) experience of the city and the urban landscape. On the map, the recreational suitability of these different areas is valuated in six grades: suitability for tourism, suitability for regional recreation with touristic potential, suitability for local and city-wide recreation, limited suitability for local recreation, low value for outdoor recreation and no suitability for outdoor recreation (Landeshauptstadt Dresden (Umweltatlas) 2007).

Barsch & Saupe (1994) aggregated type-related and individual valuations to combined recreational values on the local as well as the regional level. These complex valuations of functional units include landscape qualities, e.g. lakes or landscape diversity, recreational facilities, preferences of different user groups, relevance for regional planning as well as possibilities for recreation at and on the waters.

A number of valuations focus only on one land use type like forests (e.g. Ruppert, 1971) or agricultural land (e.g. Greif et al., 2002). Following this, the criteria are more differentiated. For example, the valuation of the suitability of agriculturally used areas for nature related recreation within the INTERREG II C project Natural Resources of the Federal Institute of Agricultural Economics (AWI) in Vienna consists of accessibility as indicator of the demand for recreation and the supply of suitable areas (scenic attractions, usability).

With all diversity of methods for recreational potential or suitability assessment, some basic aspects are visible. On the one hand most of the valuation methods focus on selected landscapes, land use or functional area types. On the other hand recreational suitability is usually valuated for different recreational activities, selected user groups or specific motives. Therefore, the landscape character of the Neusiedler See/Fertő region as well as the main recreational and sport activities, motives and interests of tourists and local recreationists have to be considered. The preferences of tourists and recreationists are due to their interests and activities together with their landscape expectations. Based upon the principles of landscape valuation, the interests of tourists and recreationists and the view of tourism sector a couple of conclusions for the valuation of landscape services can be drawn:

- The evaluation criteria relate to the characteristics of the Neusiedler See/Fertő landscape, in particular to the specific land use, Landform configuration and the different kinds of waters. In addition, the valuation will take into consideration the main image factors of the region: the combination of nature and culture, landscape and regional diversity, the lake and the wide reed belt, wine and wine-growing, tourism and tourist activities, birds, nature protection and management including the national park. Spatial differences of these landscape attributes are covered by the Landscape Character Types.
- The valuation of landscape services will be carried out in respect to recreation as a whole but with regard to the main recreational activities in the region or in the Landscape Character Type. Besides quietness and relaxation, which are not related to a specific landscape, the main nature-oriented activities in the Neusiedler See/Fertő region are cycling and bird watching. Bathing is mainly connected to the lake and the lake resorts. Museums and cultural events are located in the settlements excepting the performances in the quarries of St. Margarethen and Fertőrákos as well as the lake stage of the Mörbisch Festival within the reed belt.
- The valuation of tourism facilities is connected to the development of tourism as an economic sector. In Austria the marketing strategy of the regional tourism association is based upon the five core areas nature, culture, sports, wine & cuisine and health. In these fields tourist facilities, events and products have been advanced in the last years. This

applies to the Hungarian part of the region, too, even though no regional marketing strategy for tourism development exists.

- Whereas the landscape can be assessed on the basis of types or classifications (e.g. land use, landscape elements, altitude differences) the valuation of tourist facilities requires an individual analysis (e.g. touristic nodes, touristic trails).

Tourism within the services assessment

The assessment of the 'recreation' service and 'tourism facilities' service is based on the principles of the valuation of landscape services from the view of tourism and recreation research. 'Recreation' is part of the *Information* services as one of five sub-services (see chapter 2.2.1).

'Tourism facilities' belong to the *Carrier* services because they are related to the results of human activities in the sector of tourism and recreation. The different touristic facilities provide the basis for various kinds of tourism and recreational activities like cultural tourism, water sports, cycling, nature-oriented activities or wellness. Tourist facilities in settlements are integrated in the valuation and graduation of touristic nodes. These nodes are source and destination of the activities of tourists and recreationists. Landscape-oriented activities like hiking or cycling take place between these nodes. The usability of waters for bathing and water sports is a product of different aspects: suitability of water (e.g. water quality, access to the open water), size of the water body as precondition for the different kinds of water sports as well as a basic infrastructure (e.g. landing stage). While bathing is concentrated to the lake resorts which are integrated into the touristic nodes, water sports take place on a larger part of the water surface.

'Tourism facilities' assessment

The assessment of the 'tourism facilities' service is based on three indicators: (1) touristic nodes, (2) touristic routes and (3) water sports. 'Tourism facilities' are valuated from the landscape perspective. The spatial basic unit for the valuation of the indicators is the Landscape Character Type (LCT). In order to show the partly existent differences of tourism facilities within one LCT for those types which consist of more than one area the valuation is carried out also for each area separately (LCTA).

(1) Indicator: Touristic nodes

The indicator 'touristic nodes' is the result of a complex valuation of tourist supply and demand as well as the intraregional tourist services. Through the inclusion of all tourist and leisure facilities and a partial completion through visitor or user information, also day-visitors as well as recreationists are integrated. The touristic nodes are graduated into a three-step hierarchy: big, middle and small nodes. Big nodes represent the main touristic centres and/or main destinations for outings in the region. Middle nodes cover an average and expected supply in the region. Some of them are specialised in different kinds of tourism or leisure time activities like culture tourism or health spa. Big and middle nodes create the basic structure of the tourism region. The small nodes offer an additional touristic supply. A special case of touristic nodes in the Neusiedler See/Fertő region are 'divided nodes'. Big or middle nodes are described as a divided node if the distance between the village and the lake resort is too big, but the functional connections advise the merging into one node.

On the level of touristic nodes the first step of assessment contains the transformation of the touristic node rank into a five scale valuation. The value of the divided nodes is also divided (see Table 15).

Table 15: Touristic Node Value (TNV)

Big node	5
Big divided node	2.5 / 2.5
Middle node	2
Middle divided node	1 / 1
Small node	1

Source: Own calculations

After that, the number of touristic nodes is weighted with the Touristic Node Value (TNV). Nodes which are situated on the border of LCT areas are numbered as half a node in both LCT areas. The result is a weighted number of each touristic node (see examples in Table 16).

Table 16: Valuation on the touristic node level, first results

Nodes	TNV	Number of nodes	Weighted number of nodes
Podersdorf	5	1	5
Neusiedl Ort	2.5	1	2.5
Neusiedl See	2.5	1	2.5
Möchhof	2	1	2
Hegykő	2	1	2
Jois Ort	1	1	1
Jois See	1	1	1
Hölle	1	1	1
Csorna	1	1	1
Balf	2	1	2
St. Andrä	2	0.5	1
Bösárkány	1	0.5	0.5

Source: Own calculations

In a next step, the indicator was developed further to the Density of Touristic Nodes Weighted with Touristic Node Value (DWTN). The tourist facilities in the LCTs (Landscape Character Types) or LCTAs (Landscape Character Type Areas) are valuated via the density of big, middle and small touristic nodes. At first, the Density of Touristic Nodes is calculated as weighted number of 'touristic nodes' related to the area of LCT respectively LCTA. The measuring unit of DWTN is 100 km² (St. Martins Therme and Lodge is not included in this assessment because the valuation was not clear at the time of the assessment period). After that the Density of Touristic Nodes was normalised into the values 0-5, 0 meaning no 'touristic nodes' (see examples in Table 17). The visualisation of results is shown in Figure 22 and Figure 23.

Table 17: Valuation of touristic nodes on the LCT and LCTA level – Examples

LCT	LCTA	Weighted number of nodes per LCT/LCTA	Area LCT/LCTA (km^2)	DWTN LCT/LCTA (per 100 km^2)	DWTN LCT/LCTA normalised
1a		1.0	111.96	0.89	1
1b		19.0	264.80	7.18	2
1d		1.5	135.39	1.11	1
	1d-1	*0*	*21.55*	*0*	*0*
	1d-2	*1.5*	*113.84*	*1.32*	*1*
2a		3.0	186.35	1.61	1
	2a-1	*1.5*	*48.98*	*3.06*	*1*
	2a-2	*1.5*	*137.37*	*1.09*	*1*
2b		22.5	592.27	3.80	1
	2b-1	*0.5*	*3.03*	*16.52*	*3*
	2b-2	*9.0*	*191.64*	*4.70*	*1*
	2b-3	*13.0*	*397.60*	*3.27*	*1*
2c		14.0	106.36	13.16	3
3c		3.0	117.79	2.55	1
	3c-1	*0*	*15,93*	*0*	*0*
	3c-2	*3,0*	*47,31*	*6,34*	*2*
	3c-3	*0*	*54,55*	*0*	*0*
3d		5.0	18.73	26.70	5

Source: Own calculations

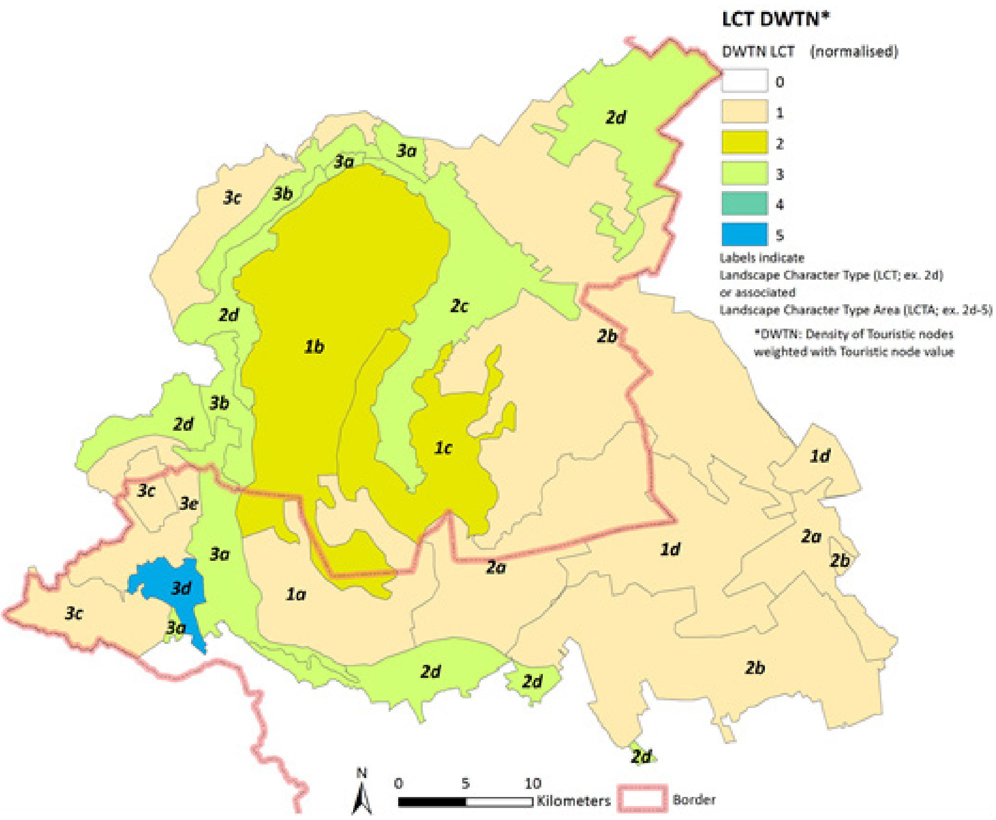


Figure 22: Density of Touristic Nodes Weighted with Touristic Node Value – valuation on the LCT level (St. Martins Therme and Lodge not integrated into the assessment)

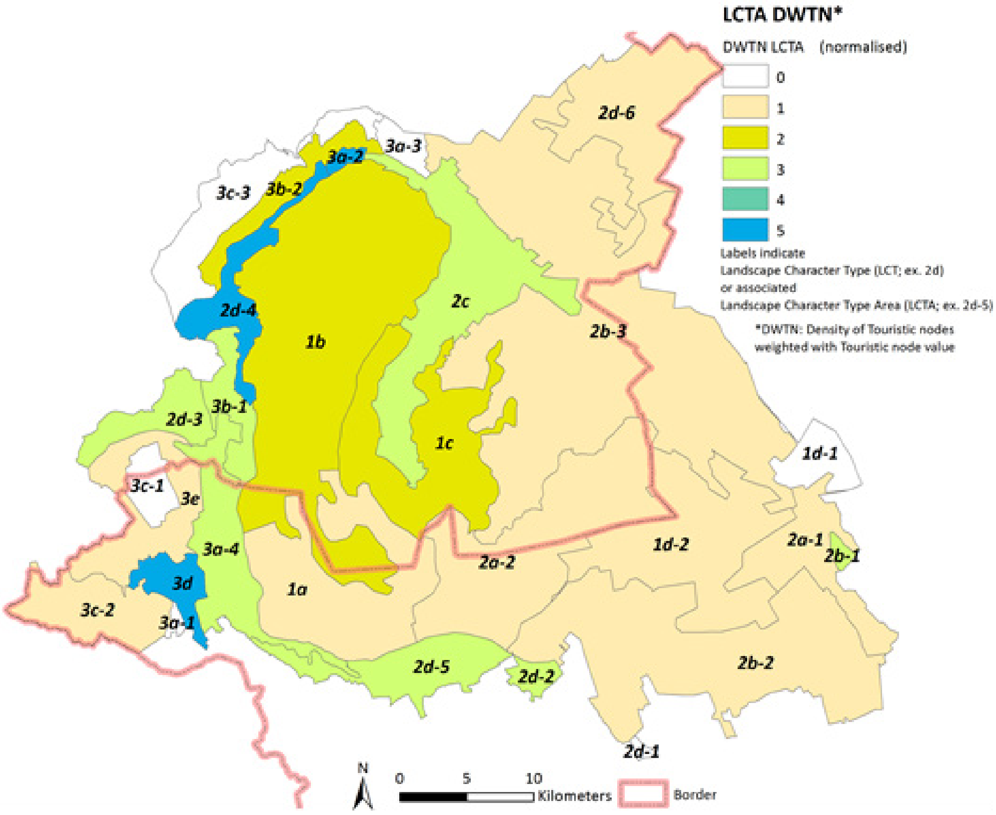


Figure 23: Density of Touristic Nodes Weighted with Touristic Node Value – valuation on the LCTA level (St. Martins Therme and Lodge not integrated into the assessment)

(2) Indicator: Touristic trails

The second indicator shows the density of touristic trails. This indicator includes all hiking, cycling, horse riding and nordic walking trails which are marked in the landscape and/or in maps. Marked and described trails and routes lead through landscape and to cultural attractions. The different trails accommodate the different needs of user groups. For example, cycling trails are mostly longer than hiking trails. Touristic trails play an important role for tourists and one-day visitors who do not know the area. In practice a way can be marked as hiking trail and as cycling trail at the same time. Moreover, defined trails can be used by different user groups like hiking trails by nordic walkers or cycling trails by hikers. Furthermore thematic trails, educational trails and experience trails belong to touristic trails. Classical educational trails include information boards which provide descriptions and explanations of natural topics.

Various maps and some information on the website of the Neusiedler See Tourism Association (NTG) are the source of information about the different kinds of touristic trails, for example NTG maps of cycle paths and horse riding paths (Neusiedler See Tourismus GmbH, 2008a and 2008b). Nordic walking trails are only documented in the two Nordic Walking Areas: Nordic Walking Trails R.O.M. on the Western shore of the lake and Running and Walking Arena Seewinkel-Heideboden. Marked horse riding trails are localised in the Seewinkel area. All these touristic trails were digitised and attributed in the GIS-environment. Finally, for all trails the length could be calculated.

Educational trails are multifunctional facilities which aim at environmental education as well as at upgrading of tourist facilities. Nowadays the term educational trail is often replaced by thematic trail. Modern forms of touristic trails combine education with nature experiences by means of interactive gathering of information and integration of all senses: sight, listening, touch, smell and taste. All types of educational trails (study trails) are part of the *Information* services. Therefore they are not considered in the indicator 'touristic trails'.

As mentioned above, this indicator comprises all hiking trails, cycling trails, horse riding trails and nordic walking trails. There is no valuation necessary on this level because all types of touristic trails get the same value. The basis for valuation is the total length of all touristic trails related to the area of LCT or LCTA - Density of Touristic Trails (DTT, see Table 18, Figure 24 and Figure 25).

Table 18: Valuation of touristic trails on the LCT and LCTA level – Examples

LCT	LCTA	Σ Length of all Touristic trails per LCT/LCTA (km)	Area LCT/LCTA (km^2)	DTT LCT/LCTA (per 100 km^2)	DTT LCT/LCTA normalised
1a		15.0	111.96	13.43	1
1b		89.6	264.80	33.83	1
1d		18.0	135.39	13.26	1
	1d-1	*0*	*21.55*	*0*	*0*
	1d-2	*18.0*	*113.84*	*15.77*	*1*
2a		48.8	186.35	26.15	1
	2a-1	*10.4*	*48.98*	*21.17*	*1*
	2a-2	*38.4*	*137.37*	*27.92*	*1*
2b		372.6	592.27	62.92	2
	2b-1	*0.4*	*3.03*	*13,82*	*1*
	2b-2	*14,8*	*191.64*	*7,75*	*1*
	2b-3	*357,4*	*397.60*	*89,89*	*2*
2c		195.1	106.36	183.40	4
3c		61.5	117.79	52.21	2
	3c-1	*2,9*	*15,93*	*18,04*	*1*
	3c-2	*52,8*	*47.31*	*111,59*	*2*
	3c-3	*5,8*	*54.55*	*10,68*	*1*
3d		13.1	18.73	70.13	2

Source: Own calculations

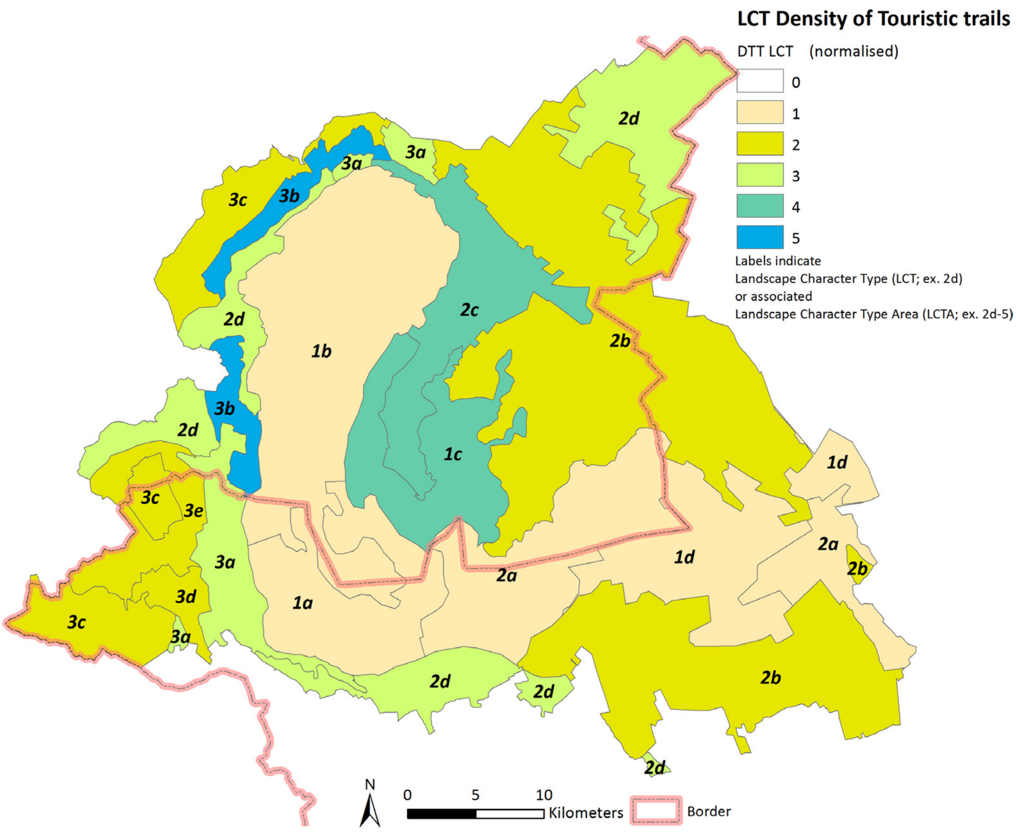


Figure 24: Density of Touristic Trails – valuation on the LCT level

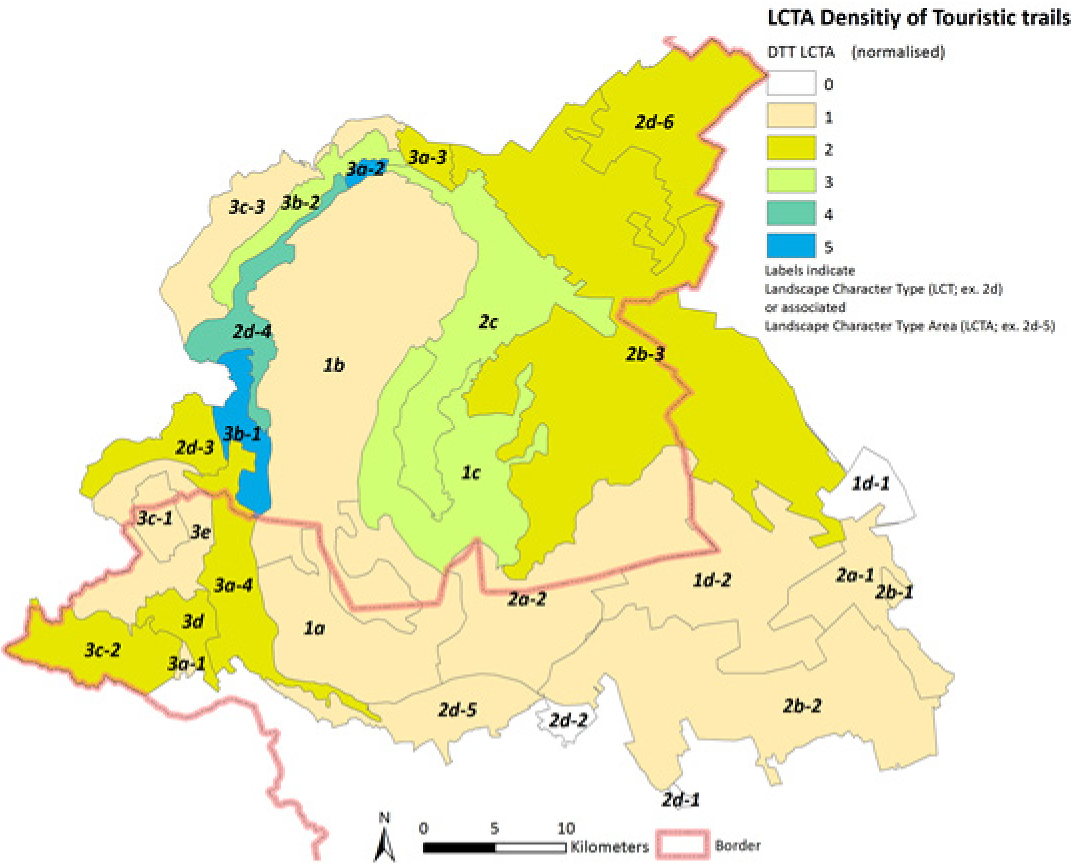


Figure 25: Density of touristic trails – valuation on the LCTA level

(3) Indicator: Water sports

In addition to 'touristic trails' the water sports possibilities are considered. This includes the access to lakes or ponds and the existence of basic infrastructure like boat bridges. However, the quantity and quality of water sports facilities is not the object of this indicator because they are already integrated in the 'touristic nodes'.

On the level of open water areas the first step of assessment comprises the valuation of possible uses for water sport activities. Fishing is not assessed separately because complete and consistent data about all small fishing areas in the region is not available (information from Burgenländischer Fischereiverband).

The Neusiedler See/Fertő is the biggest lake in the region with various water sports opportunities. There are ideal conditions for sailing, windsurfing and kite-surfing. Fishing with fishing permits is also possible. Furthermore the Neusiedler See/Fertő is large enough for regular ferry traffic and boat tours. Only one or two kinds of water sports are possible in the Zicksee near St. Andrä (windsurfing, boating) as well as in the small pond Nagy-Tómalom (boating). The whole sector of the Leitha/Lajta River is used for canoeing and paddling tours. Therefore the Neusiedler See/Fertő gets the highest Water Sports Value (WSPV) and the other waters with water sports opportunities the lowest value (see

Table **19**).

Table 19: Water Sports Value (WSPV)

Various possibilities for bathing and water sports	5	(Neusiedler See/Fertő)
Usability for 1-2 kinds of water sports	1	(Zicksee, Nagy-Tómalom, Leitha)

Source: Own calculations

Due to the big difference between the area of the Neusiedler See/Fertő and the other waters in the region the water surface is not included in the valuation of water. The LCT and LCTA get the same value as the waters itself. The WSPV is already normalised (see Table 20).

Table 20: Valuation of water sports on the LCT and LCTA level

LCT	LCTA	WSPV LCT/LCTA normalised	Waters
1b		5	Neusiedler See/Fertő
1c		1	Zicksee
2b		1	Leitha
	2b-3	*1*	*Leitha*
2d		1	Leitha
	2d-6	*1*	*Leitha*
3a		1	Nagy-Tómalom
	3a-4	*1*	*Nagy-Tómalom*

Source: Own calculations

(4) Integrated Tourism Facilities Value

These three touristic values are aggregated to the final Tourism Facilities Value (TFV). For this purpose all normalised values are summarised. The result is normalised again (see Table 21).

Table 21: Valuation of the Tourism Facilities Value on the LCT and LCTA level – Examples

LCT	LCTA	DWTN LCT/LCTA normalised	DTT LCT/LCTA normalised	WSPV LCT/LCTA normalised	Sum of normalised values	TFV normalised
1a		1	1	0	2	1
1b		2	1	5	8	5
1d		1	1	0	2	1
	1d-1	*0*	*0*	*0*	*0*	*0*
	1d-2	*1*	*1*	*0*	*2*	*1*
2a		1	1	0	2	1
	2a-1	*1*	*1*	*0*	*2*	*1*
	2a-2	*1*	*1*	*0*	*2*	*1*
2b		1	2	1	4	3
	2b-1	*3*	*1*	*0*	*4*	*2*
	2b-2	*1*	*1*	*0*	*2*	*1*
	2b-3	*1*	*2*	*1*	*4*	*2*
2c		3	4	0	7	4
3c		1	2	0	3	2
	3c-1	*0*	*1*	*0*	*1*	*1*
	3c-2	*2*	*2*	*0*	*4*	*2*
	3c-3	*0*	*1*	*0*	*1*	*1*
3d		5	2	0	7	4

Source: Own calculations

2.2.3.3 Upscaling of Landscape Service Values from single landscape elements to LFT

Except from 'habitation', 'transportation', 'energy conversion', 'aesthetic information', 'recreation', 'cultural and artistic information', 'science and education' and 'tourism facilities' services, where a regional/landscape character assessment was applied from the start, all other sub-services, which have been measured on the basis of single landscape element characteristics, had to be scaled-up to regional levels.

Starting with already pre-categorised values between [0;5] derived from the ArcGIS-model, which were called Landscape Element Service Values (LESVs) upscaling was carried out in a stepwise approach (Table 22-Table 24).

Table 22: Schematic calculation of one single sub-Service Value (sSV) per one sample site (1x1 km); area-weighted mean values of all LESVs were calculated.

	LESV (0-5)
LEL 1	3
LEL 2	5
LEL 3	2
LEL 4	0
LEL 5	1
LEL x	4
sSV per sample site (area weighted mean)	**3**

Table 23: Schematic calculation of one sub-Service Value (sSV) per one Landform Type; mean of all sSVs were calculated.

	sSV (0-5)
Sample site 1	3
Sample site 2	5
Sample site 3	2
Sample site 4	0
Sample site 5	1
Sample site 6	4
sSV per Landform (mean)	**2.5**

Table 24: Schematic aggregation of the sub-Service Values sSV (demonstrated by the example of *Habitat* service group) to the Service Group Value (SGV) per Landform; calculated by the mean of all sSVs.

Sub-services for *Habitat* service	sSV per Landform
Refugium	3.3
Nursery	2.5
SGV (mean)	**2.9**

To receive one single value for each sub-service per sample site (1x1 km) area-weighted mean values of all LESVs were separately calculated for all designated sub-services that have previously been included in the GIS-model. The outcomes, again ranging from [0;5], could be seen as the actual state of each investigated sampling site in the fulfilment of certain sub-services (Table 22). Each LFT is represented by 6 random stratified sample sites (please refer to chapter 2.2.3.1.1, Figure 8). The in-situ results of sub-service provision were consequently extrapolated to LFT level by calculating mean values out of each set of representative sample site based results (Table 23).
In the next step three out of five main service values in the frame of the landscape service assessment, such as *Regulation* service, *Habitat* service and *Provision* service could be obtained by combination and calculation of mean values for related sub-services on LFT level (Table 24), apart from LFT 1.

LFT 1, describing the lake basin, constituted a special case, because representativeness of the sample sites for upscaling possibilities on the entire LFT were limited due to inclusion of the Neusiedler See itself plus its adjacent reed belt and satellite lakes in the LFT. However, these inaccessible areas comprise more than 60% of LFT1 and therefore must be taken into account for landscape service provision.

To overcome these difficulties LFT 1 was split up into 4 parts such as the terrestrial region, characterised by sample site outcomes, the lake itself, the reed belt and the satellite lakes. For the latter three, provision of certain landscape services was derived by calculating area-based values from the BIS table and afterwards combining them with sample site based results for the terrestrial area according to their areal weights. This approach can be vindicated by the uniformity of land units that have separately been treated here which didn´t require for an additional qualifier assessment.

Interrelating services of different spatial levels for the *Carrier* and *Information* Service assessment

The *Carrier* service group comprises of 6 sub- services, particularly ‘waste disposal’, ‘transportation’, ‘habitation’, ‘energy conversion’, ‘cultivation’ and ‘tourism facilities’. The ‘tourism facility’ service (see chapter 2.2.3.2.2) was calculated on LCT basis. Taking the single LCTs as reference units was possible because LFT based results could be spatially referred to the LCT based assessment of ‘tourism facilities’. Again, mean values of the designated sub-services were calculated to reach *Carrier* main service values on the LCT-level.

For the landscape service assessment of the *Information* service, which comprises of the sub-services ‘aesthetic information’, ‘recreation’, ‘cultural and artistic information’ and ‘science and education’ please refer to chapter 2.2.3.2.1. Again, for this main service spatial reference units were set on LCT-level.

Creation of final charts, representing the actual state of landscape service provision on LFT level

In order to unite separately calculated main services and visualise them together in spiderweb diagrams, some prerequisites must be met. As previously outlined two main services (*Carrier* and *Information* service) were calculated on LCT basis. These services had to be harmonised and integrated into the spatial level of LFTs first. In the first step the spatially least abundant LCTs which did not cover more than 5% of a designated LFT were neglected in the upcoming steps. Then area-weighted partial values of the LCT based main services were calculated for each LFT-reference unit.

E.g.: LFT 2 (‘Marshlands’) dominantly comprises of LCTs 1d (covering 35.1%), 2a (35.3%) and 2b (27.6%). Summing up 98% of LFT 2 are covered by these 3 LCTs. Now, *Carrier* and *Information* service partial values were area-weighted and summed up to reach one final value for LFT 2.

After the aggregation process seven final spiderweb charts could be delineated, each consisting of five final axes which are representing the actual state of landscape service provision expressed by the five main landscape services that were chosen for the assessment.

2.2.4 *Results - Actual landscape service provision*

2.2.4.1 Socio-cultural approach

On the LCT level the Tourism Facilities Value (TFV) reflects the concentration of tourism at the lake and the immediate surroundings (see Figure 26). The high value of the northern part of the lake basin which is dominated by open water (LCT 1b) results from water sports. The big and middle divided touristic nodes on the lakeshore lie only partly in the lake basin.

The hilly areas on the western shore of the lake (LCT 3b) are higher valuated than the flat areas on the eastern shore (LCT 1c and 2c). The reasons for this situation are manifold, in particular it is due to the different landscape structure and consequently a different structure of settlements and touristic nodes.

The marshland areas (LCT 1d and 2a) as well as the southern part of the lake basin which is dominated by the reed belt and wetlands (LCT 1a) have the smallest Tourism Facilities Value. In former times the Hanság area was covered by extensive wetlands with the result that the settlements are very small. The land use is dominated by agriculture and tourism is underdeveloped.

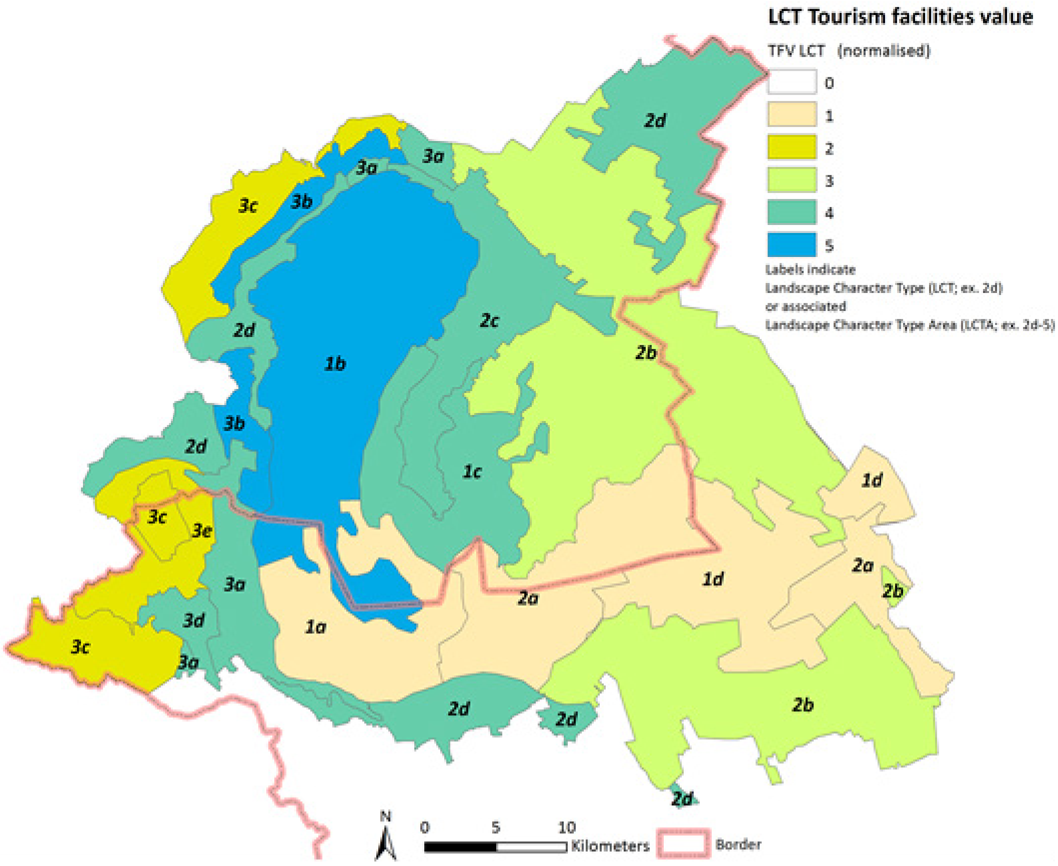


Figure 26: Tourism Facilities Value – valuation on the LCT level

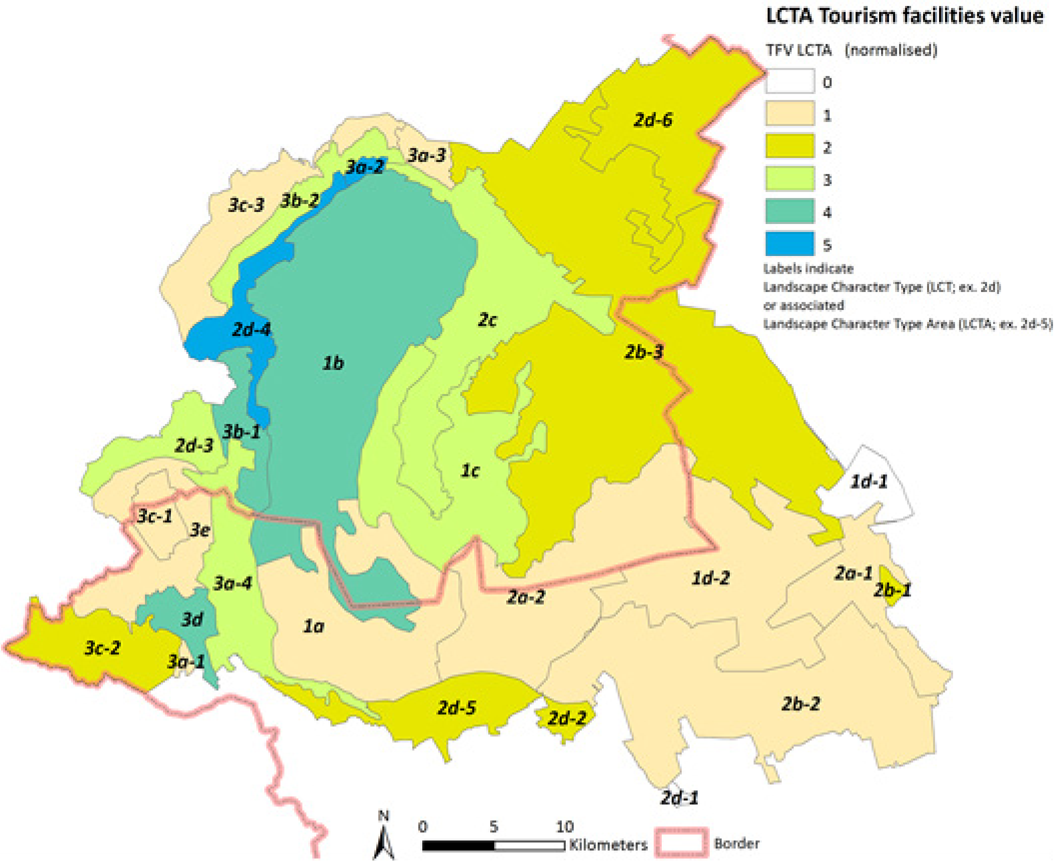


Figure 27: Tourism Facilities Value – valuation on the LCTA level

Several valuations of LCTs are the result of statistical effects. Like the valuation on LCTA level shows, tourism development is only partly connected to the Landscape Character Type (LCT) (see Figure 27). The location and distance to the lake, historical and cultural aspects as well as local and regional development and planning have influenced tourism development. Especially the different parts of the LCT 2d ('Flatland with medium or high intensity of human use and heterogeneous land cover') are valuated very differently. In the relative small area on the north-west shore of the lake (LCTA 2d-4) some touristic nodes and a lot of touristic routes are concentrated. In contrast to this, the southern flatlands around Fertőd (LCTAs 2d-5 and 2d-2) and the north-east part (LCTA 2d-6, Parndorfer Platte) have a lower Tourism Facilities Value (Figure 26, Figure 27).

2.2.4.2 Habitat approach

Within the habitat approach landscape services were assessed at the landscape element (biotope type) scale. The maps below show the biotope types´ capacity to provide specific services within different Landforms. The selected landscape sample within the Landform 'Low and middle range mountains' has a very high capacity to provide 'climate regulation', 'water regulation' and 'nursery' services mainly due to the large forested areas. The example of the 'Lake basin' reflecting mainly arable land shows the lowest values for all three services (Figure 28).

When aggregating the single sub-services to the main service groups hot and cold spots of the environmental (*Provision, Habitat* and *Regulation*) service can be identified (Figure 29).

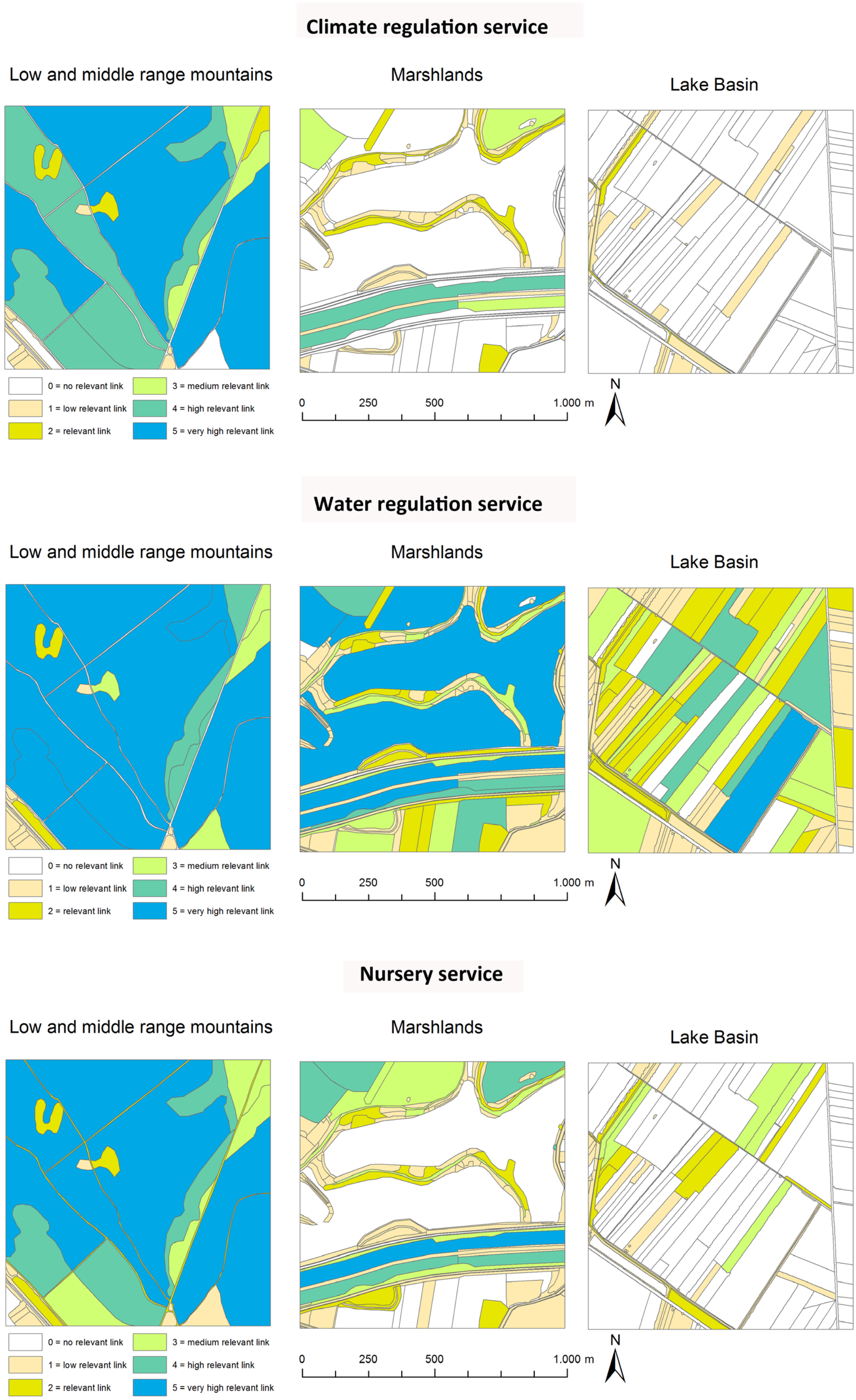


Figure 28: The landscape samples within the LFTs 'Low and middle range mountains', 'Marshland' and 'Lake basin' show the biotope types´ capacities to provide 'climate regulation', 'water regulation' and 'nursery' services.

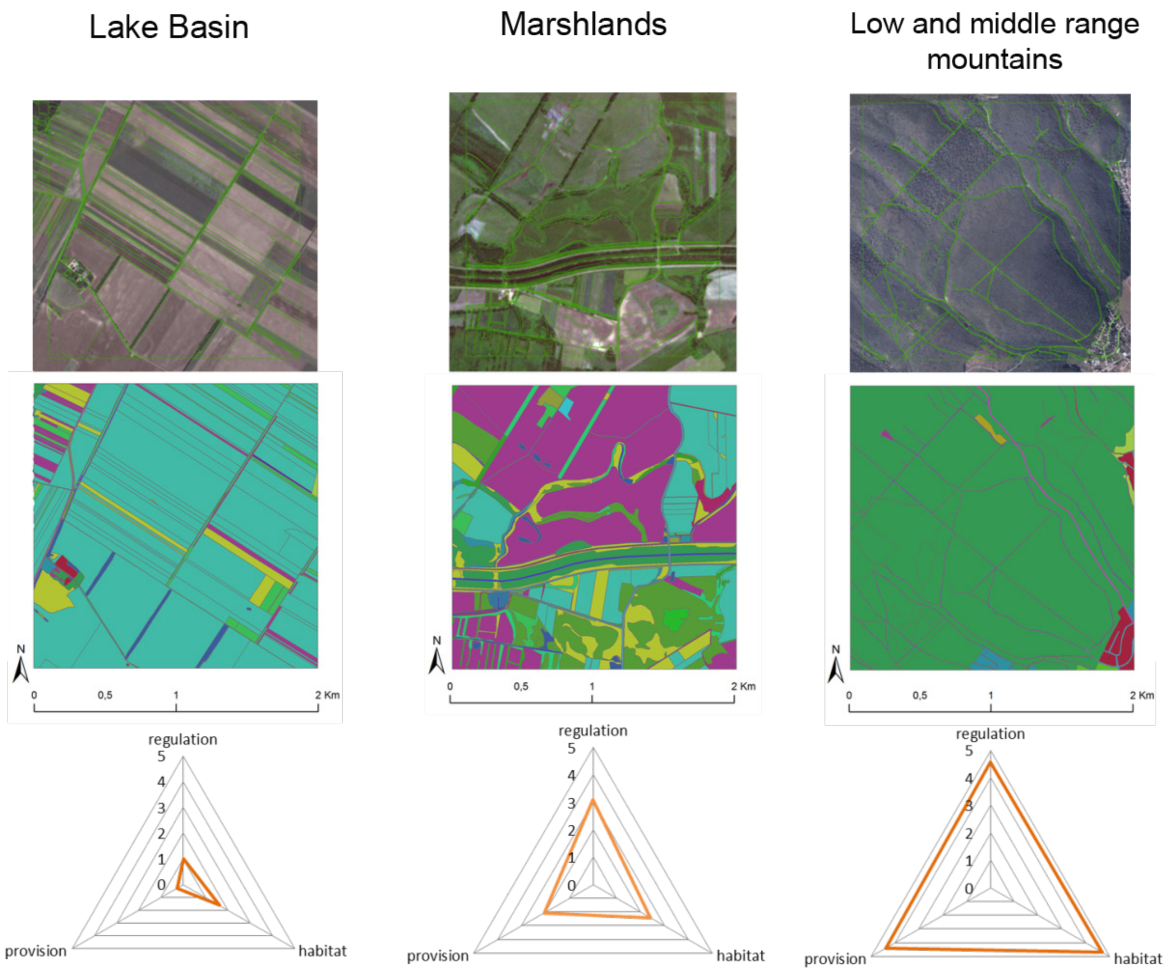


Figure 29: Hot and cold spots of the *Regulation, Provision* and *Habitat* services.

2.2.4.3 Spiderweb diagrams of each Landform

The combined results of the habitat, regional and socio-cultural approach are visualised by seven spiderweb diagrams describing the allocation and trade-offs in landscape service provision. Each Landform is characterised by one spiderweb diagram. The figures represent the high diversity within the investigation area ranging from the natural and semi-natural areas such as the shallow lake and its immense reed belt, the remaining marshland and flood plains over the extensive used hilly area to the intensive agricultural regions in the low lying terraces.

Lake Basin

Figure 30: Surrounding area of Mörbisch. Photo: Éva Konkoly-Gyuró

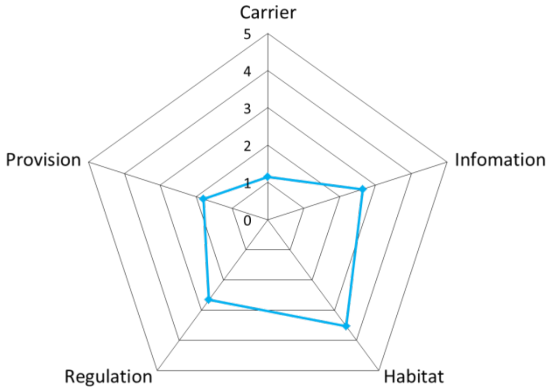


Figure 31: Allocation of landscape services for LFT 'Lake basin'

Figure 31 presents the allocation of the landscape services within the Landform 'Lake basin'. The *Habitat* ('refugium service' and 'nursery service'), *Regulatio*n (e.g. 'local climate regulation', 'water regulation' and 'nutrient regulation') and *Information* (e.g. 'aesthetic information', 'recreation', 'science and education') services have reached the highest values, which is mainly based on the dominating shallow lake surrounded by the reed belt as well as on the natural and semi-natural area in the southern and eastern part of the Landform. These areas primarily provide conservation service. The core zones of the national parks both in Hungary and in Austria belong to it mainly because of the nesting and feeding habitats it provides for colonies of reed-nesting birds (e.g. egrets, spoonbills). The open scenery of the immense reed belt in the south and the grassland area in the east intermingled with few pathways and bird watching towers provide visual diversity. However, the high values of the *Information* services is not only based on the 'aesthetic information' but mainly on the 'recreation' service provided by that area. In contrast to the idyllic southern part with low human impact (only ecotourism), the recently developed recreational district on the lake shore in the north-east at Podersdorf has a clear urban character with multi-storey hotels, large built up beach and camp site, big marina, wide multilane cycling road, parking lots and green spaces. The *Carrier* (e.g. ‘habitation’, ‘transportation’ and ‘tourism facilities’) services have the lowest values due to some villages embedded in the lake basin with agricultural use, mainly pastures and vineyards.

Marshlands

Figure 32 : Grassland with woodlots and shrubs in the southern Hanság, near Kóny. Photo: Éva Konkoly-Gyuró

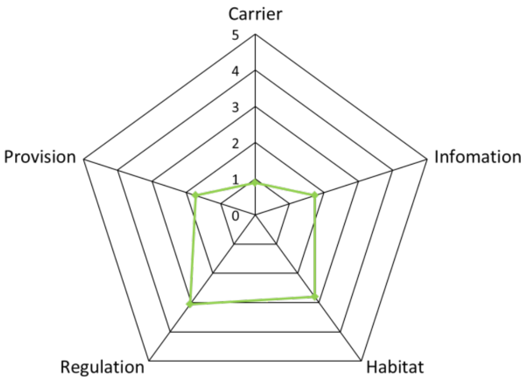


Figure 33: Allocation of landscape services for LFT ‘Marshlands’

River floodplains

Figure 34: Leitha-Auen, Photo: www.Leithaauen-neusiedlersee.at

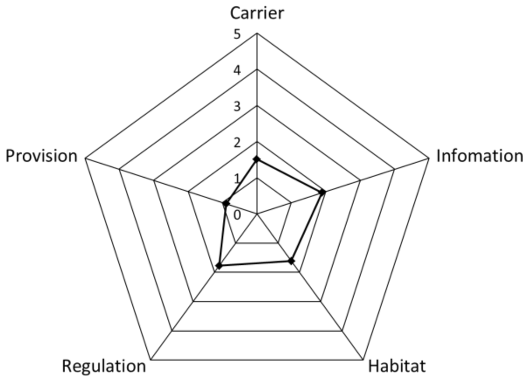


Figure 35: Allocation of landscape services for LFT ‘River floodplains’

The ‘Marshlands’ have a high capacity to provide *Habitat* and *Regulation* services (Figure 33). Lakes and some patches of wetland have remained in the lowest areas within the mosaic of forest and grassland supplying a range of *Regulation* services. Forests are dominated by poplar plantations but also some remains of the original *Alnus glutinosa* ‘marsh forest’ with high nature value providing refugium and nursery habitat for wild animals. Wet grasslands and arable land grow into the forests. In comparison to the former services the *Information* and *Provision* services reach lower values here. This might be based on the fact that the former wetlands, covered by peaty soils, adjacent to the lake on the south-east are nowadays trenched by an artificial channel network and only some wet patches remain on the lowest relief levels. Recent processes of intensification and extensification create differences in the landscape. On the one hand there are increasing biofuel crops and expanding ’plastic villages’ of vegetable production and on the other hand there are large set aside areas that lead to a different character. The very low value of *Carrier* services may also be explained by this contradictory phenomenon (intensification versus extensification). While in Austria built up surfaces are insignificant, in Hungary a series of small rural settlements can be found.

Figure 35 presents the landscape services provided by the region influenced by the river Leitha in the north east, the Wulka river in the west and the Raab flood plain in the south east of Hungary. The Leitha, the Raab and the Wulka are typical alpine rivers that are important corridors within an intensively used agricultural land. There still remain some flood plain forests and wet grasslands of high natural value providing *Habitat, Regulation* and *Provision* services. However, in relation to the whole region within this Landform the river corridors and their flood plain forests represent only a marginal percentage of area which explains the relative low values of the environmental (*Provision*, *Regulation* and *Habitat*) services. The high *Carrier* service values, including agriculture and transportation might be based on the intensively used area surrounding the river floodplains.

Low lying terraces	Elevated terraces
	
Figure 36: Flatland dominated by arable land in the north of Andau. Photo: Éva Konkoly-Gyuró	**Figure 38: Wind turbines at Plateau of Parndorf. Photo:Tamara Zhuber**

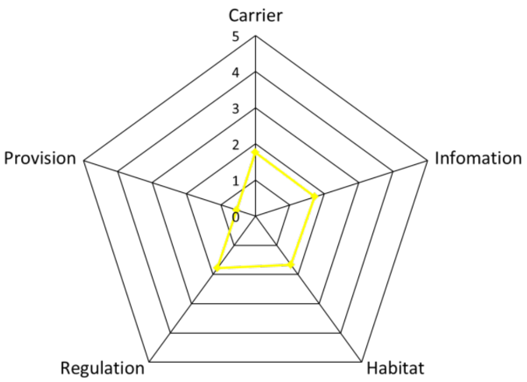
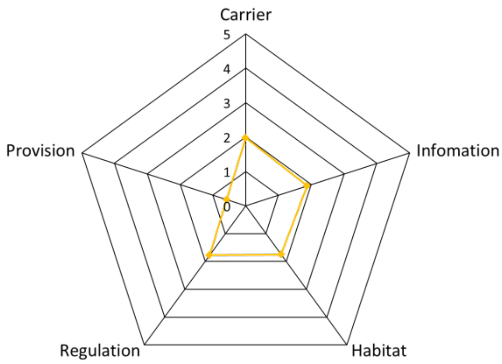

	

Figure 37: Allocation of landscape services for LFT 'Low lying terraces'	**Figure 39: Allocation of landscape services for LFT 'Elevated terraces'**

Figure 37 and Figure 39 more or less show the same allocation of landscape services. Both Landforms are characterised by complete lack or insignificant presence of surface water due to flood protection and/or the higher elevation of the terraces. Predominant is the equally flat surface covered by intensive arable land parcels and periurban zones and by growing horticultural establishments. Recently also energy production by means of wind turbines has increased in significance on the Plateau of Parndorf and in smaller scale also in Hungary. These areas are less attractive and have neither recreational nor nature conservation potential. That is why both Landforms present the lowest values in the *Provision* (e.g. wild food, raw materials) and the highest values in *Carrier* services at the same time. The relative high values in *Regulation* and *Habitat* services may be due to the well preserved nature conservation areas (wet grassland with high biodiversity) within these monotonous Landforms.

Hilly areas and hill ranges

Figure 40: Panorama image of the hilly area nearby Rust and Oggau. Photo: Éva Konkoly-Gyuró

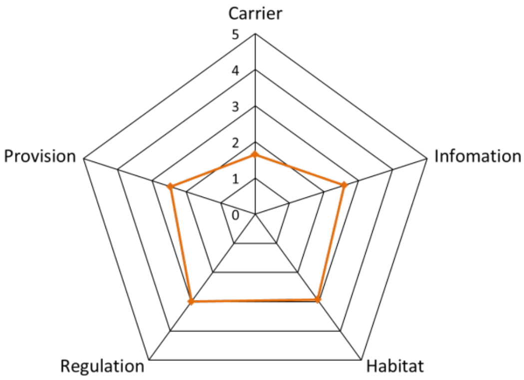


Figure 41: Allocation of landscape services for the LFT 'Hilly areas and hill ranges'

Low and middle range mountains

Figure 42: Panorama image of Löverek. Photo: Pal Balázs

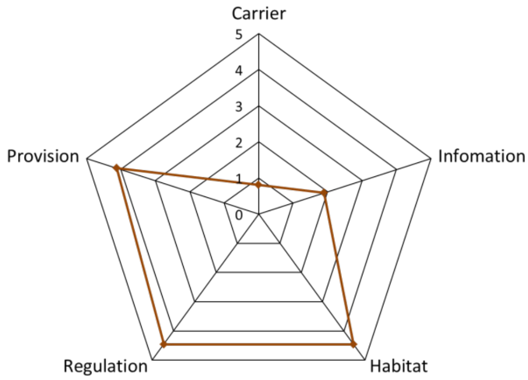


Figure 43: Allocation of landscape services for the LFT 'Low and middle range mountains'

The spiderweb diagram values of the Landform 'Hilly areas and hill ranges' are well balanced (Figure 41) reflecting a diversified landscape including both extensive and intensive rural areas accompanied by some semi-urban settlements. The relatively high values of *Regulation* and *Habitat* services are based on the semi open landscape on the western sandstone hill, mainly in Hungary, with its clear land use zonation in accordance with the relief. On the lowest level villages and small towns are embedded in grassland and arable land adjacent to a mosaic of vineyards and gardens that cover the gentle slopes and are confined by closed deciduous forest on the hilltop. The gentle undulating relief of the hills and the view on the reed covered lake as well as the settlements with their traditional architecture attract visitors during all seasons. In Austria, on the northern part of the Rust hill range, on the foothills of the Leithagebirge and on the small island hill 'Hackelsberg' the sunny southern and western slopes have a certain mediterranean character. With the exception of the hill 'Hackelsberg', where valuable dry grasslands still remain, the landscapes are intensively used and mainly covered by vineyards. Tourism is based on wine culture and the dense cycling road network inserted into the landscape.

The Landform 'Low and middle range mountains' is characterised by low mountains and foothills with low intensity human use, mainly covered by closed forests. The remarkable high values of *Provision*, *Regulation* and *Habitat* services (see

Figure **43**) are based on the almost homogeneous oak-hornbeam forest with fringes of thermophilous downy oak associations with some infiltration of *Robinia pseudo-acacia* and small grassland patches on the hillsides of the deep valleys in the Leithagebirge. The closed forests of the Sopron Mountains consist of widely spread spruce and pine plantations mixed into the oak, oak-hornbeam and beech stands. Although recreation and tourism play an important role especially in the vicinity of the towns, *Carrier* (e.g. 'tourism facilities', 'transportation', 'habitation') and *Information* (e.g. 'recreation', 'aesthetic information', 'science and education') services only reach low values within this Landform.

2.2.4.4 Critical view and conclusions on our methods

Data availability and indicator development for the socio-cultural approach

Indicator development for each component of the information service (S1: 'aesthetical information', S2: 'cultural and artistic information', S3: 'spiritual and historic information', S4: 'science and education', S5: 'recreation') was highly dependent on data availability. Three kinds of indicators have been developed: indicators related to punctual, linear, spatial elements. We set up a common data base for punctual elements. This source of data was collected from different data sources. Furthermore we collected and selected information from maps, with the legend of important touristic nodes and data from other researches e.g. inventory of landscape values (called TEKA in Hungary). In some cases we also used expert knowledge e.g. wine cellars.

Especially, there was a lack of data related to linear elements, where we calculated only the visually relevant edges in the landscape, but there are also other relevant issues (e.g. panoramic roads/roads with panoramic view, tree rows) that need to be considered.

Indicators related to spatial elements are derived from CORINE Land Cover data. Other relating issues can be mentioned, for example accessibility, visibility, diversity of land cover and also the diversity of morphology.

Data availability and spatial scales of the habitat approach

Within this approach landscapes are considered as a human ecological system that provides a wide range of services. Therefore, we build on a multifunctional view of landscapes including both natural and cultural aspects. As different landscapes have different services based on their structure and processes the individual landscape capacities to provide services are strongly linked to natural conditions: e.g. land cover, hydrology, soil conditions, fauna and flora, elevation, slope and climate as well as human impacts (mainly land use but also pollution and emissions, etc.). All this information should be as detailed as possible, however, finding appropriate indicators related to the specific service providing unit and exploring how services are correlated with different landscape scenarios are still unresolved questions (Seppelt et al., 2011, Wallace, 2007). Current landscape service indicators are still limited by insufficient data and an overall low ability to convey information (Layke, 2009). In our study we aimed at assessing a wide range of services to provide a good overview of the benefits people derive from landscapes. Therefore, we decided to use an expert driven approach expanded by the qualifiers gathered during field work to see first trends for landscape service assessments. In follow up projects the expert evaluation values of the capacity matrix can be revised by data from monitoring, measurements, computer based modelling, targeted interviews or statistics.

Some services are even relevant at more than one scale. For instance regulation services can occur both at global scale (climate regulation) and plot scale (biological nitrogen fixation) (de Groot, 1992). Also pressures on ecosystem services can have effects at different scales. In general, physical processes on small scales are often driven by the impact on long period phenomena at large scales (climate patterns, hurricanes, fires) (Limburg et al., 2002). However, large scale processes are also strongly influenced by smaller scale occurrences, for example, microbes respire enough CO_2 to keep many lakes and rivers supersaturated (Levin, 1992; del Giorgio et al., 1997). Hence, for the analyses of the dynamics of service supply it is very important to consider the drivers and processes at scales relevant for service generation. However, within the habitat approach we have only focused on the scale of the service providing unit. To integrate effects at broader scales e.g. the landscape scale, both the spatial configuration of the landscape elements and effects of neighbouring features (e.g. power plants) have to be integrated.

Spatial reference

Landscape Service Values of the socio-cultural approach were calculated in Landscape Character Types, however finally the overall results for each group of services are presented in Landform Types. Within the habitat approach service assessments have been made on Landform level due to data availability. One of the weaknesses of the project results is that not all landscape services were analysed in Landscape Character Types. However, the results of the service assessments can provide baseline information for Landscape Character Types and the on-going processes in each type.

Aggregation to main landscape services

Our approach is based on the assessment of the sub-services at the service providing unit. In a second step they are extrapolated and aggregated to the main service groups which may result in a loss of information. However, a sort of weighting of the single sub-services within one main service group could partly solve the problem. Thus, important services such as 'cultivation' or 'transportation' could be emphasised more.

Another problem may arise when extrapolating the landscape services to the landscape scale. As the services were assessed at landscape element scale or for Landscape Character Types, the effect on a broader scale could be different. Investigations on the extent of service delivery as well as trade-offs in service delivery have to be undertaken.

2.3 Landscape services in four investigation areas in the Project region Central North

Author: Hana Skokanová

PP12 – Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Pub. Res. Inst., Brno

2.3.1 Introduction

Landscape services studied in the four investigation areas situated in the Czech part of the project region Central North were outlined by partners from the University of Vienna. Their classification of landscape functions and services is based on de Groot (2006). In total 21 landscape services were distinguished and grouped into five main categories:

1) *Regulation* services – 'climate regulation', 'disturbance prevention', 'water regulation', 'water supply', 'soil retention', 'soil formation', 'nutrient regulation', 'pollination'
2) *Habitat* services – 'refugium service', 'nursery service'
3) *Provision* services – 'food', 'raw materials', 'genetic resources', 'medicinal resources'
4) *Information* services – 'science and education'
5) *Carrier* services – 'habitation', 'cultivation', 'energy conversion', 'mining', 'waste disposal', 'transportation'

Out of these 21 services, only 19 were considered in the four investigation areas in the Czech part of the project region Central North. Landscape services concerning energy conversion and mining were not considered because they were not found in the areas.

2.3.2 Methodology

The assessment of landscape services was based on the habitat approach (Burkhard et al. 2009) which uses a matrix of habitats and their related services. At the University of Vienna (PP05) an assessment strategy for landscape service provision at the landscape scale was suggested. This assessment was based on a combination of expert judgements with semi-quantitative data derived from field work and used biotope types as the spatial reference unit. Biotope types based on land use/cover classes (LUC) were linked to the landscape services by expert knowledge about the different biotope types' capacities to provide said services which resulted in a capacity matrix. At the intersections, the different biotope types' capacities to provide landscape sub-services were assigned values from 0-5. These service provision values reflect relationships between biotope type and service: 0 = no relevant link between LUC and specific service, 1 = low relevant link, 2 = relevant link, 3 = medium relevant link, 4 = high relevant link, 5 = very high relevant link

In the case of the Czech part of the project region Central North biotope types were related to landscape elements based on LUC and field survey. As the landscape elements differed from biotope types defined by PP05, the capacity matrix was slightly modified to better correspond with the landscape elements and their services.

The assessment focused on several aspects. Besides the spatial distribution of individual landscape services, also a relationship between landscape services and the mean functionality of landscape elements calculated in WP 5.1 was studied.

In the following graphs and maps the values from 0-5 relate to the capacities and the values 'a-e' relate to five functional categories (a = very low functionality, b = low functionality, c = medium functionality, d = high functionality, e =very high functionality).

2.3.3 *Results*

The following definitions of individual landscape services were generally taken from de Groot et al. (2002, 2006).

2.3.3.1 Regulation services

2.3.3.1.1 Climate regulation

Local weather and climate are determined by the complex interactions of regional and global circulation patterns with local topography, vegetation, albedo, as well as the configuration of, for example, lakes and rivers. This landscape service relates to the maintenance of a favourable local climate in terms of temperature or moisture for human habitation, health or cultivation.

The spatial distribution of this service is shown in Figure 44. Landscape elements with no relevant or low capacity (values 0 and 1) prevail in Dunajovické kopce and Skalky where they cover more than 60% of the area. Unlike in Dunajovické kopce, landscape elements with high capacity cover about 20% of the Skalky area and thus contribute to the local climate regulation. Landscape elements with high capacity (values 4 and 5) prevail in the Floodplain forest and Ostravice where they cover nearly 60% of the area.

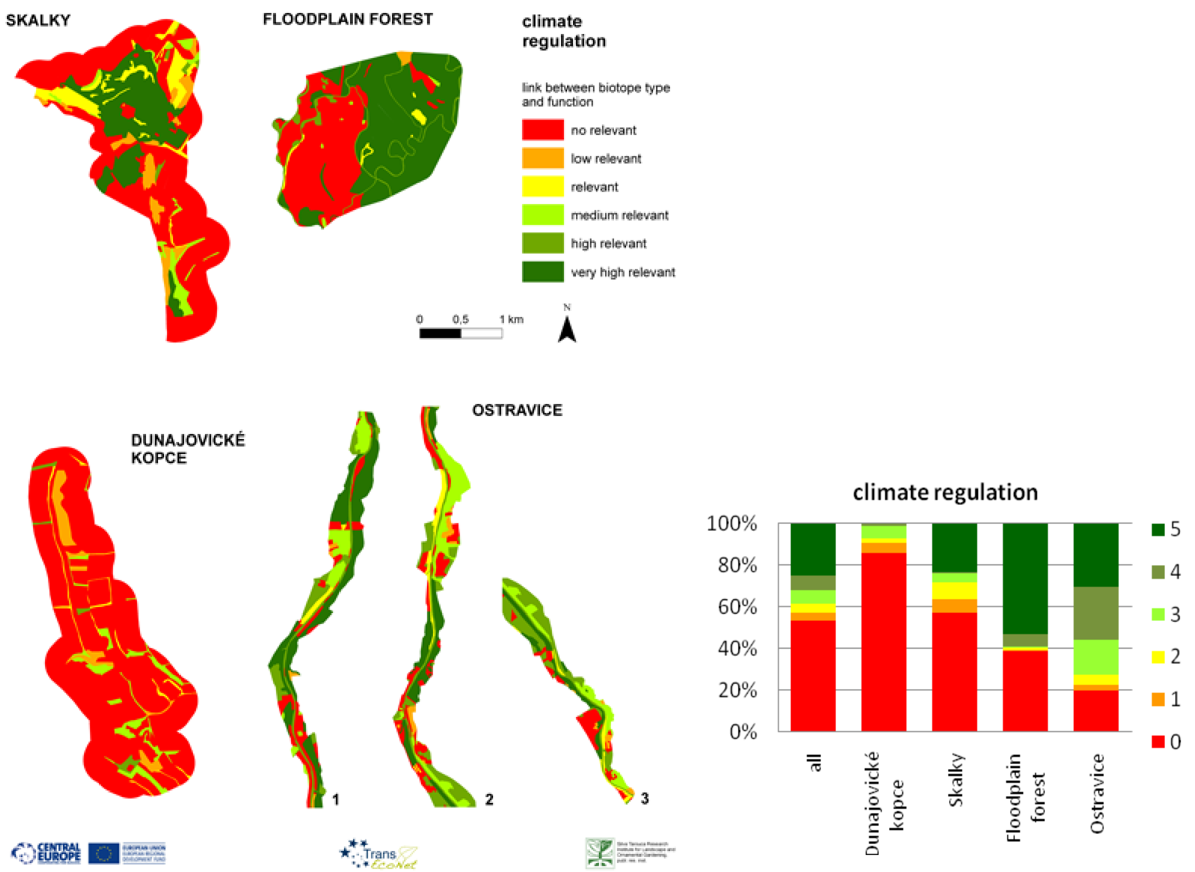


Figure 44: Spatial distribution (left) and area proportion (right) of the 'climate regulation' service in all investigation areas

When comparing the mean functionality in the landscape elements with different capacities to provide the ‘climate regulation’ service, the Kruskal-Wallis test shows significant differences regardless of the investigation areas. Post hoc comparisons using Tukey HSD test identified significant differences between capacities as following: The mean functionality in capacity value 0 was significantly different than in capacity values 2 and 5 and did not significantly differ from capacity values 1, 3 and 4. Similar results were noted for capacity values 1 and 4. Mean functionality in capacity value 2 significantly differed besides capacity value 0 also in capacity value 1 and 4 and the same results were found for capacity value 5. There were found no significant differences in capacity value 3.
Mean functionality was generally high in capacity value 5 and low in capacity value 4. Other capacity values showed relatively similar mean functionality as can be seen in Figure 45.

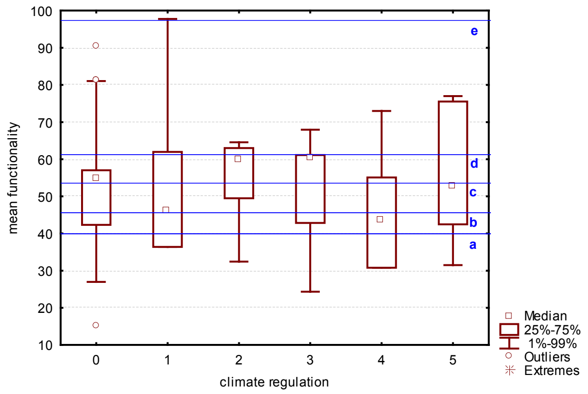


Figure 45: Mean functionality in the capacity values to provide the ‘climate regulation’ service regardless of the investigation areas; blue hatches show borders of functional categories

The Kruskal-Wallis test also confirmed significant differences between mean functionality and capacity values in all investigation areas. Post hoc comparisons identified significant differences in all investigation areas. Similar results typical for two capacity values were recorded in Dunajovické kopce (capacity values 2 and 3) and Skalky (capacity values 1 and 2) and for three in the Floodplain forest (capacity values 0, 4 and 5). In Ostravice there were two different groups with similar significant differences in mean functionality – the first group includes capacity values 0, 2 and 5, the second group includes capacity values 1 and 4. Similar results in capacity value 2 were identified in both Dunajovické kopce and Skalky.
A different behaviour of mean functionality in capacity values in the investigation areas is also clear from Figure 46. A very high functionality in capacity value 5 was found in the Floodplain forest and partly in Skalky and Ostravice; in the capacity values 0 and 4 in the Floodplain forest; capacity value 2 in Dunajovické kopce and to some extent in the capacity value 3 in Ostravice. Low functionality was typical for capacity value 0 in Skalky, 1 and 3 in the Floodplain forest and 2 and 4 in Ostravice.

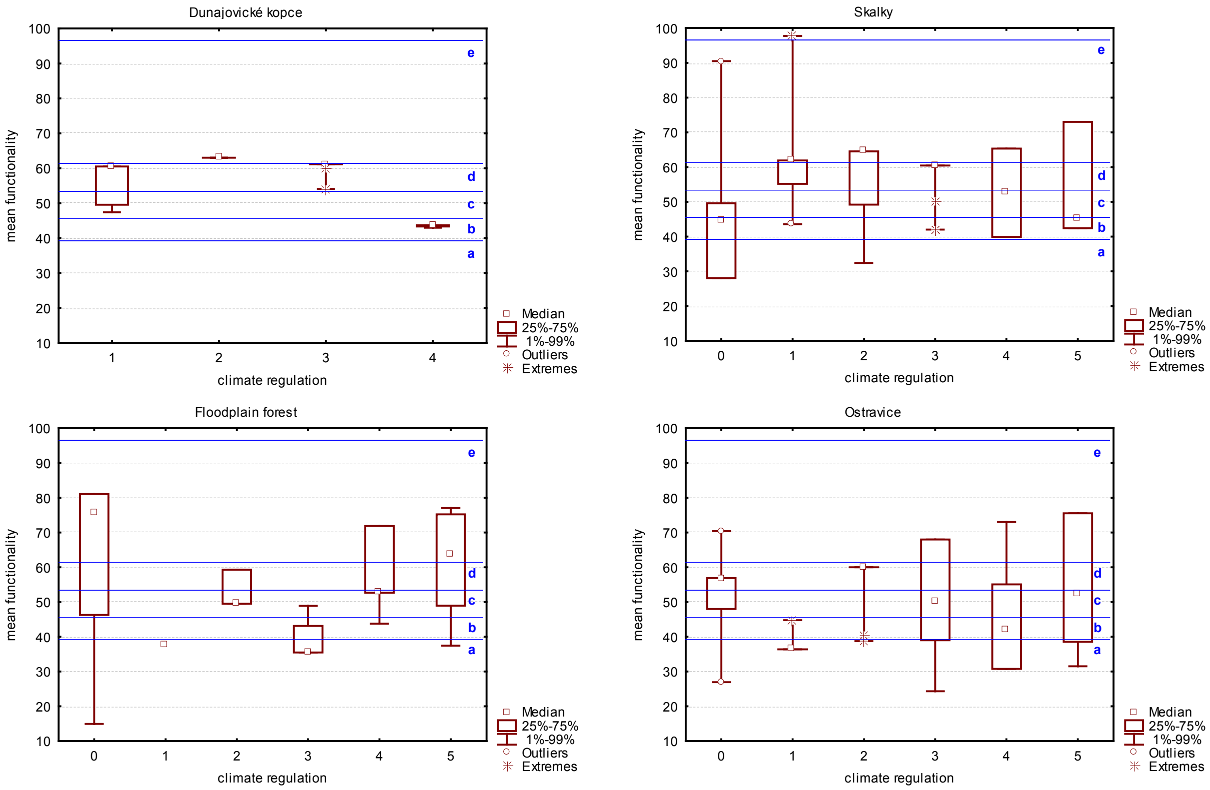


Figure 46: Mean functionality in the capacity values to provide the 'climate regulation' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.1.2 Disturbance prevention

We understand the service ‘disturbance prevention’ as the influence of landscape structure on environmental disturbances. The service includes mainly storm protection or flood prevention for the sake of human life and human constructions.

Only in Skalky the spatial distribution of ‘no relevant capacity’ (value 0) reaches almost 50% of the area. On the other hand the other half belongs to capacities with medium, high and very high values (Figure 47). The floodplain forest can be considered as an investigation area with very good disturbance prevention (more than 50% of the area belongs to capacity values 4 and 5). Good disturbance prevention is also typical for Ostravice (capacity values 3 and 4 cover more than 60% of the area). Disturbance prevention in Dunajovické kopce is rather low.

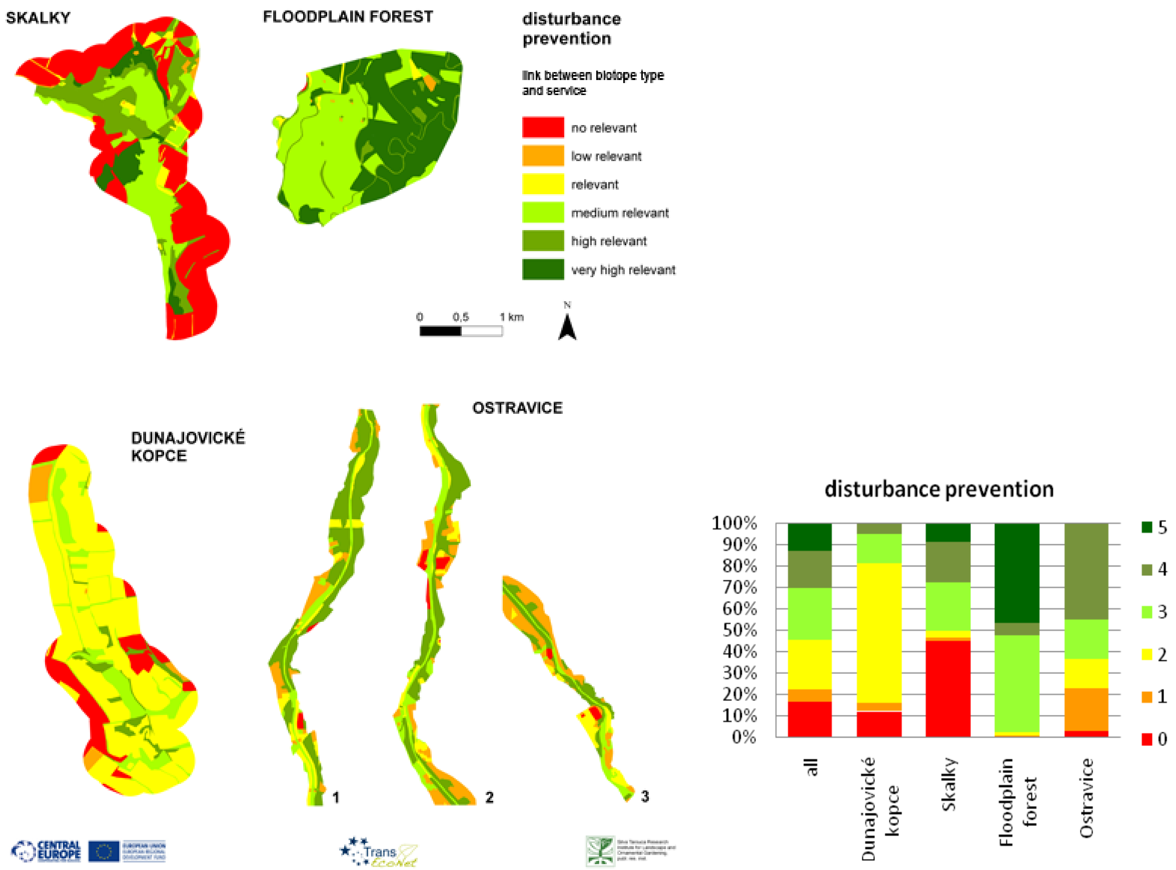


Figure 47: Spatial distribution (left) and area proportion (right) of the ‘disturbance prevention’ service in all investigation areas

Significant differences between mean functionality and capacity to provide the ‘disturbance prevention’ service were revealed by a Kruskal-Wallis test. Post hoc comparisons using the Tukey HSD test identified four different groups with similar significant differences between capacities. Group 1 includes capacity value 0 where significant differences were identified in capacity values 2, 3, 4 and 5; group 2 consists of capacity value 1 with significant differences in capacity values 3, 4 and 5; group 3 holds capacity value 2 where significant differences were calculated for mean functionality in capacity values 0, 3, 4 and 5; and group 4 includes capacity values 3, 4 and 5 with significant differences in capacity values 0, 1 and 2.

Very high mean functionality was typical for capacity value 4 while low mean functionality was found in capacity values 0 and 1 (Figure 48). Mean functionality in capacity values 2 and 5 was medium even though in capacity value 5 the range was rather wide and some landscape elements with this capacity had very high functionality. High functionality was typical for capacity value 3.

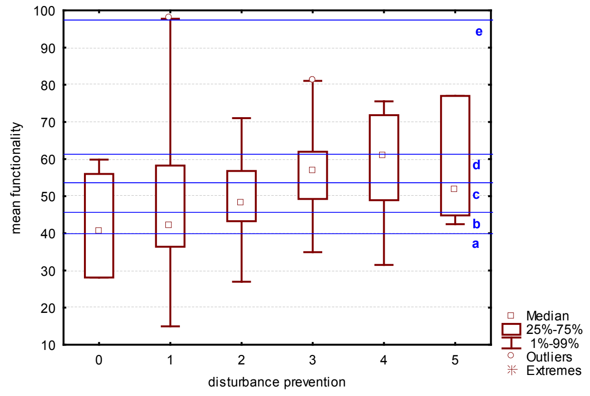


Figure 48: Mean functionality in the capacity values to provide the 'disturbance prevention' service regardless of the investigation areas; blue hatches show borders of functional categories

Concerning investigation areas, a Kruskal-Wallis test confirmed significant differences between mean functionality and capacity values. Post hoc comparisons by Tukey HSD test revealed significant differences only between capacity values 4 and 5 in the Floodplain forest. In Dunajovické kopce significant differences were found between values 3 and 4 in capacity value 0, and 4 in capacity value 2. Three capacity values (0, 3 and 4) showed the same significant differences in Ostravice; other significant differences were found also in capacity value 1 and no significant differences were found in capacity value 2. With the exception of capacity value 5, significant differences in mean functionality were found in all capacity values in Skalky. In this investigation area capacity values 1 and 3 showed similar results. Similar results were also identified in Dunajovické kopce and Skalky and concerned capacity values 3 and 4. Figure 49 illustrates the ranges of mean functionality in capacity values in the investigation areas. Very low functionality was present in capacity value 2 in Dunajovické kopce, 0 in Skalky and the Floodplain forest and 1 in Ostravice. Very high functionality was found in capacity value 5 (Floodplain forest), 4 (Skalky and Ostravice), 3 (Floodplain forest) and 1 (Floodplain forest).

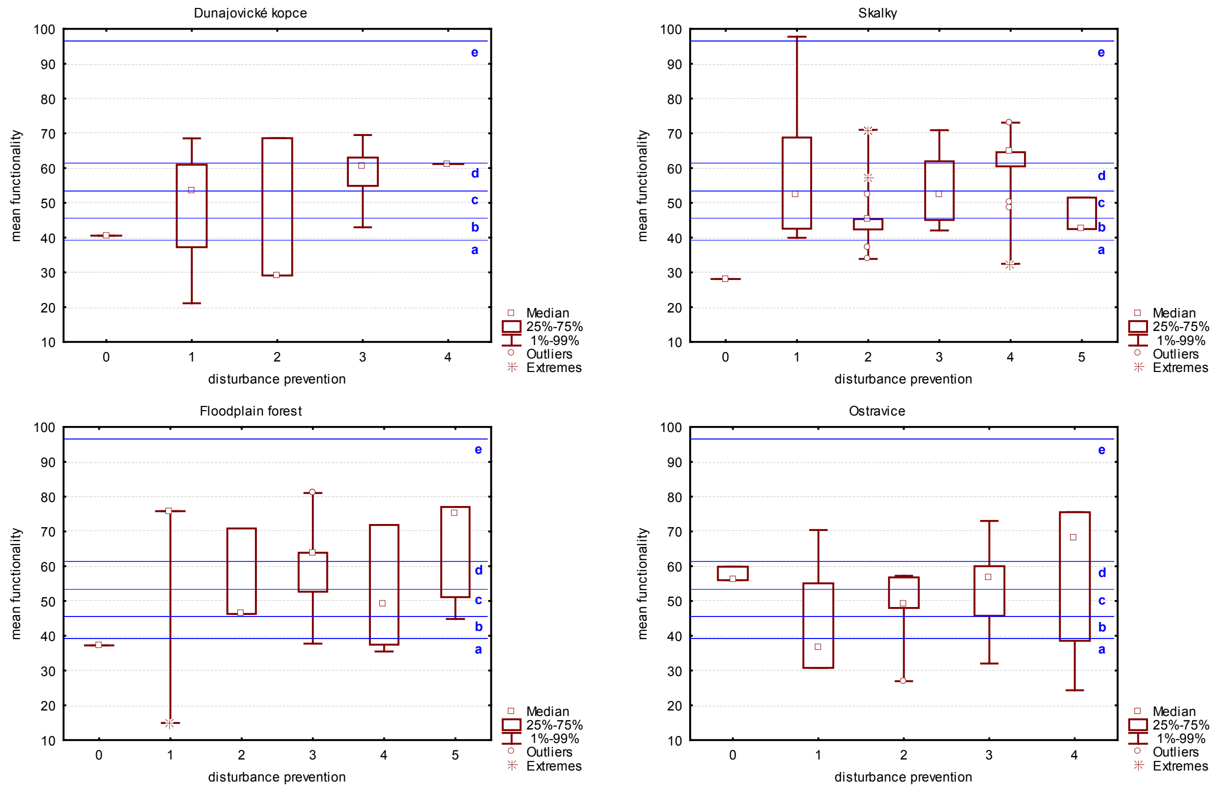


Figure 49: Mean functionality in the capacity values to provide the 'disturbance prevention service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.1.3 Water regulation

This service is expressed through landscape elements which regulate runoff and river discharge providing for example drainage or natural irrigation.

All investigation areas are quite well covered by landscape elements with higher capacities of 'water regulation' service as can be seen in Figure 50. High to very high capacity covers more than 50% in two investigation areas, the other two investigation areas are covered by medium to very high capacity for more than 50% (Skalky) or rather 85% (Dunajovické kopce). Only in Ostravice there are larger areas (covering slightly more than 20% of the total area) with 0 'water regulation' capacity which is due to the settlements in this investigation area.

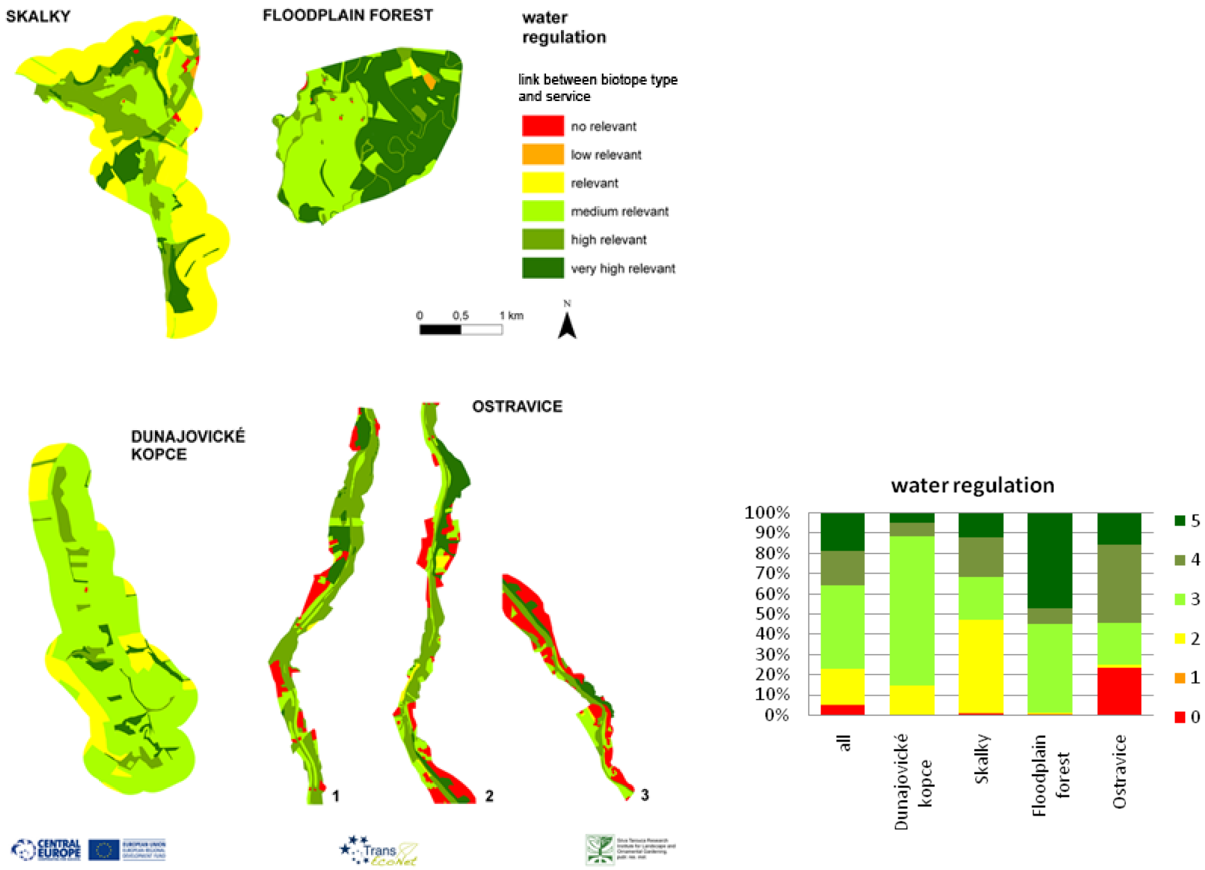


Figure 50: Spatial distribution (left) and area proportion (right) of the 'water regulation' service in all investigation areas

The comparison of mean functionality with different capacities to provide the 'water regulation' service with the help of a Kruskal-Wallis test showed significant differences. Post hoc comparisons identified significant differences in mean functionality between capacities 2, 3, 4 and 5 in capacity value 0; 4 and 5 in capacity value 1; 0, 3, 4 and 5 in capacity value 2; 0 and 2 in capacity value 3; and 0, 1 and 2 in capacity values 4 and 5.

Mean functionality was very high in landscape elements with high capacity and very low in landscape elements with capacity values 1 and 2 (Figure 51). Mean functionality in capacity values 3 and 5 showed a similar range while in capacity value 0 mean functionality was somewhat lower.

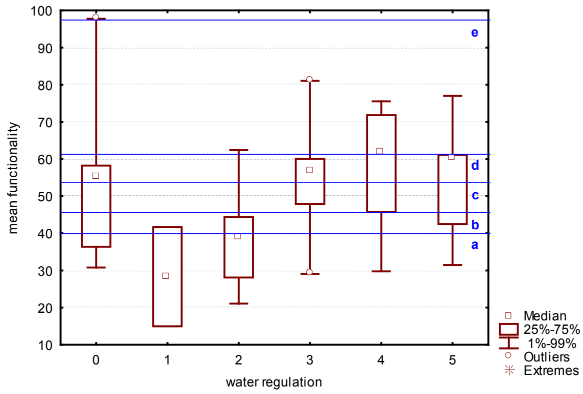


Figure 51: Mean functionality in the capacity values to provide the 'water regulation' service regardless of the investigation areas; blue hatches show borders of functional categories

Significant differences between mean functionality and capacity values were revealed by a Kruskal-Wallis test also in investigation areas. Post hoc comparisons identified significant differences in one capacity value in Dunajovické kopce, in five in the Floodplain forest as well as in Skalky and in four in Ostravice. Similarities were typical only for the Floodplain forest (capacity value 0 and 5) and Skalky (capacity values 0 and 4).

Figure 52 illustrates the ranges of mean functionality in the capacity values in investigation areas. Very low functionality was present in capacity value 2 in Skalky and 1 in the Floodplain forest. Very high functionality was found in capacity values 4 (Skalky and Ostravice), 3 (Floodplain forest) and 0 (Floodplain forest, Skalky and Dunajovické kopce).

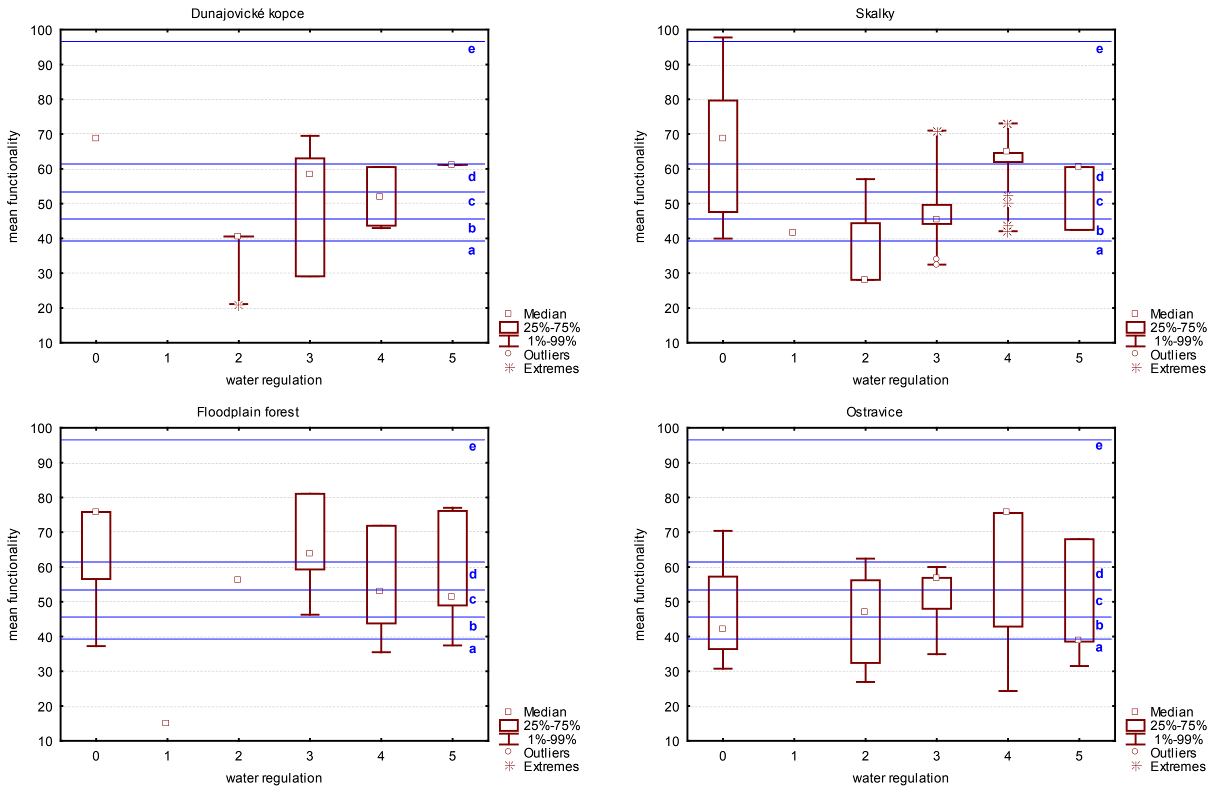


Figure 52: Mean functionality in the capacity values to provide the 'water regulation' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.1.4 Water supply

The ‘water supply’ service refers to filtering, retention and storage of fresh water in streams, lakes and aquifers providing water for consumptive use, e.g. drinking, irrigation or industrial use.
Medium to very high capacity of this service covers more than 40% of the total area in Skalky where it is bound mainly to the pond and surrounding forests in the north, 50% in Ostravice (especially in the northern half) and nearly 60% in the Floodplain forest where it occurs in the forested north-eastern part of the investigation area (Figure 53, left). Only in Dunajovické kopce this service has lower capacity values. In Skalky, more than 40% of the area is covered by landscape elements with no relevant capacity (Figure 53, right).

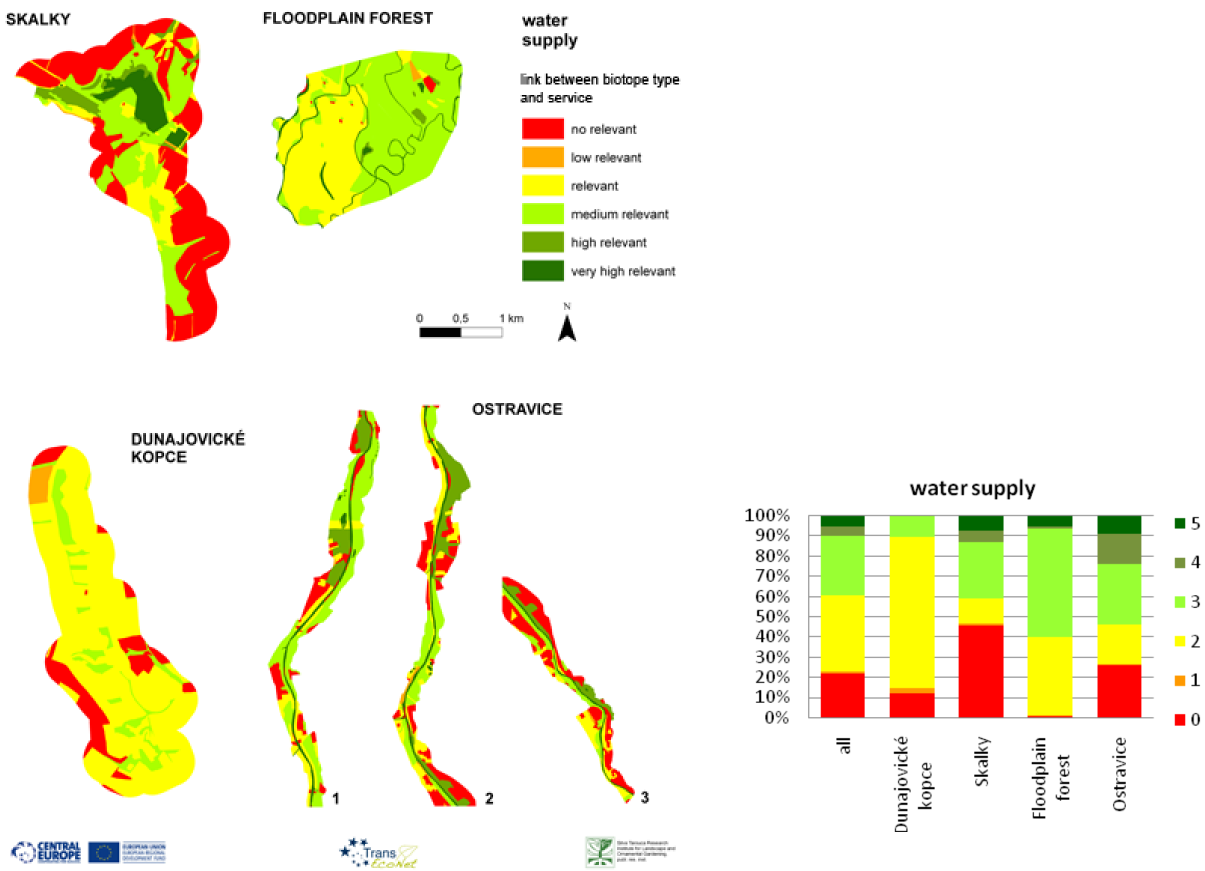


Figure 53: Spatial distribution (left) and area proportion (right) of the ‘water supply’ service in all investigation areas

Significant differences between mean functionality and capacity values were found when using the Kruskal-Wallis test. Post hoc comparisons revealed significant differences of mean functionality between capacity values 2, 3, 4 and 5 in capacity value 0 and 1; values 0, 1 and 3 in capacity value 2; values 0, 1, 2 and 5 in capacity value 3; values 0, 1 and 5 in capacity values 4; and values 3 and 4 in capacity value 5.
Very high functionality was typical for landscape elements with medium capacity and for landscape elements with high capacity (Figure 54). Landscape elements with the capacities 0 and 1 belong to the functional category low.

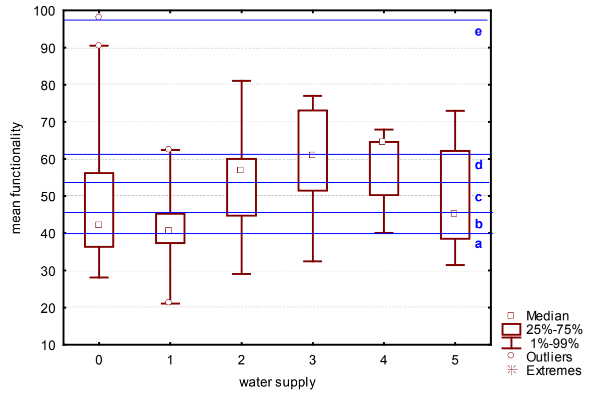


Figure 54: Mean functionality in the capacity values to provide the 'water supply' service regardless of the investigation areas; blue hatches show borders of functional categories

The Kruskal-Wallis test revealed significant differences only in Dunajovické kopce, Skalky and Ostravice. Significant differences in mean functionality between capacity values were found by post hoc comparisons only in Ostravice and Skalky. In Skalky, capacity values 1, 2 and 3 showed significant differences only in one capacity value (values 1 and 2 can be considered as similar), capacity value 0 in two values and capacity value 4 in three values. No significant differences were found in capacity value 5 in this investigation area. No similarity in significance was found in Ostravice. Here only one significant difference was found in one capacity value; two were noted for three capacity values and three and four for one capacity value respectively.
Very high functionality related to four capacity values in the Floodplain forest (Figure 55) was not significant as was mentioned earlier. Very high functionality was also found in capacity values 3 and 4 in Ostravice and 4 in Skalky. On the contrary, very low functionality in this investigation area is typical for landscape elements with capacity value 1. Very low functionality was also found in capacity value 1 in Dunajovické kopce (not significant) and in value 0 in Skalky (Figure 55).

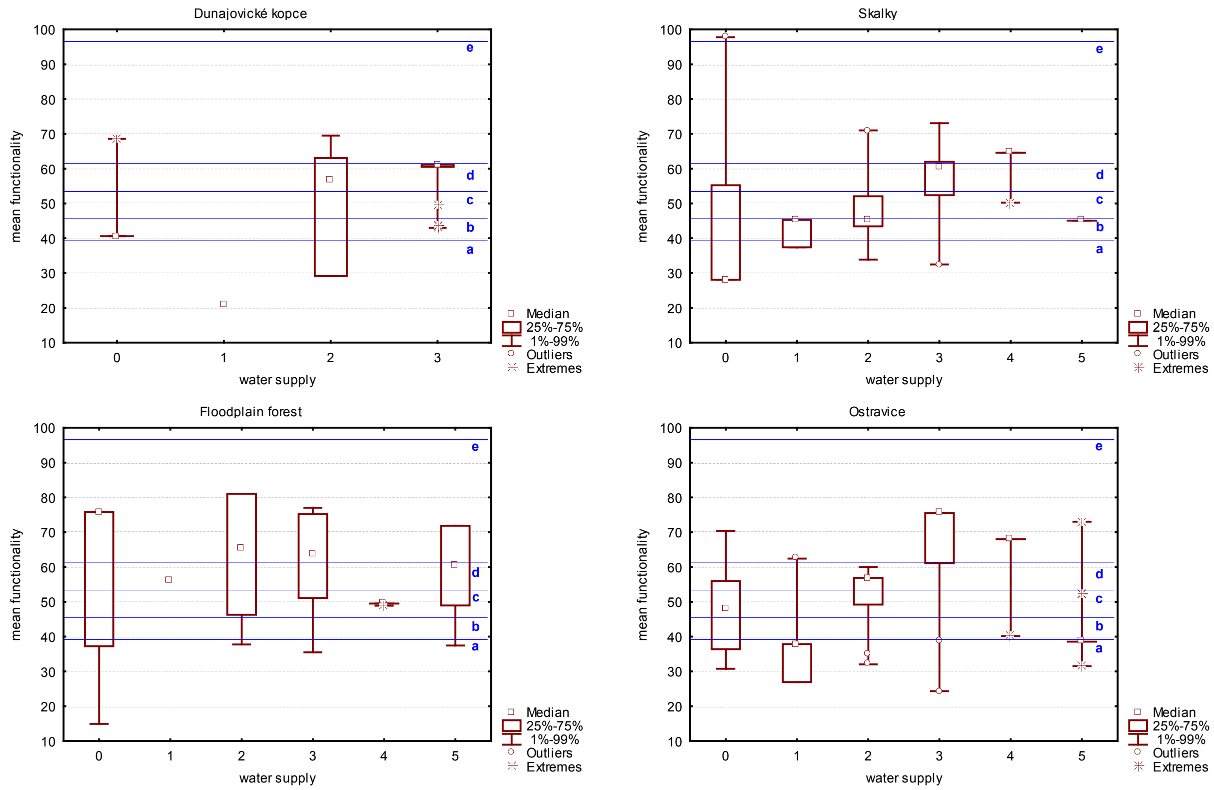


Figure 55: Mean functionality in the capacity values to provide the 'water supply' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.1.5 Soil retention

This service depends on vegetation cover and root systems that stabilise the soil thus preventing soil erosion and siltation and providing maintenance of arable land.

Landscape elements with no relevant capacity of this service dominate in Skalky and are largely present also in Ostravice (Figure 56). While in Skalky the 0 capacity values are bound mainly to arable land at the edges of the investigation areas and to the pond in the northern part, in Ostravice they are bound mainly to settlements. On the contrary, the Floodplain forest is a very good example of investigation area with high capacity of soil retention. In Dunajovické kopce, soil retention with capacity value 2 prevails, yet medium to very high capacity values play also significant roles as they cover more than 30% of the area. They are situated mainly in the middle part (see Figure 56, left).

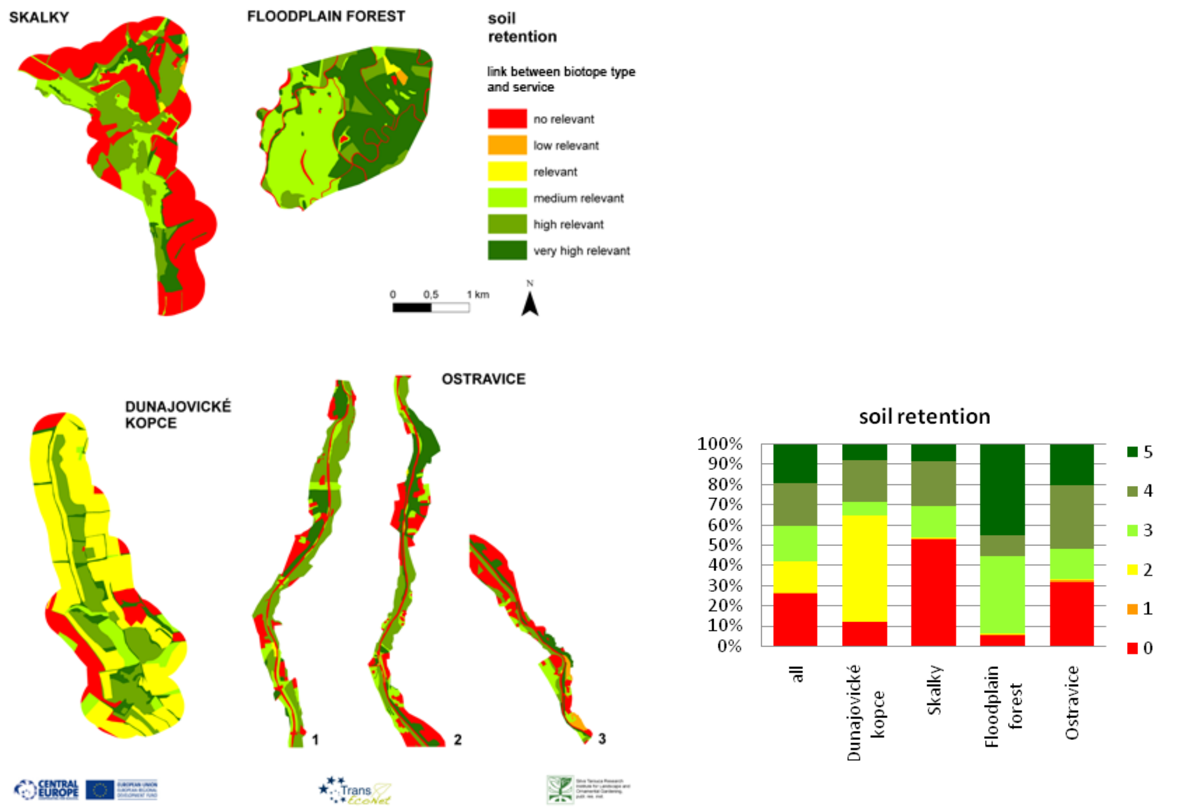


Figure 56: Spatial distribution (left) and area proportion (right) of the 'soil retention' service in all investigation areas

According to the Kruskal-Wallis test, differences in mean functionality between capacity values were significant. Also post hoc comparisons found significant differences between capacity values with the exception of capacity value 1. In capacity values 3, 4 and 5 mean functionality significantly differed in landscape elements with capacity values 0 and 2. Mean functionality in capacity value 0 was also significantly different from mean functionality in capacity value 2.

Very high functionality was found in landscape elements with high capacity while very low functionality was found in landscape elements with capacity value 2 (Figure 57). Medium to high functionality was typical for capacity values 1, 3 and 5. Landscape elements with no capacity to provide soil retention had a wide range of mean functionality from low to high values.

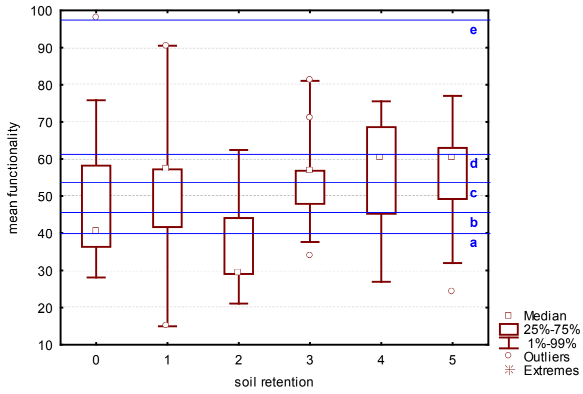


Figure 57: Mean functionality in the capacity values to provide the 'soil retention' service regardless of the investigation areas; blue hatches show borders of functional categories

Significant differences between mean functionality and capacity values were found in Dunajovické kopce, Skalky and Ostravice. Surprisingly, post hoc comparisons using a Tukey HSD test also revealed significant differences between capacity values in the Floodplain forest. Ostravice and Skalky show similarities in the occurrence of significant differences – in landscape elements with capacity values 3, 4 and 5 mean functionality significantly differed only in one capacity value, and in capacity value 0 it differed in three capacity values. Mean functionality in Dunajovické kopce was significantly different in two capacity values in case of capacity values 0, 4 and 5, in three capacity values in case of capacity value 2 and in once capacity value in case of capacity value 3. Capacity values 4 and 5 displayed similar results. While in capacity values 2 and 4 no significant differences were found in the Floodplain forest, in capacity values 0, 3 and 5 mean functionality significantly differed from mean functionality in capacity value 1.Very high functionality was found in capacity values 4 in Dunajovické kopce and Ostravice, 1 in Skalky and 0, 3 and 5 in the Floodplain forest (Figure 58). Very low functionality was typical for capacity value 0 in Skalky, 1 in the Floodplain forest and 2 in Dunajovické kopce and Ostravice.

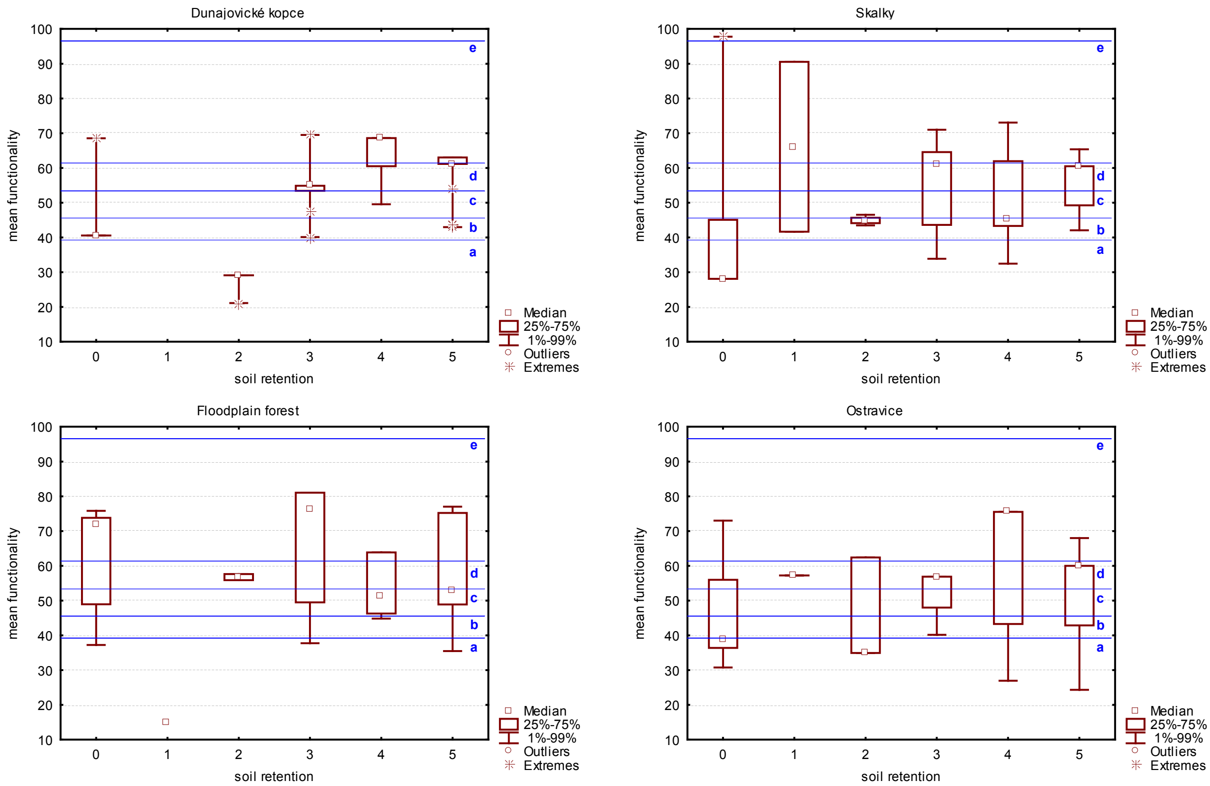


Figure 58: Mean functionality in the capacity values to provide the 'soil retention' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.1.6 Soil formation

Soil is formed through weathering of rock and accumulation of organic matter. Since this maintains natural productive soils this landscape service is of prime importance.

Both Dunajovické kopce and the Floodplain forest have a large proportion of landscape elements with high to very high capacity to provide the 'soil formation' service (more than 80% and more than 90% of the area). In case of Skalky and Ostravice the proportion of landscape elements with higher capacities is somewhat smaller, yet they still cover more than 40% and 50% respectively. Landscape elements with no capacity are widely distributed especially in the southern part of Ostravice (Figure 59 – marked as 3 in the Ostravice investigation area); this investigation area also has the highest proportion of these elements. Landscape elements with low capacity dominate in Skalky as they cover about 45% of the total area.

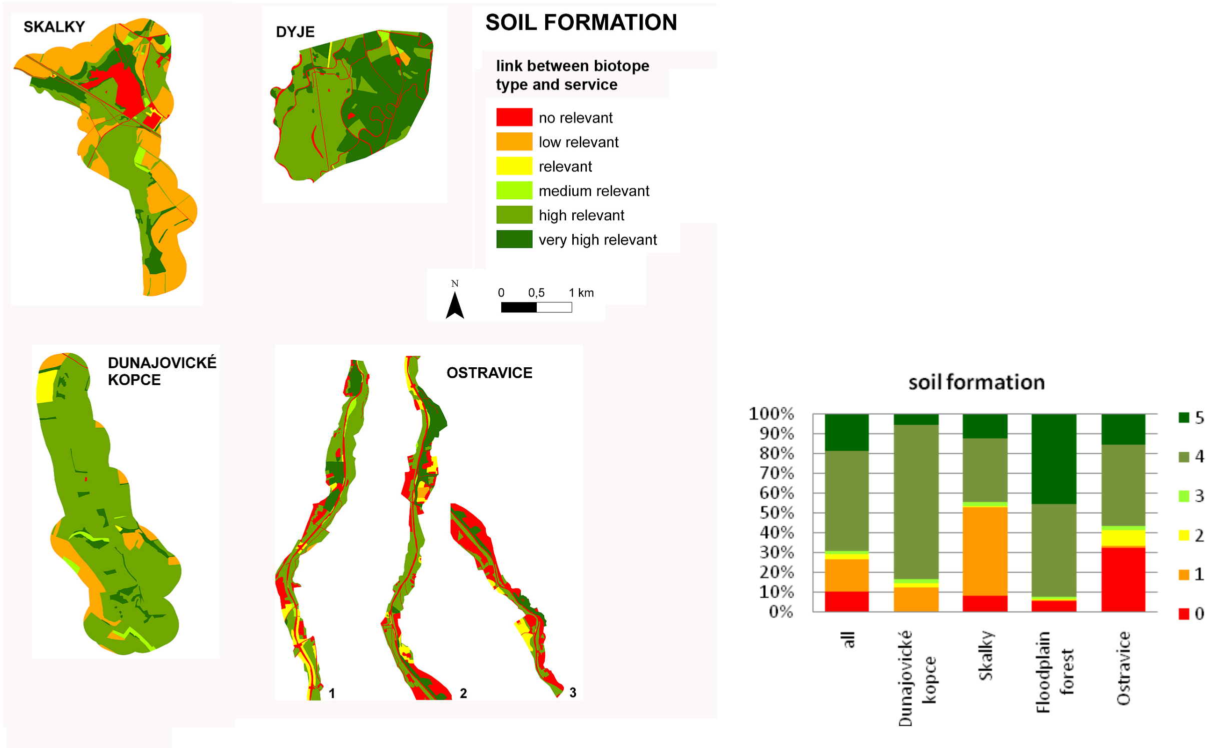


Figure 59: Spatial distribution (left) and area proportion (right) of the 'soil formation' service in all investigation areas

Mean functionality significantly differs in capacity values according to the Kruskal-Wallis test. Post hoc comparisons show significant differences between all capacity values in capacity value 1. In capacity values 4 and 5, mean functionality did not significantly differ only from capacity value 2 and in capacity value 0 mean functionality did not significantly differ from capacity value 3.

Mean functionality was very low in landscape elements with capacity value 1. Higher mean functionality was typical for landscape elements with capacity values 2, 4 and 5 (see Figure 60). Landscape elements with capacity values 0 and 3 showed low to medium functionality.

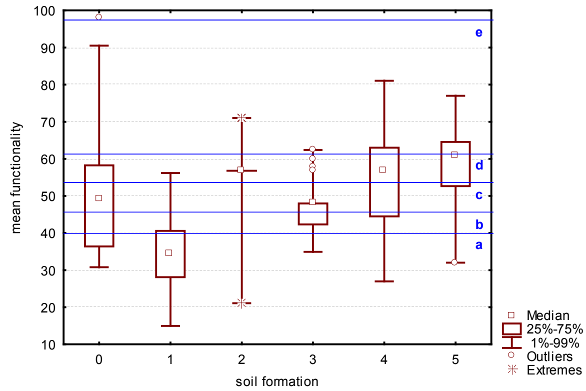


Figure 60: Mean functionality in the capacity values to provide the 'soil formation' service regardless of the investigation areas; blue hatches show borders of functional categories

A Kruskal-Wallis test revealed significant differences between mean functionality and capacity values in Dunajovické kopce, Skalky and Ostravice. Post hoc comparisons identified significant differences only in Ostravice and Skalky. In Ostravice mean functionality in capacity value 0 differed significantly from two capacity values, in capacity values 2 and 4 it differed from one capacity value. Other capacity values did not show significant differences in mean functionality. Significant differences were found in all capacity values in Skalky and similar results were typical for three capacity values, namely 0, 2 and 4. In capacity value 1, mean functionality differed from all other capacity values with the exception of capacity value 3. Similar results in both investigation areas regarded capacity values 2 and 4. Very low functionality was found in capacity value 1 in the Floodplain forest and 2 in Dunajovické kopce. Very high functionality in capacity values 0 and 2 is typical for the Floodplain forest and in capacity value 2 for Skalky (Figure 61). Very high functionality was also recorded in capacity values 5 in Ostravice and 0 in Dunajovické kopce.

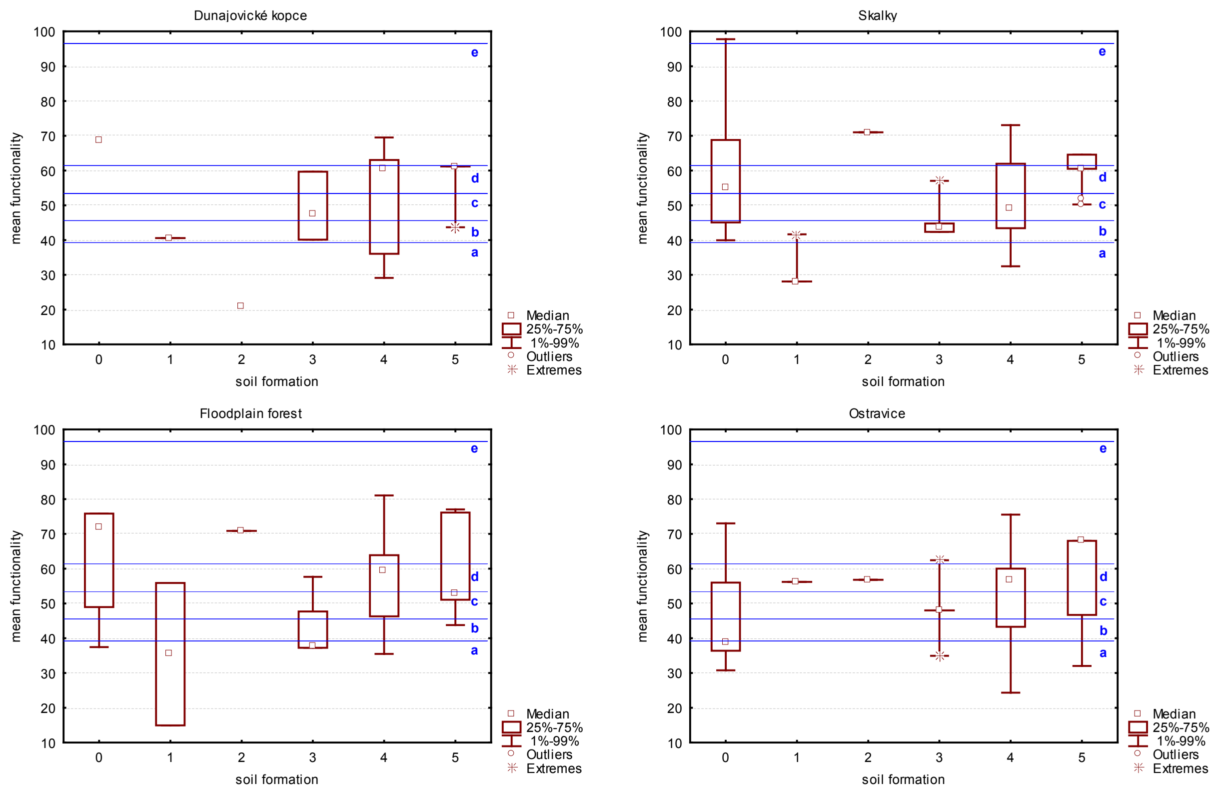


Figure 61: Mean functionality in the capacity values to provide the 'soil formation' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.1.7 Nutrient regulation

Biota play a key role in storage and recycling of nutrients, especially nitrogen, sulphur and phosphor. This landscape service is mainly related to maintenance of healthy and productive soils and subsequently ecosystems.

Very high capacity to provide the ‘nutrient regulation’ service is typical for the Floodplain forest. This investigation area also has large areas covered by landscape elements with medium capacity (nearly 50%). Nearly 50% of the Ostravice area is covered by landscape elements with high or very high capacity values (Figure 62, right). In Dunajovické kopce, landscape elements with capacity value 2 prevail as they can be found at 66% of the area. Capacity to provide this service is rather low in Skalky; here landscape elements with capacity values 0 and 1 cover more than 50% and are situated mainly at the edges as well as in the middle of the northern part of the investigation area (Figure 62, left).

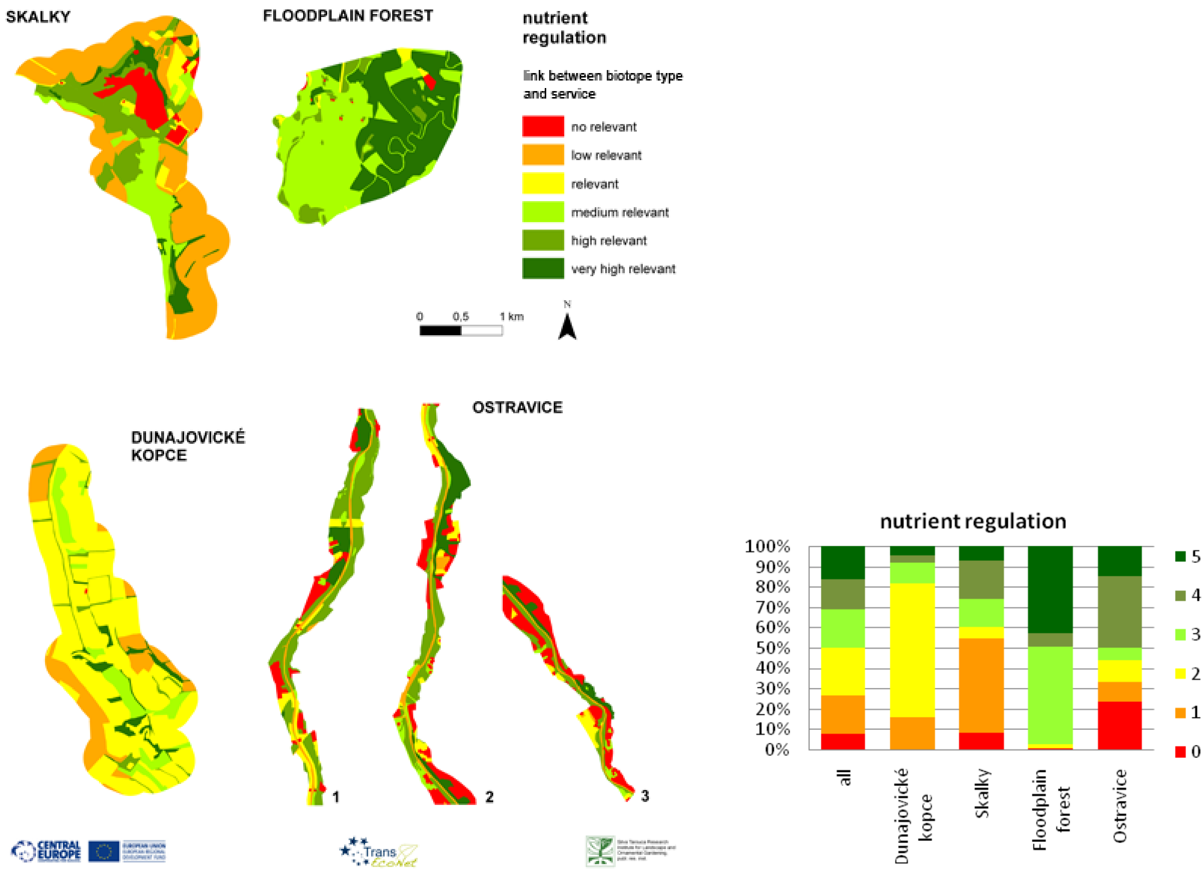


Figure 62: Spatial distribution (left) and area proportion (right) of the ‘nutrient regulation’ service in all investigation areas

There are significant differences in mean functionality between capacity values which were confirmed by a Kruskal-Wallis test. Significant differences between capacity values were also identified by post hoc comparisons using the Tukey HSD test. Similar results were typical for capacity values 3 and 4 and 0 and 3. In capacity value 1, mean functionality significantly differed in all capacity values.

Very high functionality was found in capacity value 5 while low functionality was typical for capacity value 1 (Figure 63). Medium to high functionality is associated mainly with capacity values 2, 3 and 4.

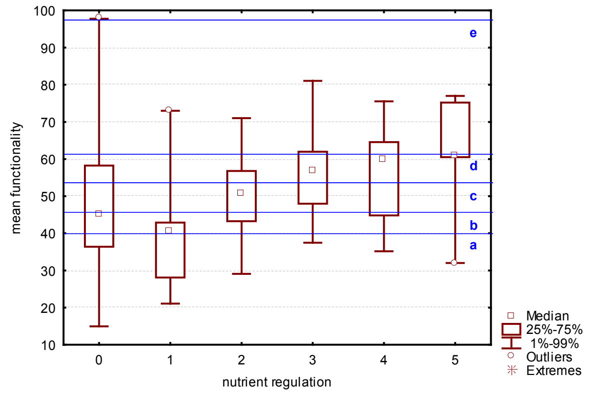


Figure 63: Mean functionality in the capacity values to provide the 'nutrient regulation' service regardless of the investigation areas; blue hatches show borders of functional categories

Also in all investigation areas the Kruskal-Wallis test revealed significant differences of mean functionality in capacity values and a post hoc test identified significant differences in these values. Only in Skalky significant differences were found in all capacities. No significant differences were found in capacity value 0 for both Dunajovické kopce and the Floodplain forest. These two investigation areas also revealed identical results for capacity value 2. Similar results were identified for capacity values 3 and 4 in Dunajovické kopce. Concerning Ostravice, no significant differences were found with regard to other capacity values in capacity values 1 and 2. Similar results were valid for capacity value 3 in following pairs of investigation areas: in Dunajovické kopce and Skalky significant differences were identified for capacity value 1; in the Floodplain forest and Ostravice significant differences were identified for capacity value 4. Similar results concerned Dunajovické kopce and Skalky also in capacity value 4 (significant differences found in capacity value 1). Very high functionality was typical for capacity values 0 (Dunajovické kopce and the Floodplain forest), 3 (Floodplain forest), 4 (partly Dunajovické kopce, Skalky, and Ostravice) and 5 (Floodplain forest and Ostravice). Very low functionality was found only in Skalky in capacity value 1 (Figure 64).

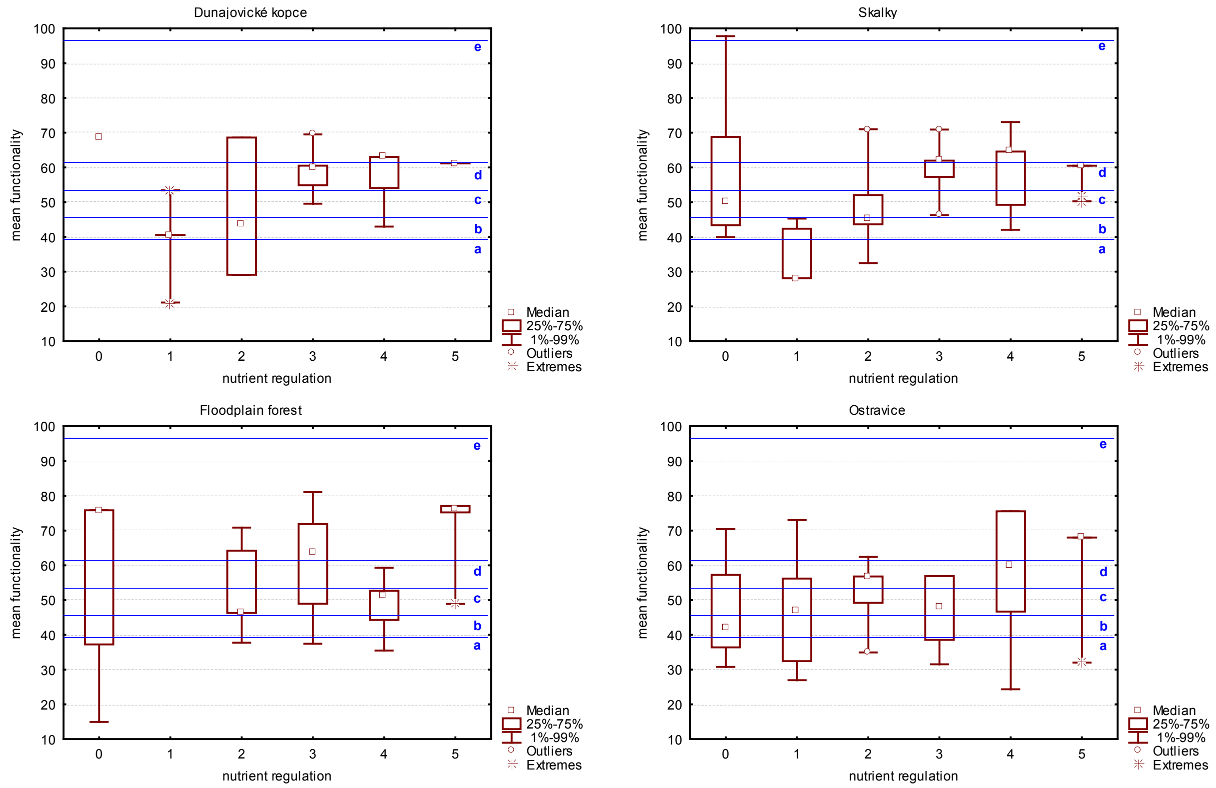


Figure 64: Mean functionality in the capacity values to provide the 'nutrient regulation' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.1.8 Pollination

Pollination is essential to most plants for reproduction. Thus without this service, many plant species would go extinct and cultivation of most modern crops would be impossible. This service can be derived from the dependence of cultivation on natural pollination (is there any suitable habitat available for pollinators?).

All investigation areas with the exception of the Floodplain forest tend to have low capacities to provide the ‘pollination’ service. In case of Skalky and Ostravice, a significant proportion of the area is covered by landscape elements with no capacity at all (Figure 65). However, the fact that in all investigation areas landscape elements with medium to high capacity are present can be considered as positive.

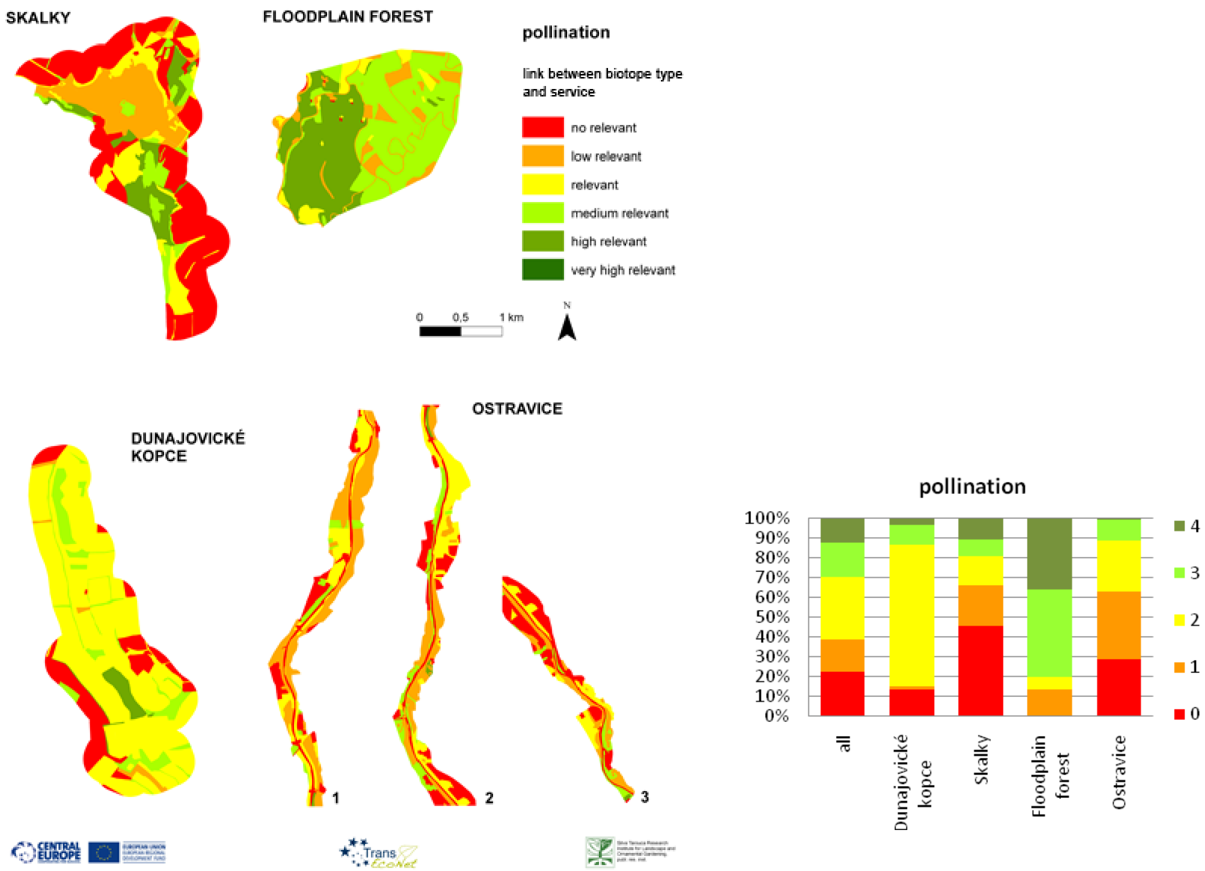


Figure 65: Spatial distribution (left) and area proportion (right) of the ‘pollination’ service in all investigation areas

Significant differences between mean functionality and capacity values were found by both Kruskal-Wallis test and Tukey HSD test. Although in three capacity values (1, 2 and 3) two significant differences and in two capacity values (0 and 4) three significant differences were identified, no capacity values display similar results.

High mean functionality was found in capacity values 3 and mainly 4. Low functionality was found in capacity value 0 (Figure 66) and medium functionality was typical for capacity values 1 and 2.

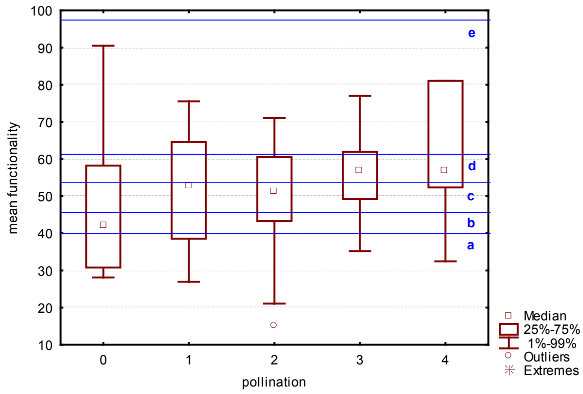


Figure 66: Mean functionality in the capacity values to provide the 'pollination' service regardless of the investigation areas; blue hatches show borders of functional categories

Significant differences between mean functionality and capacity values in all investigation areas were confirmed by a Kruskal-Wallis test. Post hoc comparisons revealed significant differences only in the Floodplain forest and in Skalky. At least one significant difference of mean functionality is present in all capacity values in the Floodplain forest. Here similar results were found for capacity values 0 and 3. Significant differences of mean functionality were found for capacity values 0, 1 and 3 in Skalky; capacity values 1 and 3 revealed similar results.
Very high functionality was found in capacity value 1 in Skalky and 0, 3 and 4 in the Floodplain forest. Very low functionality was typical for landscape elements with no capacity to provide the 'pollination' service in Skalky (Figure 67).

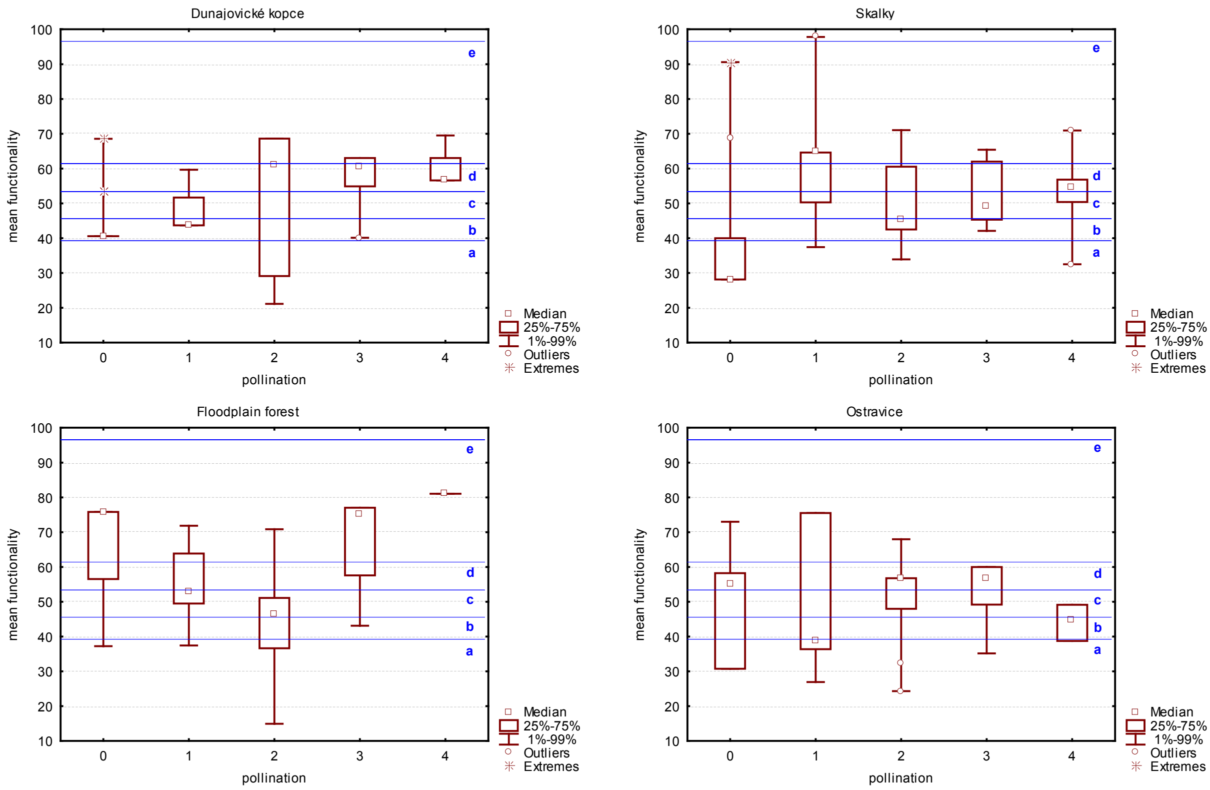


Figure 67: Mean functionality in the capacity values to provide the 'pollination' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.2 Habitat services

2.3.3.2.1 Refugium service

This service provides suitable living space for wild plants and animals and represents a ‘storehouse’ of genetic information. Maintenance of biodiversity in particular is a very important characteristic of this landscape service.

From the spatial distribution perspective (Figure 68) the ‘refugium’ service is most pronounced in the Floodplain forest. Landscape elements with high or very high capacity to provide this service in Skalky are situated mainly in the southern and western part along the Austrian border. Overall, landscape elements with low capacity prevail in this investigation area. Concerning Dunajovické kopce and Ostravice the majority of landscape elements have medium capacity to provide the ‘refugium’ service. In Ostravice also quite large areas are covered by landscape elements with no capacity at all (Figure 68, right).

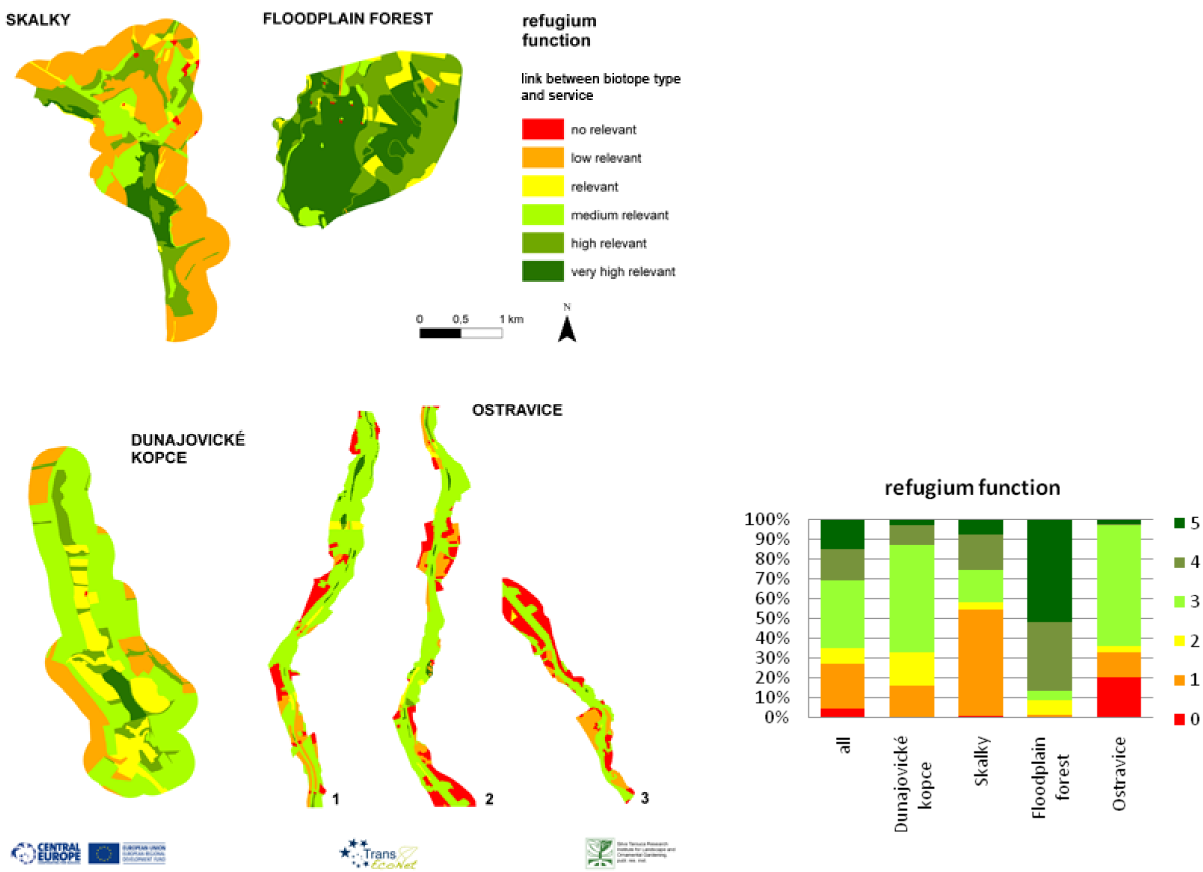


Figure 68: Spatial distribution (left) and area proportion (right) of the ‘refugium’ service in all investigation areas

When comparing mean functionality in the landscape elements with different capacities to provide the ‘refugium’ service a Kruskal-Wallis test showed significant differences regardless of the investigation areas. Also post hoc comparisons identified significant differences between capacity values: Mean functionality in capacity value 0 was significantly different than in capacity value 4. Similar results were valid also for capacity values 2 and 5. Mean functionality in capacity value 1 significantly differed in capacity value 4 as well as in capacity value 3. Mean functionality in capacity value 3 significantly differed from functionality in capacity values 1 and 4. Consequently, significant differences regarding capacity value 4 were found in all other capacity values.

High functionality occurred in capacity values 3 and 4 and partly in 1, 2 and 5. Low functionality was recorded for capacity value 0 (Figure 69).

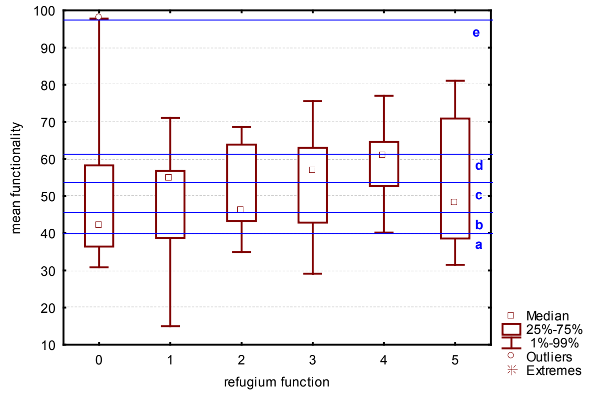


Figure 69: Mean functionality in the capacity values to provide the 'refugium' service regardless of the investigation areas; blue hatches show borders of functional categories

A Kruskal-Wallis test confirmed significant differences between mean functionality and capacity values in all investigation areas. Post hoc comparisons identified significant differences in 5 out of 6 capacity values in the Floodplain forest, Ostravice and Skalky and in 4 out of 6 capacity values in Dunajovické kopce. Similar results were found for capacity values 4 and 5 in the Floodplain forest, 1 and 5 in Ostravice and 1 and 4 in Skalky. Very high functionality is typical for capacity values 0 (Dunajovické kopce, Skalky and Floodplain forest), 1 (Floodplain forest), 2 (Dunajovické kopce), 4 (Skalky and Floodplain forest) and 5 (Dunajovické kopce and Floodplain forest). Very low functionality was recorded in capacity values 0 (Ostravice) and 1 (Skalky, partly Floodplain forest) – see Figure **70**.

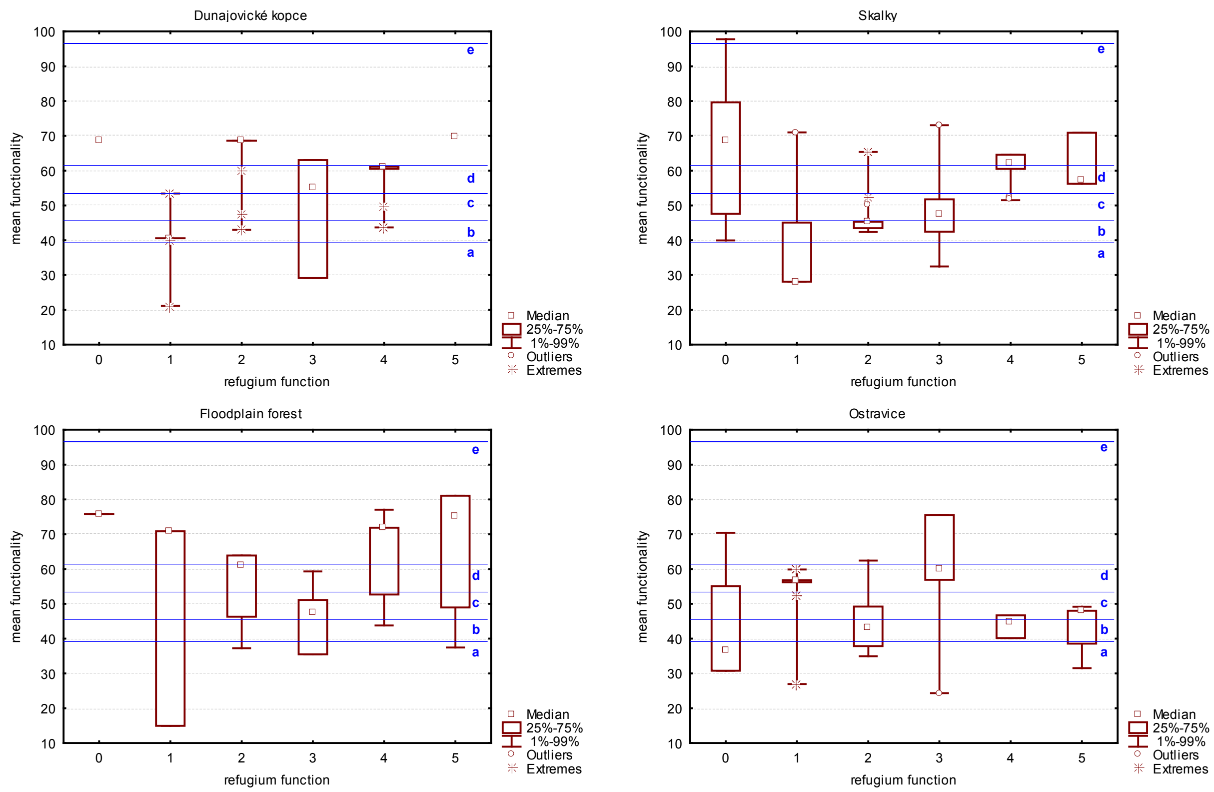


Figure 70: Mean functionality in capacity values to provide the 'refugium' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.2.2 Nursery service

The 'nursery' service provides habitats for juveniles of certain species as it represents a suitable reproduction-habitat, e.g. for the maintenance of commercially harvested species. Many ecosystems provide nursery areas to species which as adults are harvested elsewhere for either subsistence or commercial purposes.

High to very high capacity to provide the 'nursery' service is most pronounced in the Floodplain forest where it covers nearly half of the investigation area (Figure 71, right). Another 40% of this investigation area is covered by landscape elements with medium capacity. These landscape elements are situated mainly in the western part (Figure 71, left). Large proportions of landscape elements with medium to high capacity can also be found in Skalky (in the middle) and Ostravice (mainly in the northern part), but in both investigation areas landscape elements with capacity values 0-2 prevail (**Figure 71**, right). Dunajovické kopce where landscape elements with no or low capacity dominate can be marked as the least suitable investigation area for the nursery service.

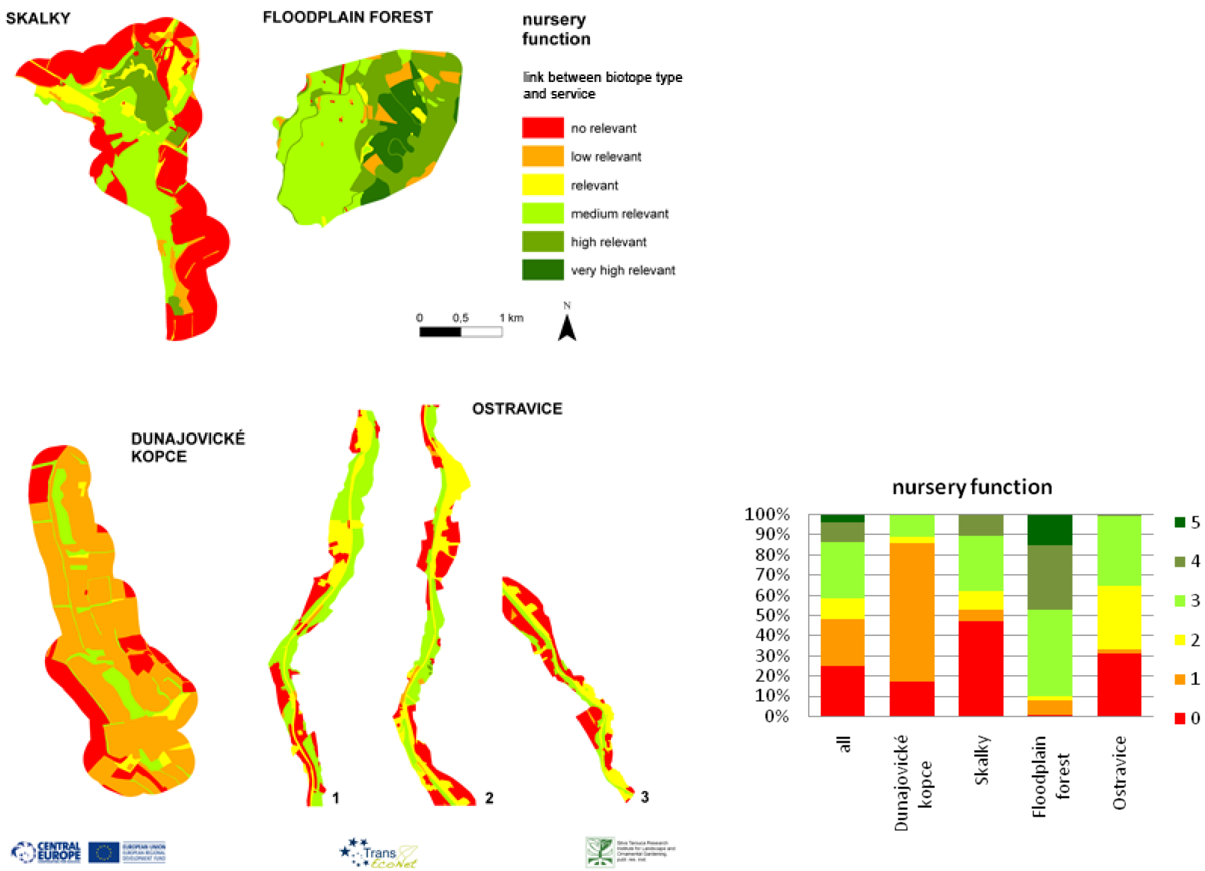


Figure 71: Spatial distribution (left) and area proportion (right) of the 'nursery' service in all investigation areas

Significant differences between mean functionality and capacity values regardless of the investigation areas were confirmed by a Kruskal-Wallis test. Through post hoc comparisons significant differences between capacity values could also be found. Significant differences of mean functionality were identified between capacity value 0 and 2, 3 and 4. Similar results were found for capacity value 1. Considering capacity value 2, mean functionality significantly differed in capacity values 0, 1 and 3; in capacity value 3, significant differences were in capacity values 0, 1, 2 and 5. Mean functionality in capacity value 4 significantly differed in capacity values 0, 1 and 5 and in capacity value 5 significant differences were identified for capacity values 3 and 4.

Very high functionality was typical for landscape elements with high or very high capacity to provide the ‘nursery’ service. Landscape elements with capacity value 3 and partly 0 had high functionality while landscape elements with capacity values 1 and 2 obtained medium functionality (Figure 72).

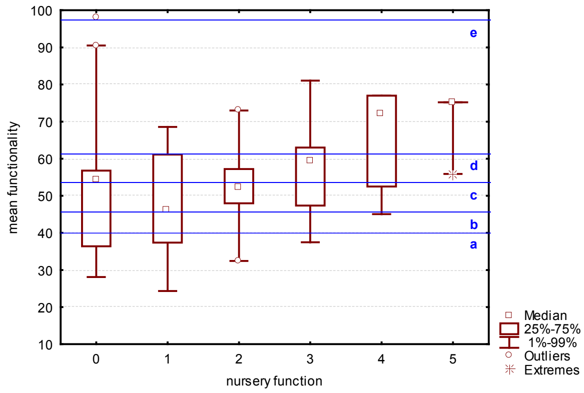


Figure 72: Mean functionality in the capacity values to provide the ‘nursery’ service regardless of the investigation areas; blue hatches show borders of functional categories

A Kruskal-Wallis test revealed significant differences between mean functionality and capacity values in all investigation areas. Post hoc comparisons using the Tukey HSD test identified similar behaviour for Dunajovické kopce, Ostravice and Skalky in capacity value 0 and for Dunajovické kopce and Skalky in capacity value 3. Significant differences in the Floodplain forest were identified in five capacity values; in Dunajovické kopce as well as in Skalky in two capacity values and in Ostravice in three capacity values. Very high functionality is typical for the Floodplain forest where it was found in capacity values 0, 4 and 5 (Figure 73). Low functionality was attributed to capacity values 0 (Dunajovické kopce and Skalky) and 1 (Ostravice).

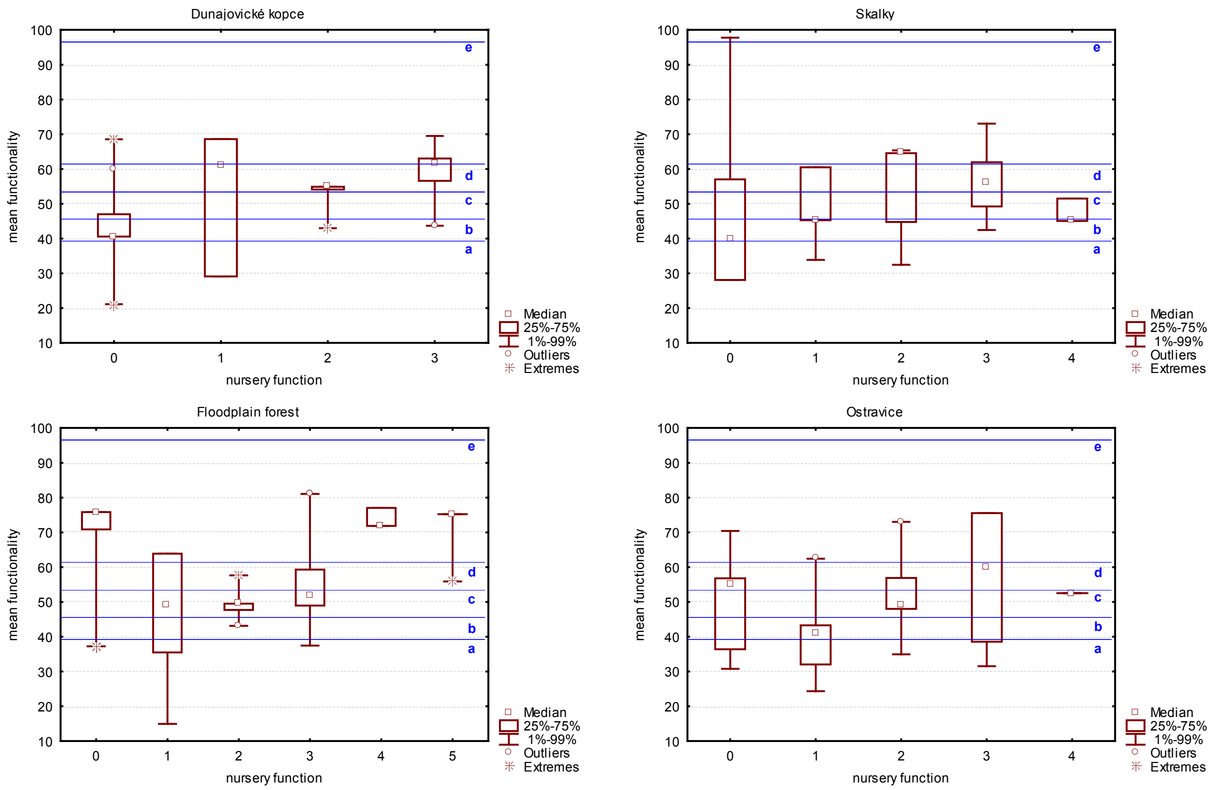


Figure 73: Mean functionality in the capacity values to provide the ‘nursery’ service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.3 Provision services

2.3.3.3.1 Food

This service reflects the conversion of solar energy into wild edible plants and animals. It is related to maintenance of edible wild plants, uncultivated fungi, game and fish.

Higher proportions of landscape elements with no capacity to provide the 'food' service are typical for Ostravice and especially for Skalky (Figure 74, right). Dunajovické kopce are covered mainly by landscape elements with low capacity while Ostravice and the Floodplain forest are dominated by landscape elements with capacity value 2. In the Floodplain forest landscape elements with medium capacity play an important part in the eastern part of the investigation area (Figure 74, left).

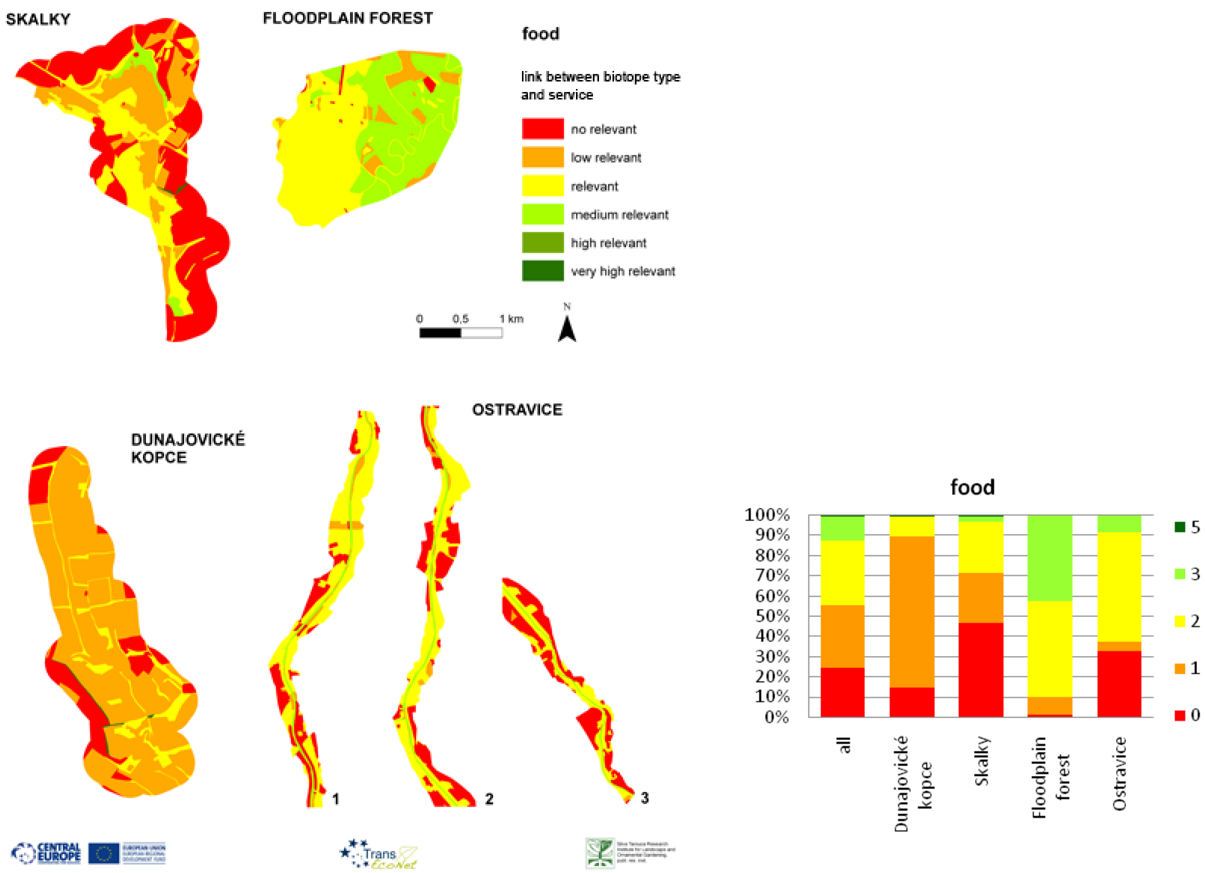


Figure 74: Spatial distribution (left) and area proportion (right) of the 'food' service in all investigation areas

The comparison of mean functionality and capacity values by a Kruskal-Wallis test revealed significant differences. Further insight into the differences between capacity values with the help of post hoc comparisons identified the following significant differences: Mean functionality in capacity value 0 differs significantly from mean functionality in capacity values 2 and 3, similar results apply to capacity value 1. In capacity value 2, mean functionality significantly differs from mean functionality in capacity values 0, 1 and 3. In capacity value 3, significant differences are in capacity values 0, 1 and 2. There are no significant differences in capacity value 5.

Very high functionality is typical for capacity value 3, high functionality was found in capacity values 0, 2 and 5 and medium functionality occurs in landscape elements with capacity value 1 (Figure 75).

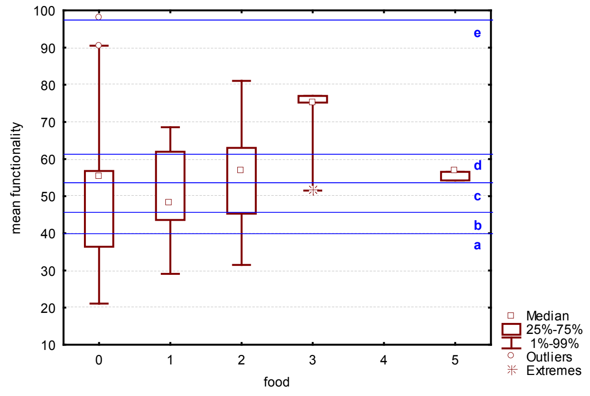


Figure 75: Mean functionality in the capacity values to provide the 'food' service regardless of the investigation areas; blue hatches show borders of functional categories

The Kruskal-Wallis test revealed significant differences between mean functionality and capacity values in all investigation areas. Post hoc comparisons identified similar results for capacity value 0 in Dunajovické kopce and Ostravice and for capacity values 1 and 2 in the Floodplain forest. Significant differences besides these capacity values were found also in capacity value 1 in Ostravice, 2 in Dunajovické kopce and Ostravice and 3 in the Floodplain forest. In Skalky no significant differences in mean functionality between capacity values were identified.

Figure 76 reveals very high functionality in the Floodplain forest (capacity values 0 and 3) and Ostravice (capacity value 3) and very low functionality in Skalky (capacity value 0). High mean functionality is typical for capacity values 0 (Ostravice), 1 (Dunajovické kopce, partly Skalky and Floodplain forest) and 2 (Dunajovické kopce and Ostravice).

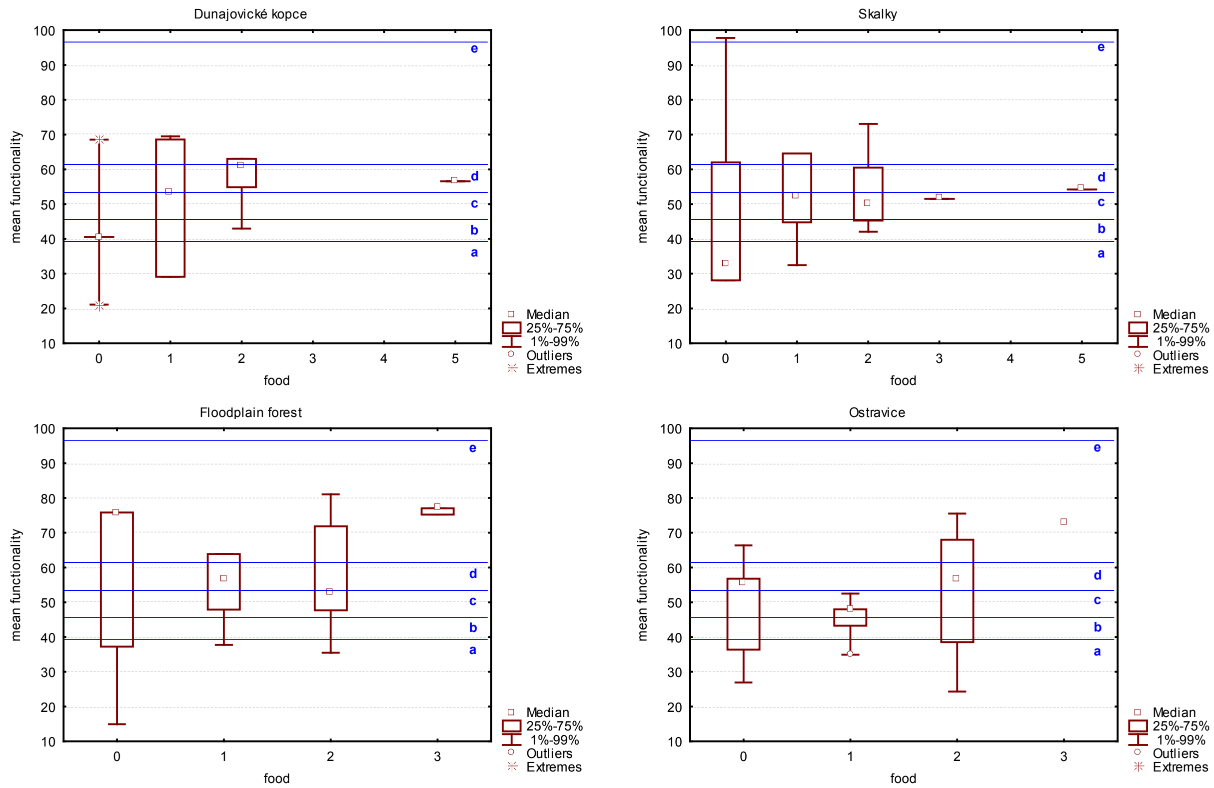


Figure 76: Mean functionality in the capacity values to provide the 'food' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.3.2 Raw materials

Analogical to the 'food' service, this service also reflects the conversion of solar energy, but more generally into biomass. As such, materials for human constructions (building and manufacturing) like lumber, fuel and energy wood are considered as landscape services.

Raw materials can be obtained mainly from the eastern part of the Floodplain forest and the northern part of Ostravice (Figure 77, left) where they occupy about 50% of the territory. They are also present to some extent (about 20% of the area) in Skalky. The remaining proportion of the investigation areas have either no or low capacity to provide this service.

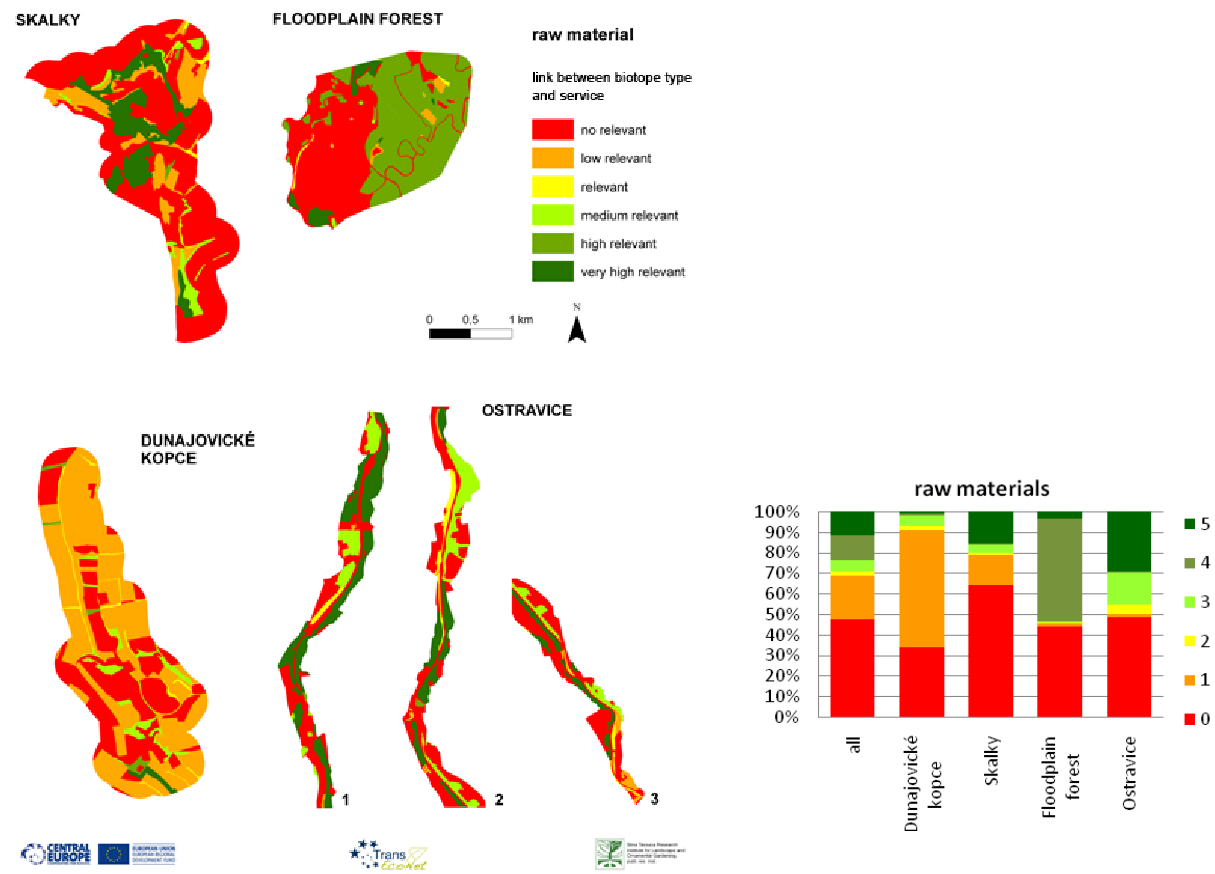


Figure 77: Spatial distribution (left) and area proportion (right) of the 'raw materials' service in all investigation areas

A Kruskal-Wallis test revealed significant differences between mean functionality and capacity values. Use of post hoc comparisons identified two groups with similar significant differences: one includes capacity values 0 and 1, the other capacity values 2 and 4. Significant differences were also found in capacity values 3 and 5.

Very high functionality was recorded for landscape elements with high and very high capacity to provide raw materials. Landscape elements with high functionality have capacity values 1, 2 and 3. Medium functionality is typical for landscape elements with no capacity (Figure 78).

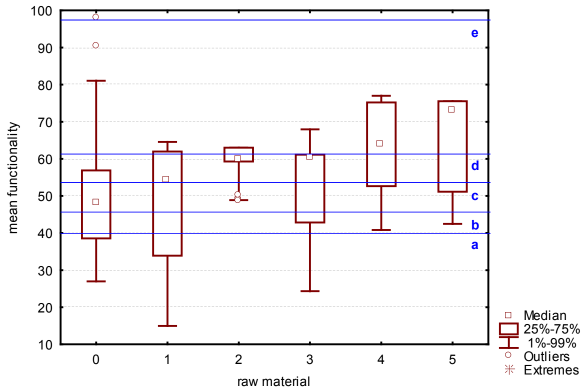


Figure 78: Mean functionality in the capacity values to provide the 'raw materials' service regardless of the investigation areas; blue hatches show borders of functional categories

Also in all investigation areas a Kruskal-Wallis test confirmed significant differences between mean functionality and capacity values. Post hoc comparisons identified capacity values with similar results in each investigation area. These concern capacity values 0, 2 and 3 in Dunajovické kopce, 0 and 4 and 1 and 3 in the Floodplain forest, 0, 1 and 3 in Ostravice, and 1 and 3 in Skalky. Other capacity values where significant differences were found include 0 (Skalky), 1 (Dunajovické kopce) and 5 (Ostravice).

Figure 79 shows capacity values with very high functionality (0 in the Floodplain forest, 1 in Skalky, 2 in Dunajovické kopce, 4 in Skalky and Floodplain forest, and 5 in Ostravice) as well as with very low functionality (1 in Dunajovické kopce and 3 in the Floodplain forest).

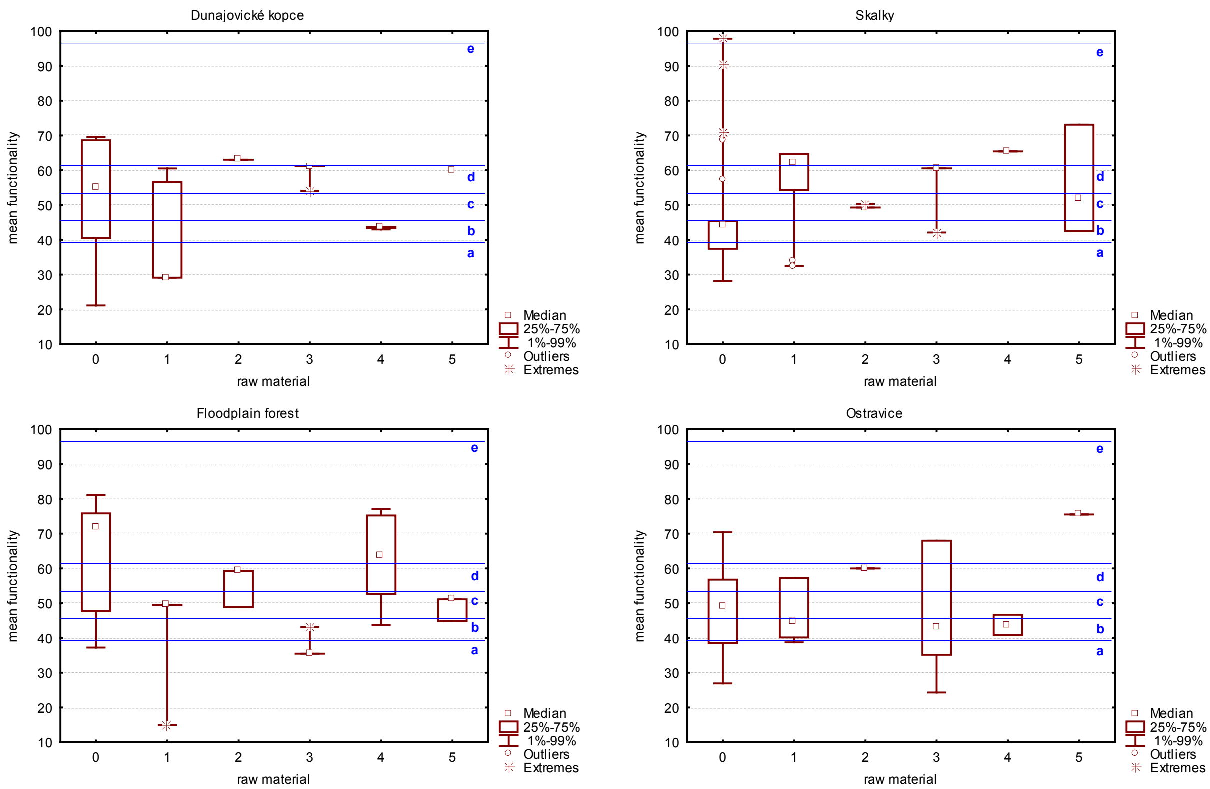


Figure 79: Mean functionality in the capacity values to provide the 'raw materials' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.3.3 Genetic resources

Genetic material and evolution in wild plants and animals are very important for cultivation of plants and domestication of animals with commercial potential. This landscape service includes for example improvement of crop resistance to pathogens and pests and maintenance of old cultivated plants.
The spatial distribution of this service is shown in Figure 80, left. Only medium capacity is typical to provide this service and landscape elements with capacity values 3 are present to a higher degree only in Dunajovické kopce and the Floodplain forest (Figure 80, right). Skalky and Ostravice generally have no capacity to provide genetic resources or their capacity is low.

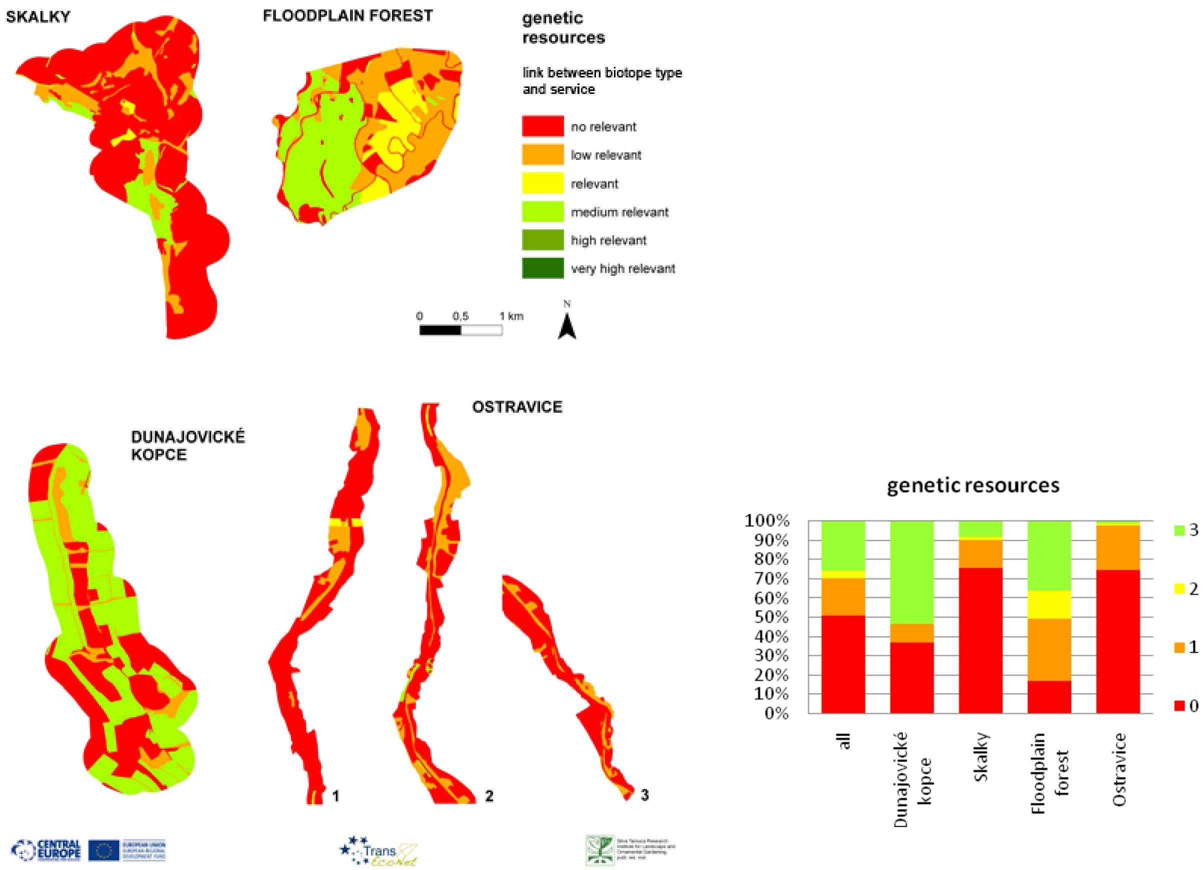


Figure 80: Spatial distribution (left) and area proportion (right) of the 'genetic resources' service in all investigation areas

Significant differences between mean functionality and capacity values were confirmed by a Kruskal-Wallis test. Post hoc comparisons by using the Tukey DSH test identified that mean functionality in capacity value 0 significantly differed from mean functionality in capacity values 1 and 2, but not from mean functionality in capacity value 3.
High functionality was found in capacity value 1 (Figure 81). Medium functionality was typical for capacity values 0 and 2 and low functionality for capacity value 3.

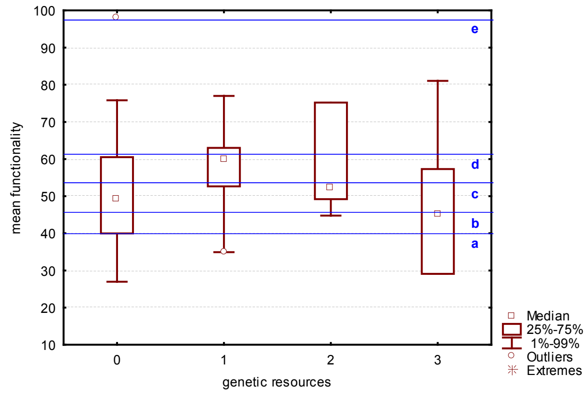


Figure 81: Mean functionality in the capacity values to provide the 'genetic resources' service regardless of the investigation areas; blue hatches show borders of functional categories

Also in all investigation areas mean functionality significantly differed in capacity values as was confirmed by a Kruskal-Wallis test. Post hoc comparisons identified significant differences only in Dunajovické kopce, the Floodplain forest and Ostravice. Similar results were found for capacity values 0 and 1 in Dunajovické kopce. Dunajovické kopce and the Floodplain forest shared similar results concerning capacity values 1 and 3. Significant differences of mean functionality besides the ones mentioned above were also identified in capacity values 0 (Floodplain forest and Ostravice), 1 (Ostravice) and 2 (Floodplain forest). Very high functionality was typical for landscape elements with capacity values 2 and 3 in the Floodplain forest and 1 in Skalky. Very low functionality occurred in landscape elements with capacity value 3 in Ostravice (Figure 82). Medium functionality in capacity value 2 was found in Ostravice and Skalky and in capacity value 0 in the Floodplain forest and Ostravice. Landscape elements with capacity value 1 that belonged to Dunajovické kopce and Ostravice had high functionality.

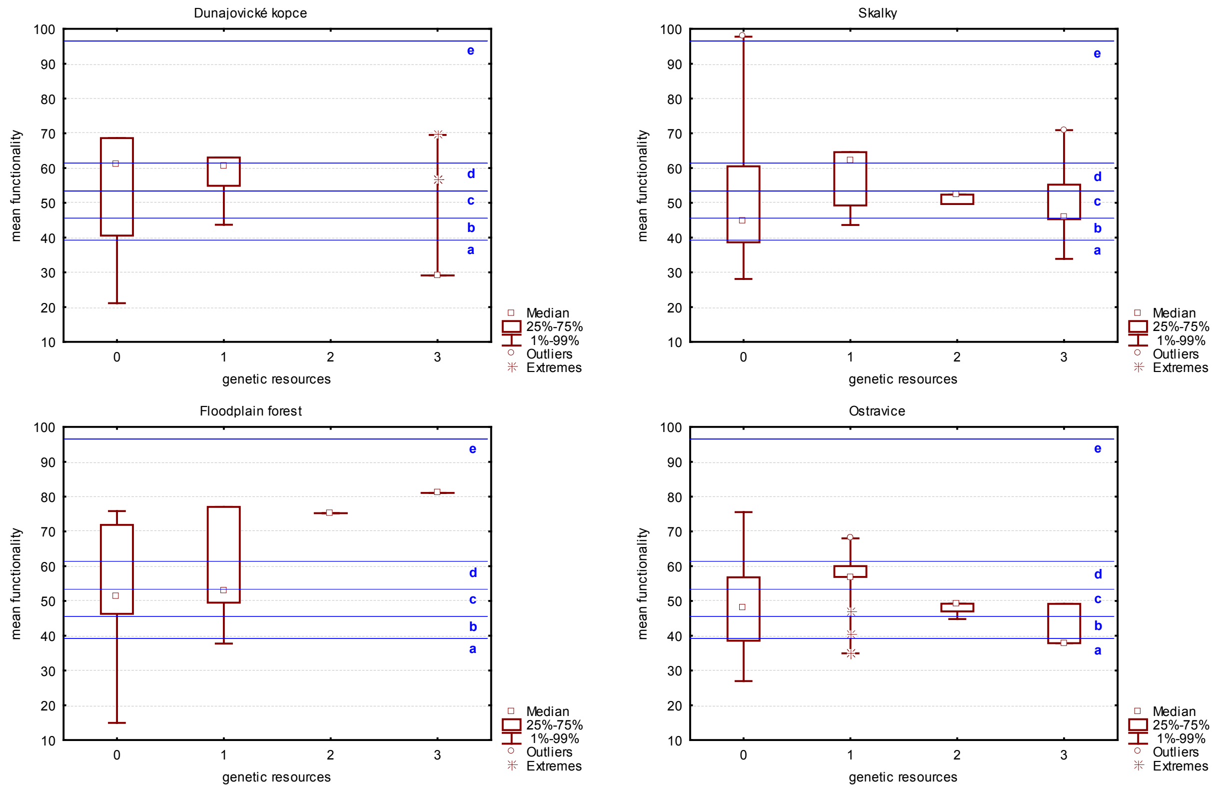
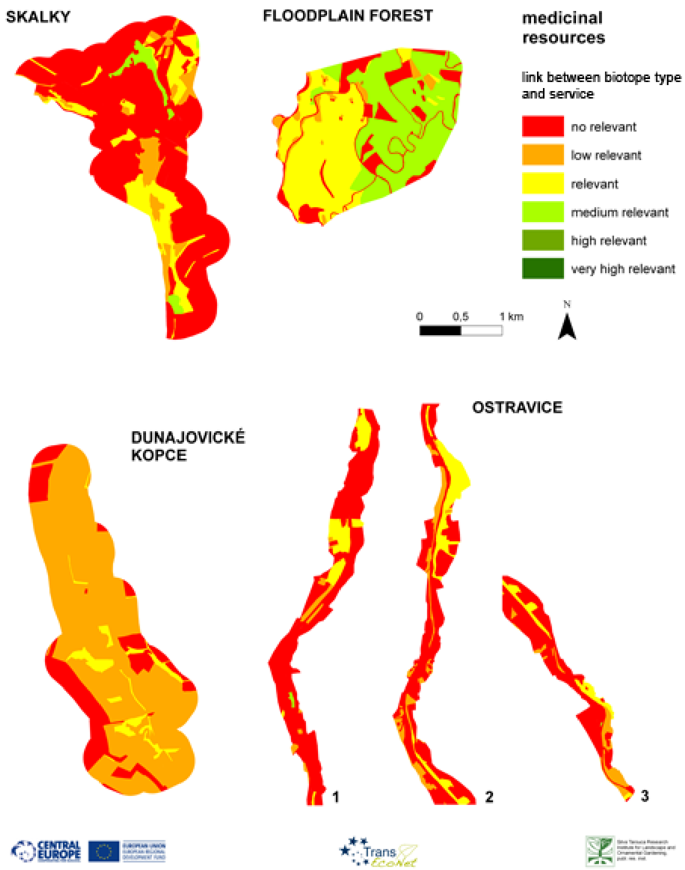


Figure 82: Mean functionality in the capacity values to provide the 'genetic resources' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.3.4 Medicinal resources

A variety of chemical substances in natural biota contributes to the maintenance of human health in the form of drugs and pharmaceuticals or their synthesised equivalents.

Medium capacity to provide medicinal resources to a larger extent is typical for the eastern part of the Floodplain forest (Figure 83, left). Landscape elements with capacity 2 are present in larger areas not only in the Floodplain forest but also in Skalky and Ostravice (Figure 83, right). However, in these two investigation areas landscape elements with no capacity dominate. The majority of the Dunajovické kopce area is covered by landscape elements with low capacity to provide this service.



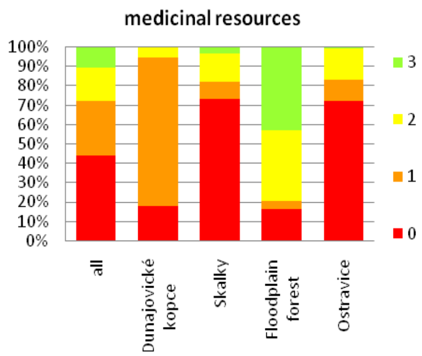


Figure 83: Spatial distribution (left) and area proportion (right) of the 'medicinal resources' service in all investigation areas

A Kruskal-Wallis test confirmed significant differences between mean functionality and capacity values. Post hoc comparisons identified that mean functionality in capacity value 0 significantly differed from mean functionality in capacity values 2 and 3, but not from mean functionality in capacity value 1.

Very high functionality was found in capacity value 3, high functionality in capacity values 1 and 2 and medium functionality in capacity value 0 (Figure 84).

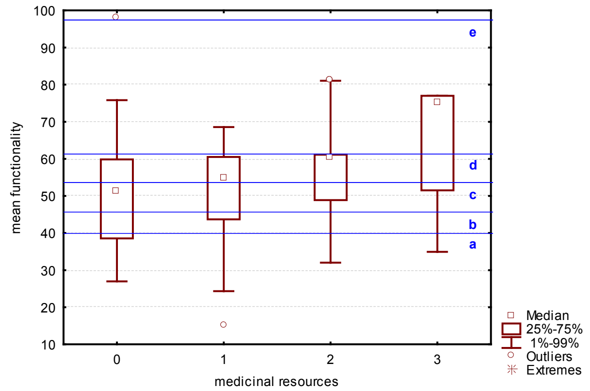


Figure 84: Mean functionality in the capacity values to provide the 'medicinal resources' service regardless of the investigation areas; blue hatches show borders of functional categories

Significant differences were found in Dunajovické kopce, the Floodplain forest and Ostravice. Post hoc comparisons identified significant differences only in the Floodplain forest and these differences concerned all capacity values. However, no similarity between capacity values was found.

Figure 85 shows that very high functionality was found in capacity values 0, 2 and 3 in the Floodplain forest and very low functionality was in capacity value 3 in Ostravice. High functionality was found in capacity values 1 (Dunajovické kopce and Ostravice) and 2 (Dunajovické kopce, Skalky and Ostravice).

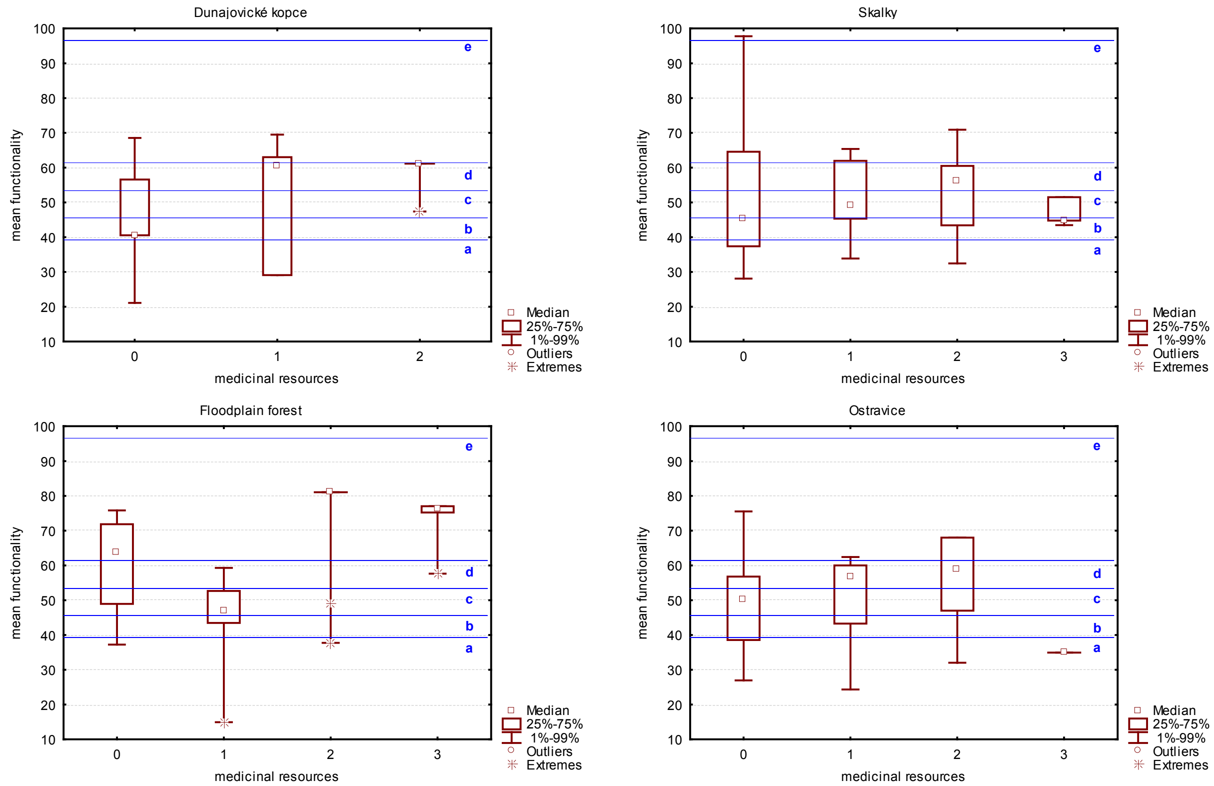


Figure 85: Mean functionality in the capacity values to provide the 'medicinal resources' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.4 Information services

2.3.3.4.1 Science and education

Natural ecosystems and natural elements provide a sense of continuity and understanding of our place in the universe which is expressed through ethical and heritage values.

Landscape elements with no or low capacity to provide this service dominate in all investigation areas (Figure 86). Landscape elements with capacity values 2 and 3 are more spatially distributed in the Floodplain forest where they cover 33% and 16% respectively. Larger extents of landscape elements with capacity values 2 can be found also in Skalky (12%) and Ostravice (15%).

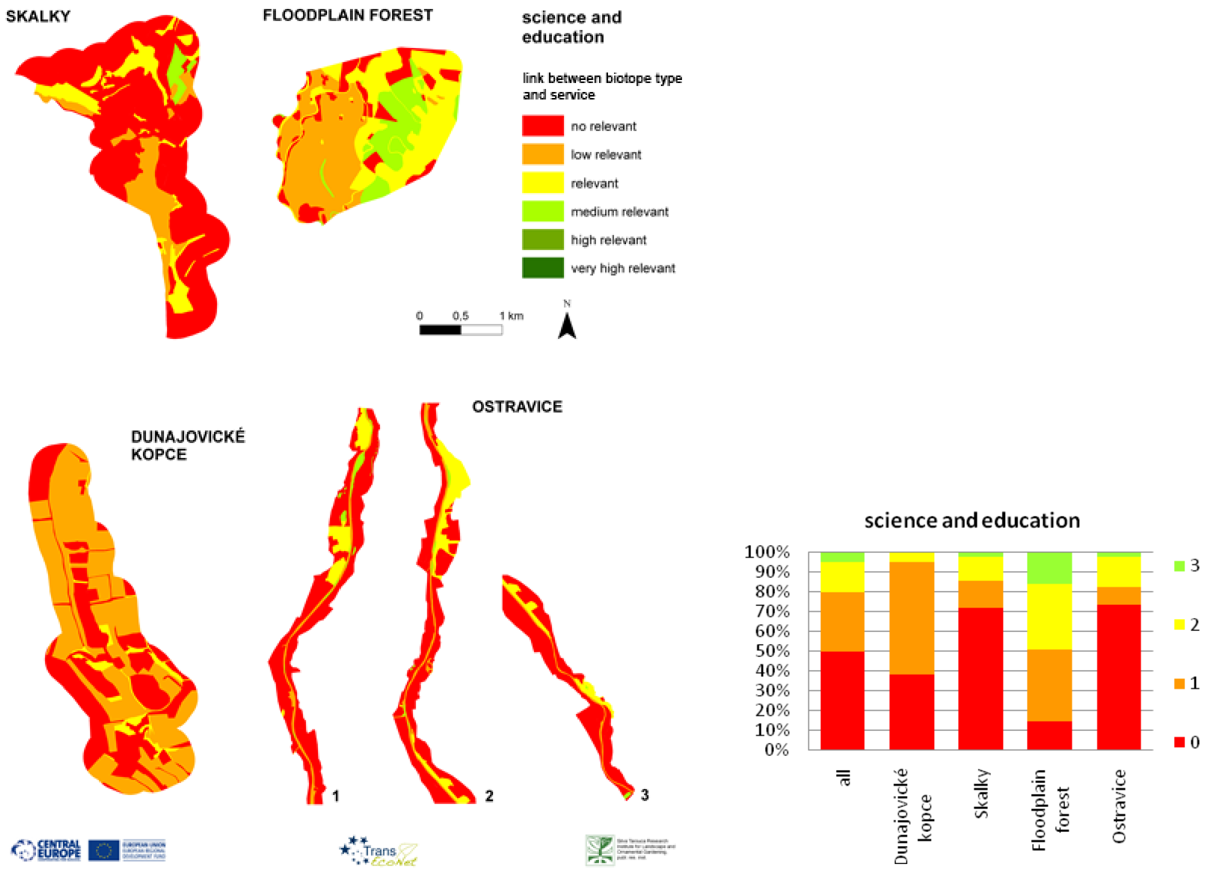


Figure 86: Spatial distribution (left) and area proportion (right) of the 'science and education' service in all investigation areas

The presence of significant differences between mean functionality and capacity values was confirmed by a Kruskal-Wallis test. From the post hoc comparison it is clear that mean functionality in capacity value 0 significantly differed from mean functionality in capacity value 2. The same results are valid for capacity values 1 and 3.

High functionality was found in landscape elements with capacity values 0, 1 and 2 (Figure 87). Landscape elements with capacity value 3 had medium to low functionality.

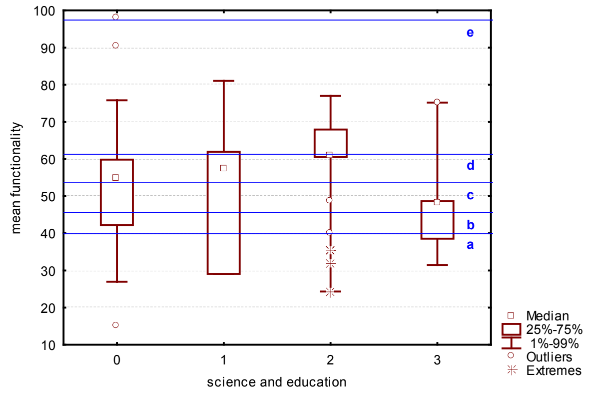


Figure 87: Mean functionality in the capacity values to provide the ‘science and education’ service regardless of the investigation areas; blue hatches show borders of functional categories

A Kruskal-Wallis test revealed significant differences between mean functionality and capacity values in all investigation areas. Post hoc comparisons identified significant differences only in Dunajovické kopce, the Floodplain forest and Skalky. Similar results were found for capacity values 0 and 1 in both Dunajovické kopce and the Floodplain forest. Similar results were also identified in Dunajovické kopce for capacity values 0 and 2 and in the Floodplain forest for capacity values 0 and 3. In Skalky, significant differences in mean functionality were found in capacity values 0 and 2.
Very high functionality in capacity value 2 was typical for the Floodplain forest and Ostravice. Very low functionality in capacity value 1 can be found in Dunajovické kopce (Figure 88). High functionality in capacity value 0 is typical for Dunajovické kopce, Skalky and Ostravice and partly also for the Floodplain forest.

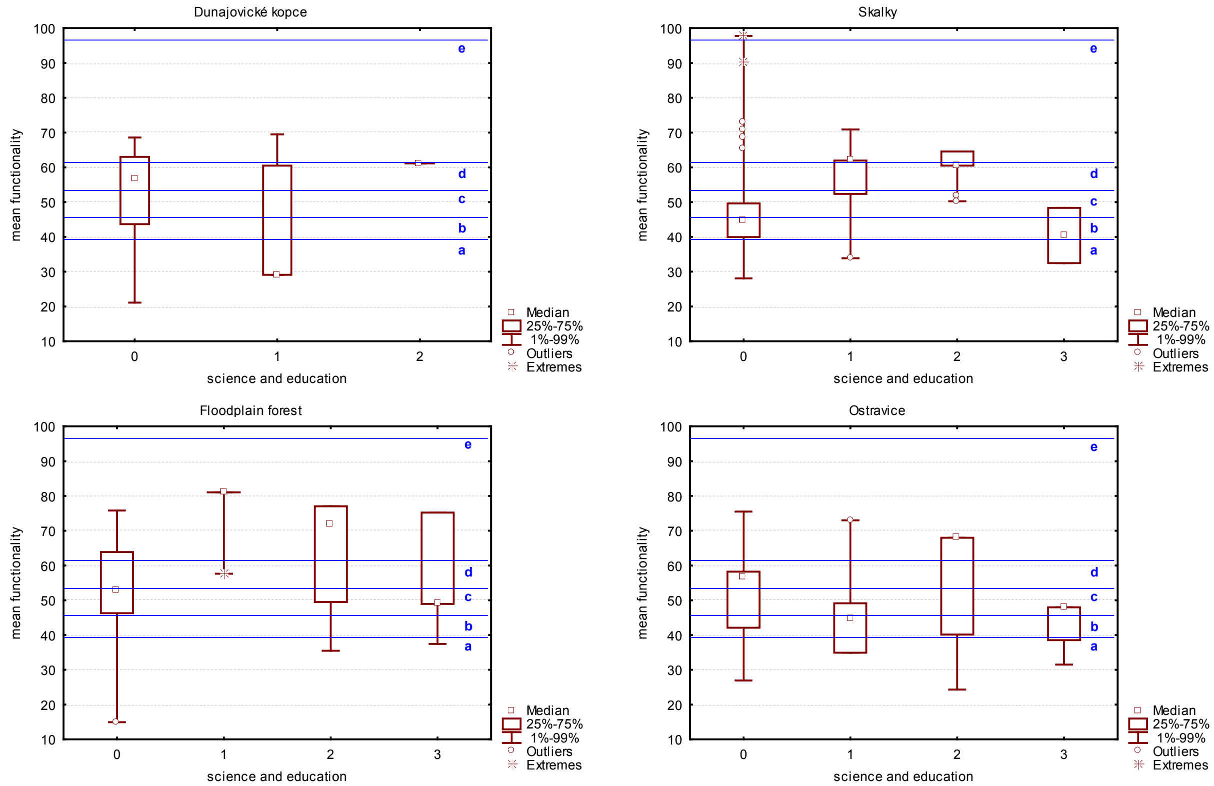


Figure 88: Mean functionality in the capacity values to provide the ‘science and education’ service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.5 Carrier services

2.3.3.5.1 Habitation

This service reflects the provision of suitable space for human living which can range from small settlements to large urban areas.

Since the majority of landscape elements in all investigation areas belong either to agriculture or forestry, the capacity to provide the 'habitation' service is largely non-existent (Figure 89). Only in Ostravice where settlements are present, landscape elements with very high capacity cover a notable area (about 20% - Figure 89, right).

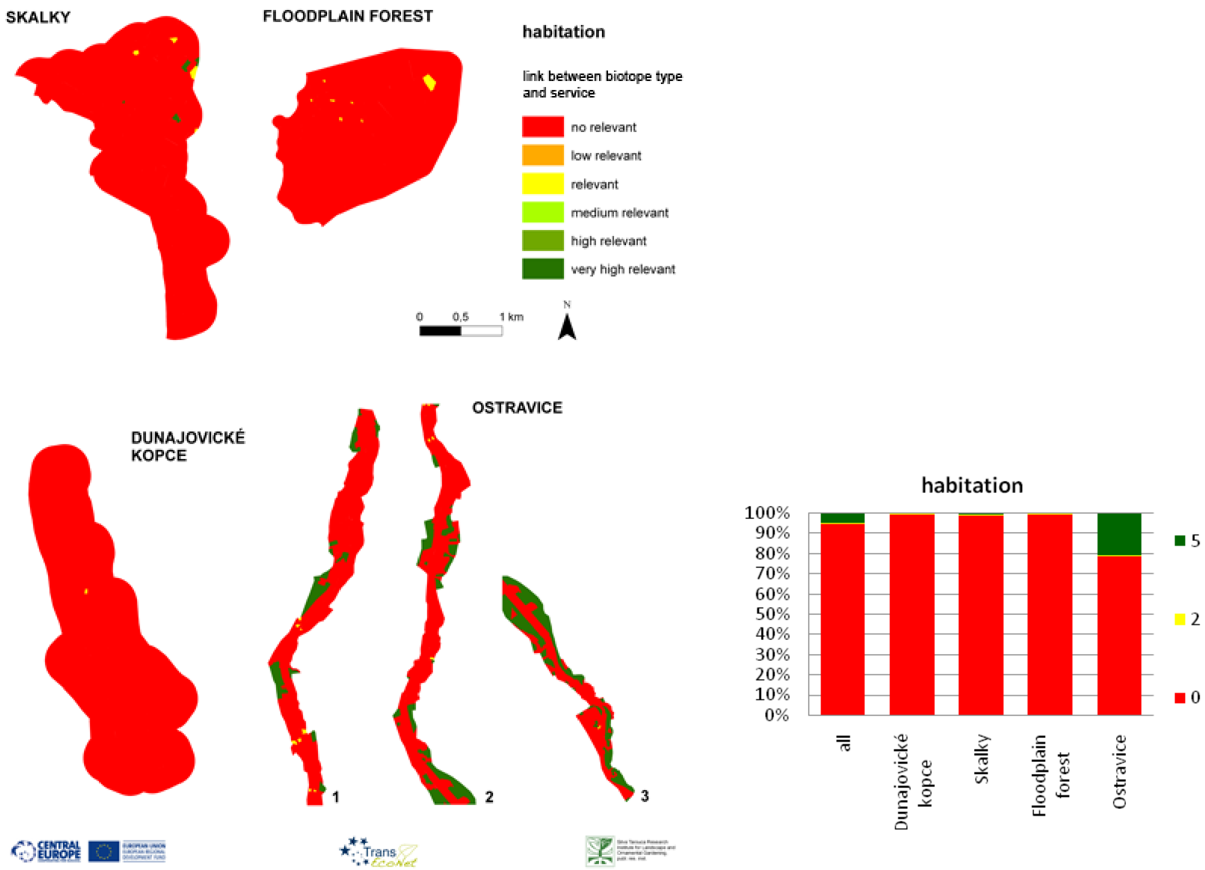


Figure 89: Spatial distribution (left) and area proportion (right) of the 'habitation' service in all investigation areas

Significant differences between mean functionality and capacity values were confirmed by a Kruskal-Wallis test. Post hoc comparisons indicated that mean functionality in capacity value 0 was significantly different than mean functionality in capacity values 2 and 5.

High to very high functionality was typical for landscape elements with capacity value 2; high to medium functionality was found in landscape elements with no capacity to provide habitation service. Very low functionality values were found in landscape elements with very high capacity to provide this service (Figure 90).

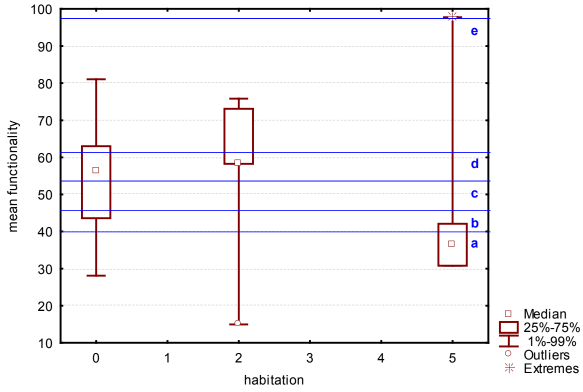


Figure 90: Mean functionality in the capacity values to provide the 'habitation' service regardless of the investigation areas; blue hatches show borders of functional categories

A Kruskal-Wallis test revealed significant differences between mean functionality and capacity values only in Ostravice and this was confirmed also by post hoc comparisons using the Tukey HSD test. Mean functionality in capacity value 5 significantly differed from capacity values 0 and 2.

Figure 91 shows that high functionality was typical for capacity values 0 (Dunajovické kopce, Floodplain forest and Ostravice) and 2 (Ostravice). Very high functionality was found in Dunajovické kopce and the Floodplain forest and related to capacity value 2. Very low functionality related to capacity value 5 in Ostravice.

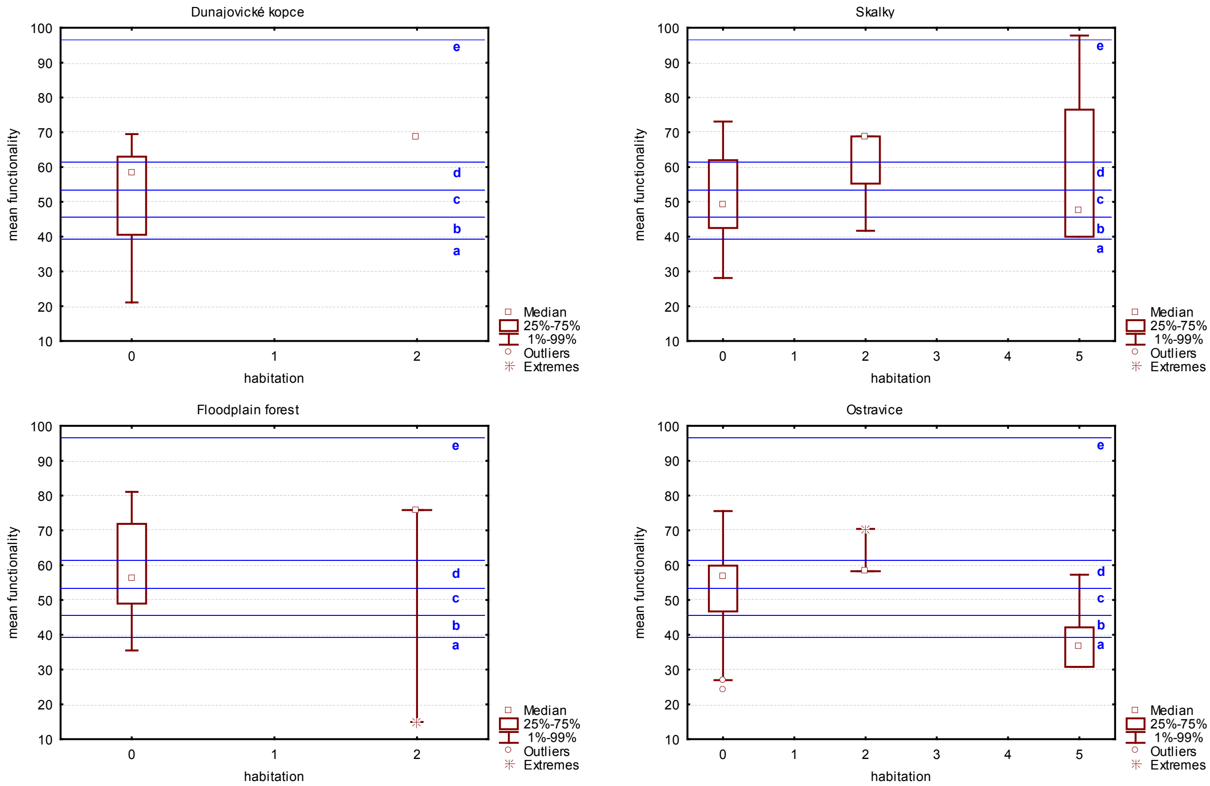


Figure 91: Mean functionality in the capacity values to provide the 'habitation' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.5.2 Cultivation

The ‘cultivation’ service provides food and raw materials from cultivated land and aquaculture, especially cultivated plants and domesticated animals.

High or very high capacity to provide this service is typical for Skalky (in total more than 60% of the investigation area is covered by landscape elements with these capacities). Medium to very high capacity prevails in Dunajovické kopce (Figure 92) where landscape elements with medium capacity dominate. Approximately the same proportion of the area is covered by landscape elements with no capacity in the Floodplain forest and Ostravice (about 52%). The rest of these investigation areas is covered by landscape elements with medium to very high capacity; one third of the Floodplain forest belongs to medium capacity while one third of Ostravice belongs to high capacity (Figure 92, right).

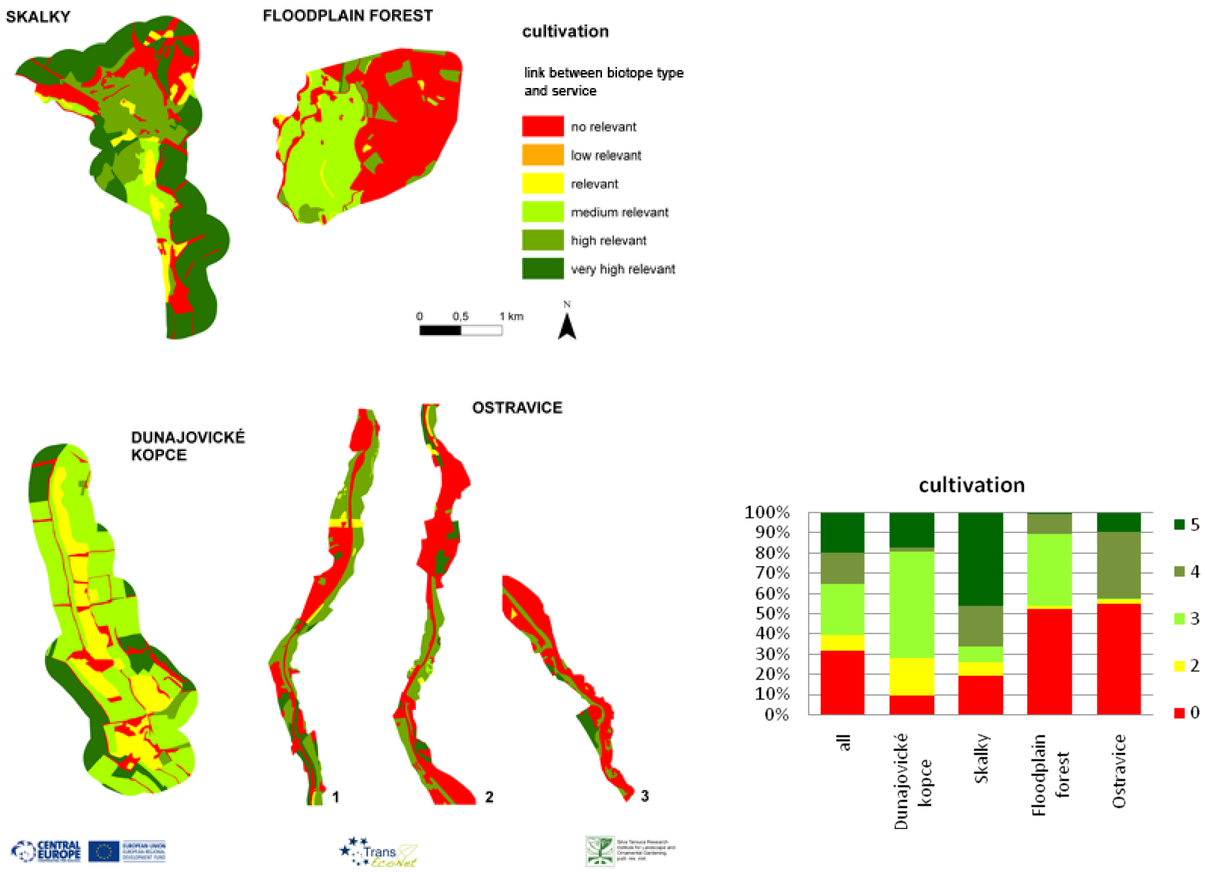


Figure 92: Spatial distribution (left) and area proportion (right) of the ‘cultivation’ service in all investigation areas

A Kruskal-Wallis test confirmed significant differences between mean functionality and capacity values. Post hoc comparisons identified significant differences in all capacity values; similar results were found for capacity values 2 and 3. Mean functionality in capacity value 4 significantly differed from mean functionality in all other capacity values.

High functionality was recorded for capacity values 0, 4 and 5 while low functionality was found in capacity value 3 (Figure 93). However, in this capacity value mean functionality had a wide range and some landscape elements can reach very high functionality.

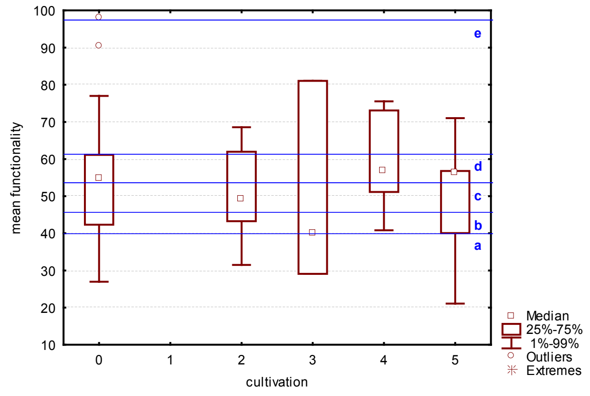


Figure 93 Mean functionality in the capacity values to provide the 'cultivation' service regardless of the investigation areas; blue hatches show borders of functional categories

Significant differences between mean functionality and capacity values were found in all investigation areas according to the Kruskal-Wallis test. Post hoc comparisons identified similar results for capacity values 3 and 4 between Dunajovické kopce and the Floodplain forest and 5 between Dunajovické kopce and Ostravice. Within investigation areas similar results were found for capacity values 0 and 2 (Dunajovické kopce, Ostravice), 0, 2 and 3 (Skalky) and 4 and 5 (Ostravice). No significant differences were identified for capacity value 3 in Ostravice and Skalky and 5 in the Floodplain forest.

Very high functionality was found in capacity value 2 (Dunajovické kopce, partly Skalky), 3, 4 and 5 (Floodplain forest). Very low capacity was identified in landscape elements with capacity value 3 (Dunajovické kopce) and 5 (Skalky). The majority of landscape elements belonged to functionality categories medium and high as can be seen in Figure 94.

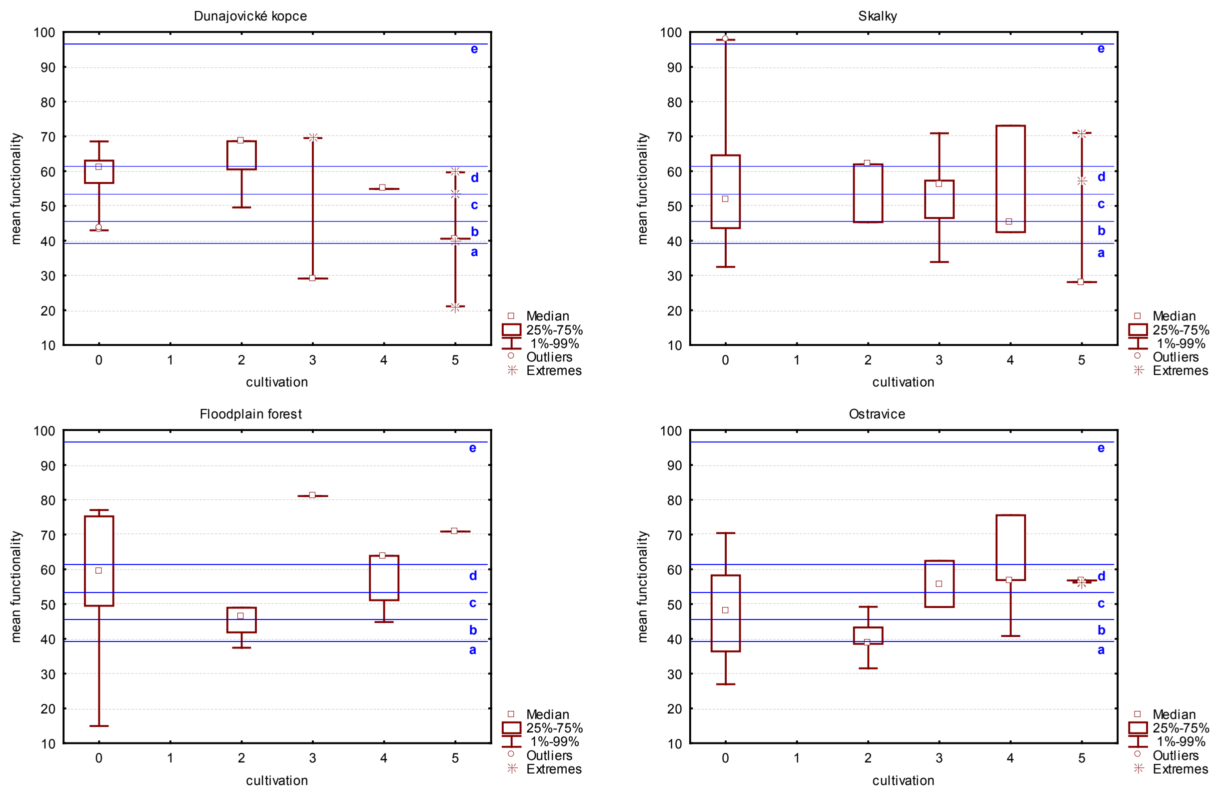


Figure 94: Mean functionality in the capacity values to provide the 'cultivation' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.5.3 Waste disposal

This service provides space for either potential or actual solid waste disposal. It is important that the area provides permanent storage for the duration of the waste's biological and chemical activity.
As is clear from Figure 95 capacity to provide the 'waste disposal' service is almost non-existent and landscape elements with such capacity, be it low or very high, can be found only in about 0,4% of the investigation areas.

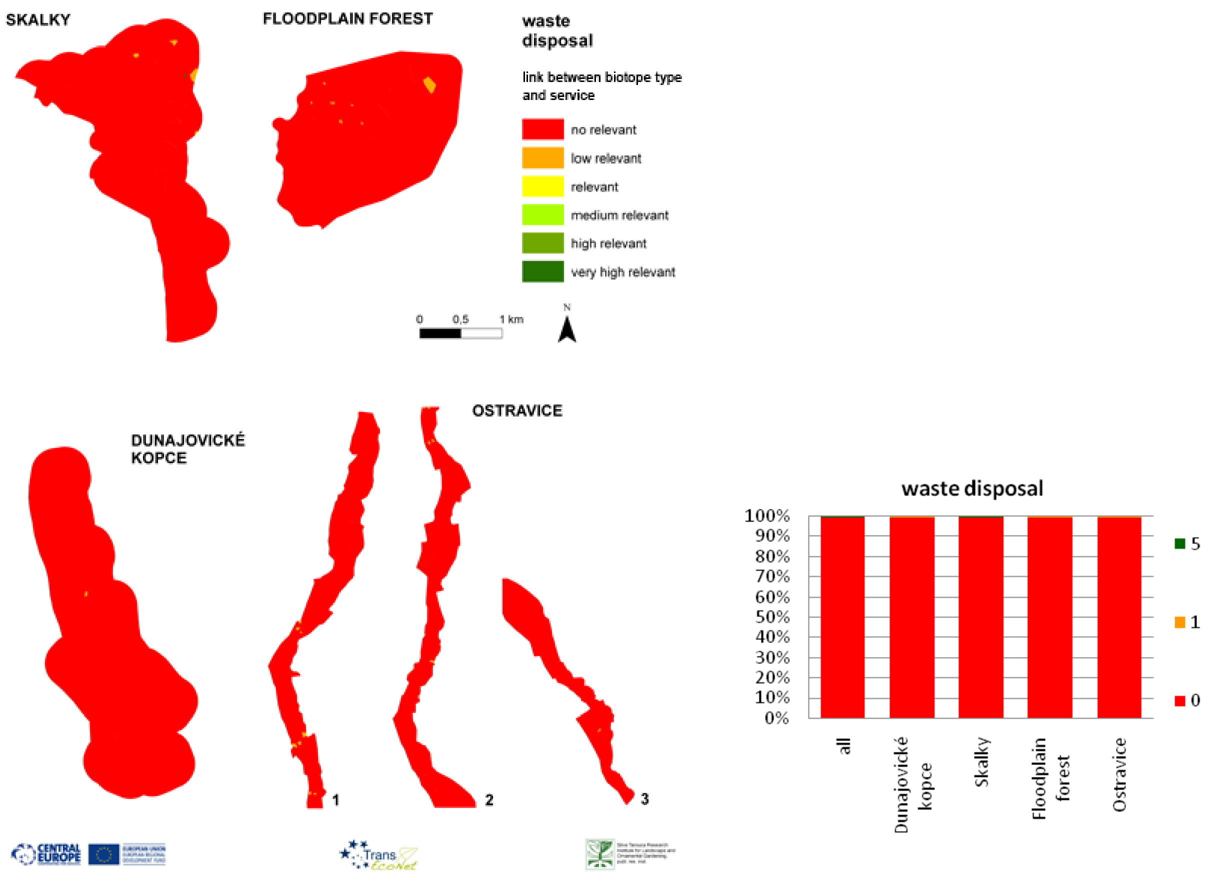


Figure 95: Spatial distribution (left) and area proportion (right) of the 'waste disposal' service in all investigation areas

The presence of significant differences between mean functionality and capacity values was revealed by a Kruskal-Wallis test. Post hoc comparisons identified that mean functionality in capacity value 0 was significantly different from mean functionality in capacity values 1 and 5.
Functionality in capacity values 1 and 5 was higher than functionality in landscape elements with no capacity to provide the 'waste disposal' function (Figure 96).

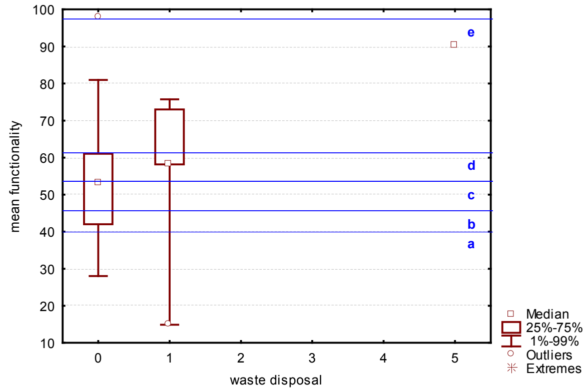


Figure 96: Mean functionality in the capacity values to provide the 'waste disposal' service regardless of the investigation areas; blue hatches show borders of functional categories

Significant differences between mean functionality and capacity values were confirmed only in Ostravice. However, post hoc comparisons identified no significant differences of mean functionality in any capacity value.

Figure 97 shows very high functionality in capacity values 1 in Dunajovické kopce, the Floodplain forest and Skalky and 5 in Skalky. Medium to high functionality in capacity value 0 was identified for investigation areas Skalky and Floodplain forest. Low to high functionality in this capacity value was typical for Dunajovické kopce and Ostravice.

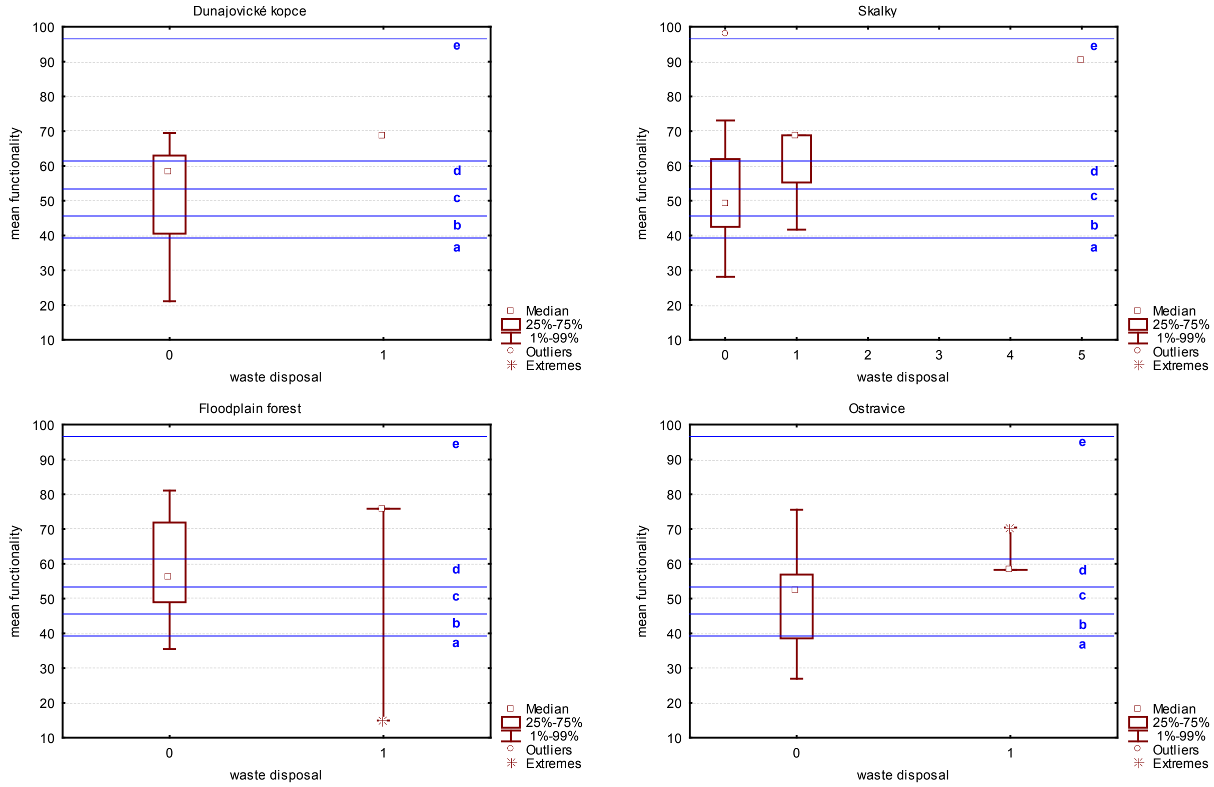


Figure 97: Mean functionality in the capacity values to provide the 'waste disposal' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.5.4 Transportation

Transportation is a simple service providing suitable substrate or medium for transportation by land and/or water.

Landscape elements with the capacity to provide this service are notably present only in Ostravice where they cover approximately 20% of the total area (Figure 98). In other investigation areas their spatial extent is insignificant.

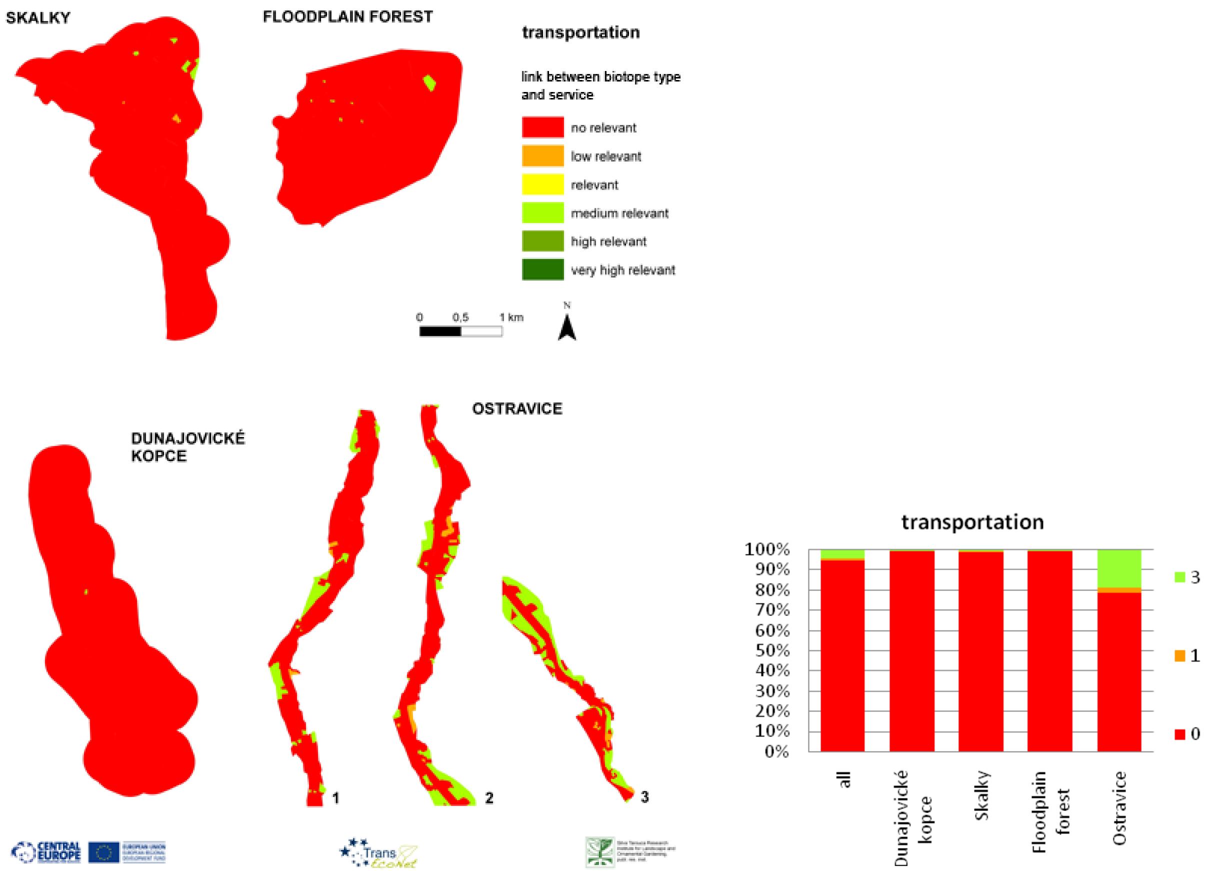


Figure 98: Spatial distribution (left) and area proportion (right) of the 'transportation' service in all investigation areas

A Kruskal-Wallis test confirmed significant differences between mean functionality and capacity values. Post hoc comparisons identified that mean functionality in capacity value 0 differed significantly from mean functionality in capacity values 1 and 3. Mean functionality in capacity value 1 did not significantly differ from mean functionality in capacity value 3.

Landscape elements with no capacity at all to provide the 'transportation' service had medium to high functionality, landscape elements with capacity value 3 had low to high functionality (Figure 99).

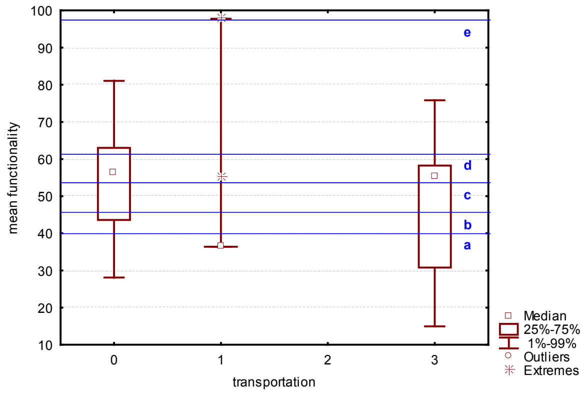


Figure 99: Mean functionality in the capacity values to provide the 'transportation' service regardless of the investigation areas; blue hatches show borders of functional categories

Only in Ostravice did the Kruskal-Wallis test confirm significant differences between mean functionality and capacity values. Using the Tukey HSD test, post hoc comparisons identified significant differences of mean functionality between capacity values 0, 1 and 3.
Very high functionality was found in landscape elements with capacity value 1 in Skalky and capacity value 3 in Dunajovické kopce (Figure 100). High to very high functionality was related to capacity value 0 in the Floodplain forest. Medium to high functionality in capacity value 0 was in Dunajovické kopce, Ostravice and Skalky while low to high functionality was typical for capacity value 3 in Skalky and Ostravice.

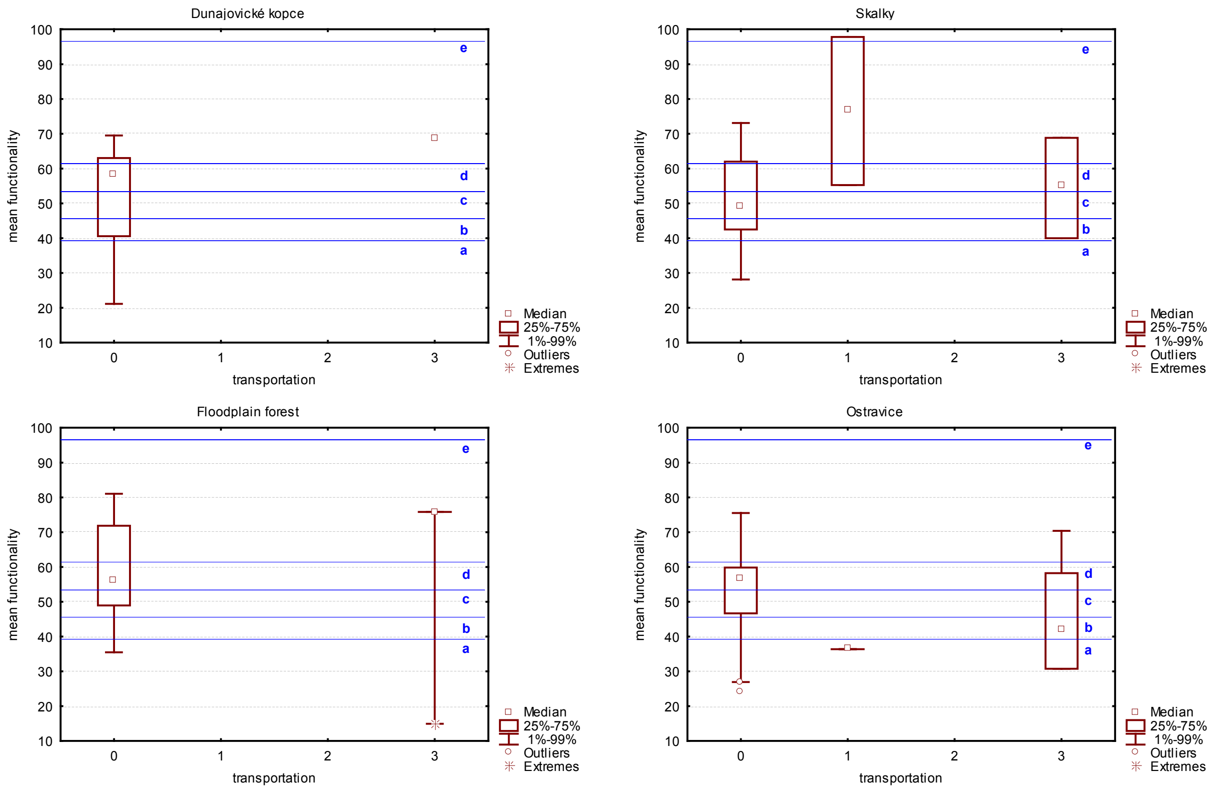


Figure 100: Mean functionality in the capacity values to provide the 'transportation' service in the individual investigation areas; blue hatches show borders of functional categories

2.3.3.6 Summary of service assessment

Figure 101 summarises the proportion of capacity values in the individual landscape services. In general, landscape services belonging to *Regulation* services tend to have higher proportions of capacity values 4 and 5 while landscape services belonging to *Carrier* services tend to have higher proportions of capacity value 0 (with the exception of the 'cultivation' service). Areas of landscape elements with medium to high capacity and with no to relevant capacity in *Habitat* services display a relatively even proportion whereas proportions of landscape elements with capacity values 0 to 2 in *Provision* services are higher than proportions of landscape elements with capacity values 3 to 5.
High proportions were noted for landscape elements with high to very high capacity to provide the 'soil formation' service which contrasts with the 'waste disposal' service and the 'transportation' service where high proportions were typical for landscape elements with no capacity to provide these services.

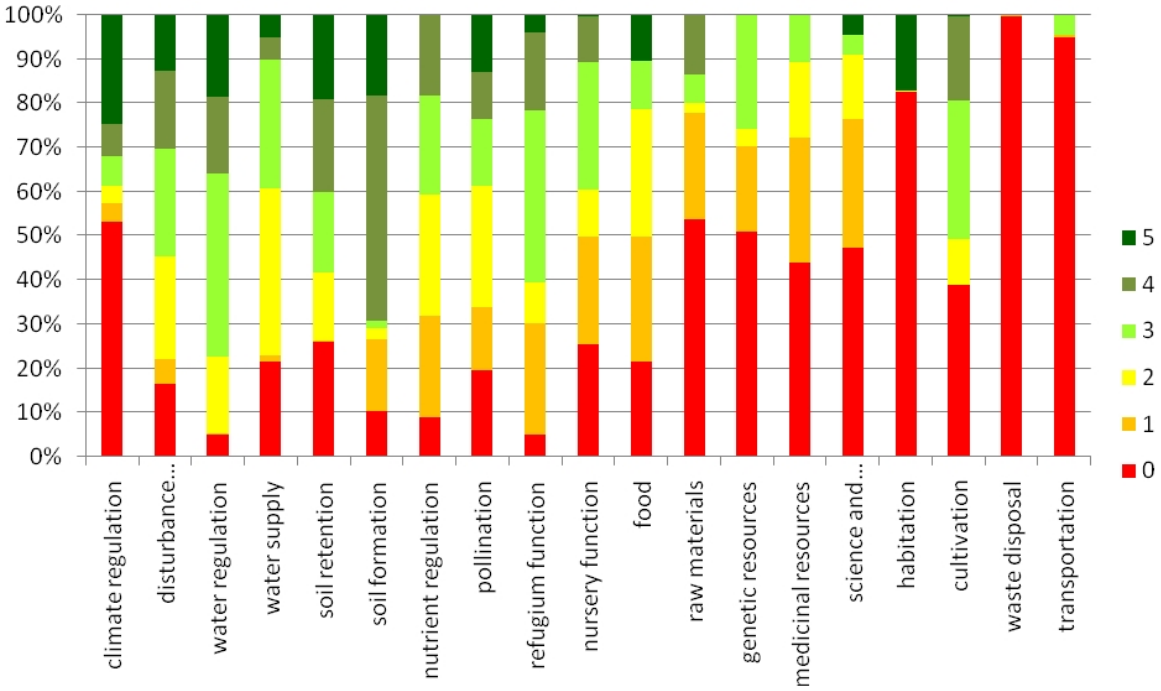


Figure 101: Area proportion of capacity values in the individual landscape services

In all landscape services mean functionality significantly differed between different capacity values and these findings were confirmed by a Kruskal-Wallis test. Such unambiguous results were not valid for individual investigation areas. At least in one investigation area significant differences were not found in seven landscape services which belonged either to the group of *Regulation* services or *Carrier* services (and in one case also to *Provision* services). Post hoc comparisons revealed ten landscape elements where at least one investigation area had no significant differences between mean functionality and capacity values.

The aggregation of separately calculated sub-services to main services is visualised in a spiderweb diagram representing the actual state of landscape service provision for 3 different Landform types within the Project region Central North (Figure 102).

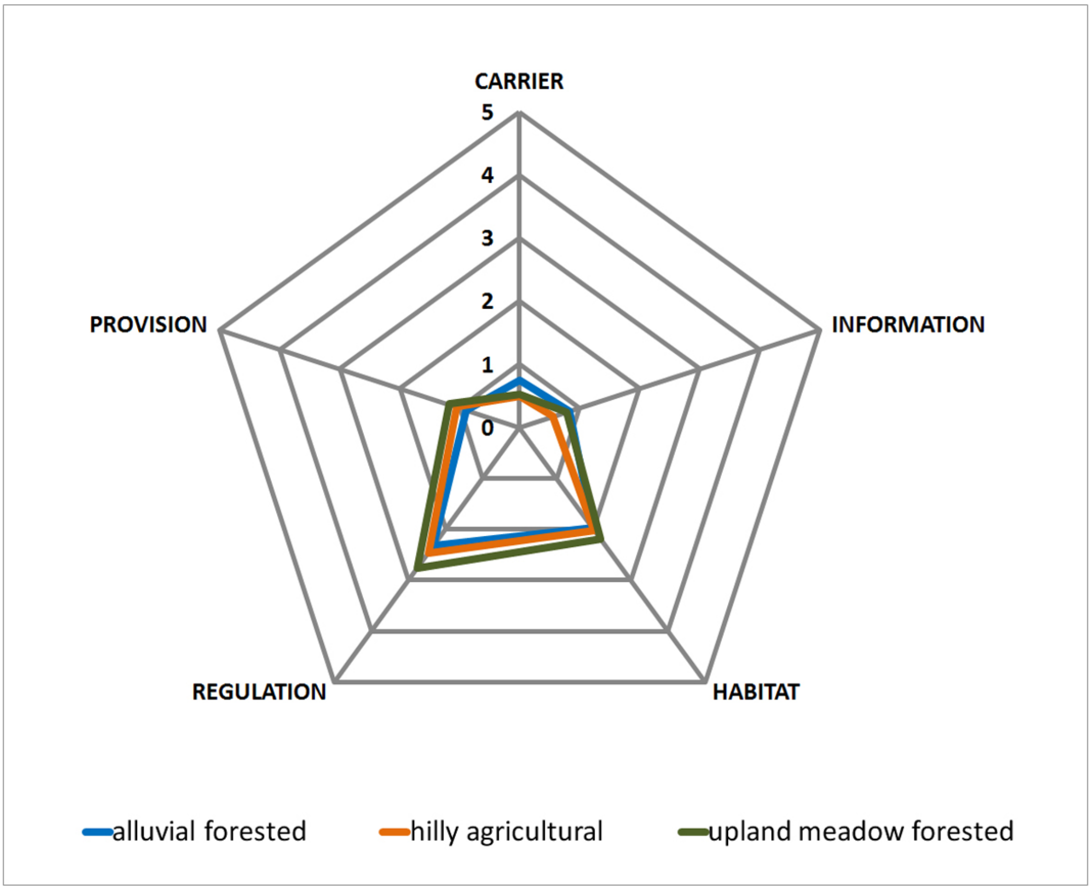


Figure 102: Allocation of landscape services in the 3 different Landform types of the investigation area

2.4 Landscape services in the investigation area of the Northern Project region

Authors: Sylvi Bianchin, Marco Neubert
PP2 – Leibniz Institute of Ecological and Regional Development (IOER), Dresden

2.4.1 Investigation area

As a transboundary investigation area for the analysis in work package 5 we choose the Erzgebirge and Sandstone mountain border region along the German-Czech border. It is an area where different protected areas (e.g. German and Czech eastern Erzgebirge (Krusne hory) landscape protection area, Saxon and Bohemian Sandstone mountains landscape protection area, different nature protection areas e.g. the mountain meadows around Oelsen and Fürstenau as well as a variety of Natura 2000 sites) are interlinked. One of the high priority gaps (Hotspot) identified by the gap analysis in work package 3 is located within this investigation area.

The investigation area is located along the ridge of the Erzgebirge around 600 m a.s.l. The dominating land use is a mixture of forest, arable fields and natural grasslands with a lot of linear structures such as hedgerows, tree rows and stone ridges. The investigation area has a total size of 150 km², where 64,8 km² (43 %) are situated on Czech site and 86,1 km² (57 %) on German side. The delineation of the German part of the investigation area is based on the Meso-Geochore Fuerstenau-Oelsa (Haase & Mannsfeld 2002).

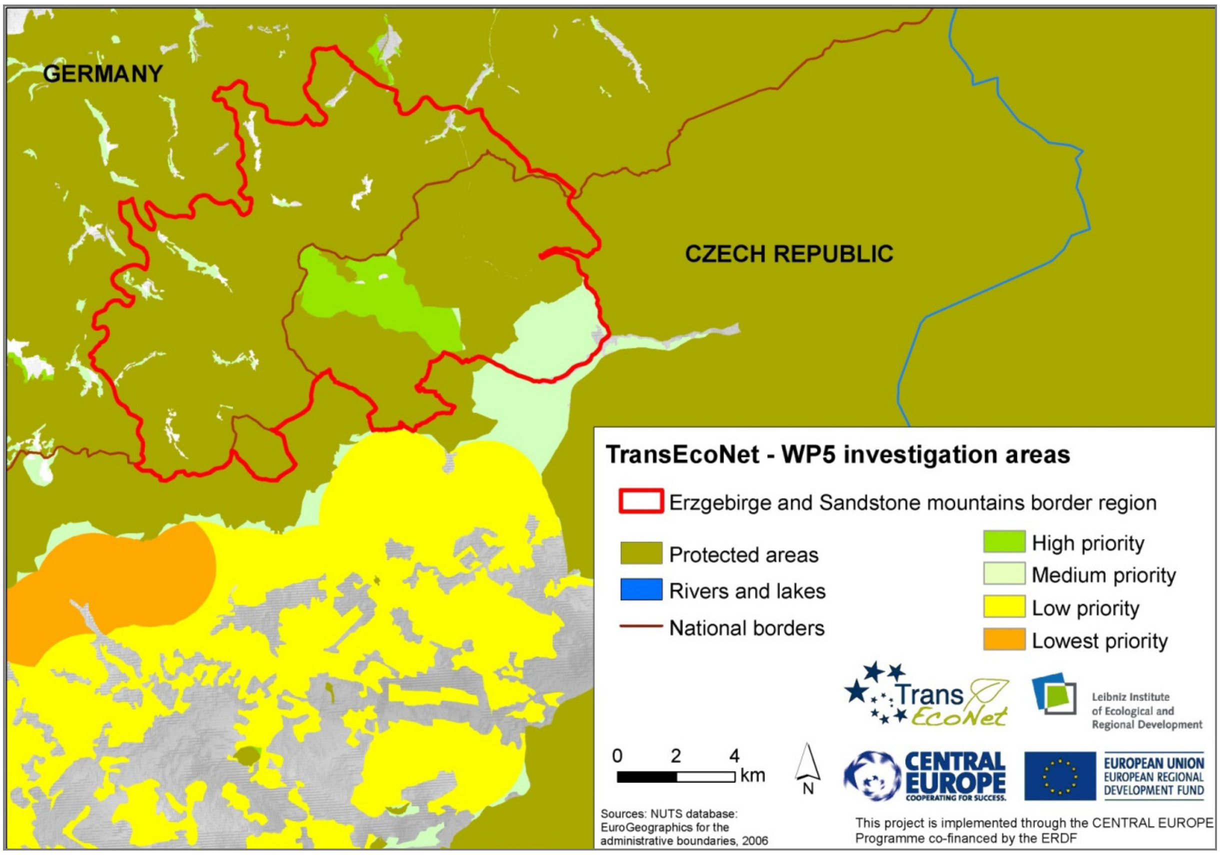


Figure 103: Investigation area Erzgebirge and Sandstone mountains border region

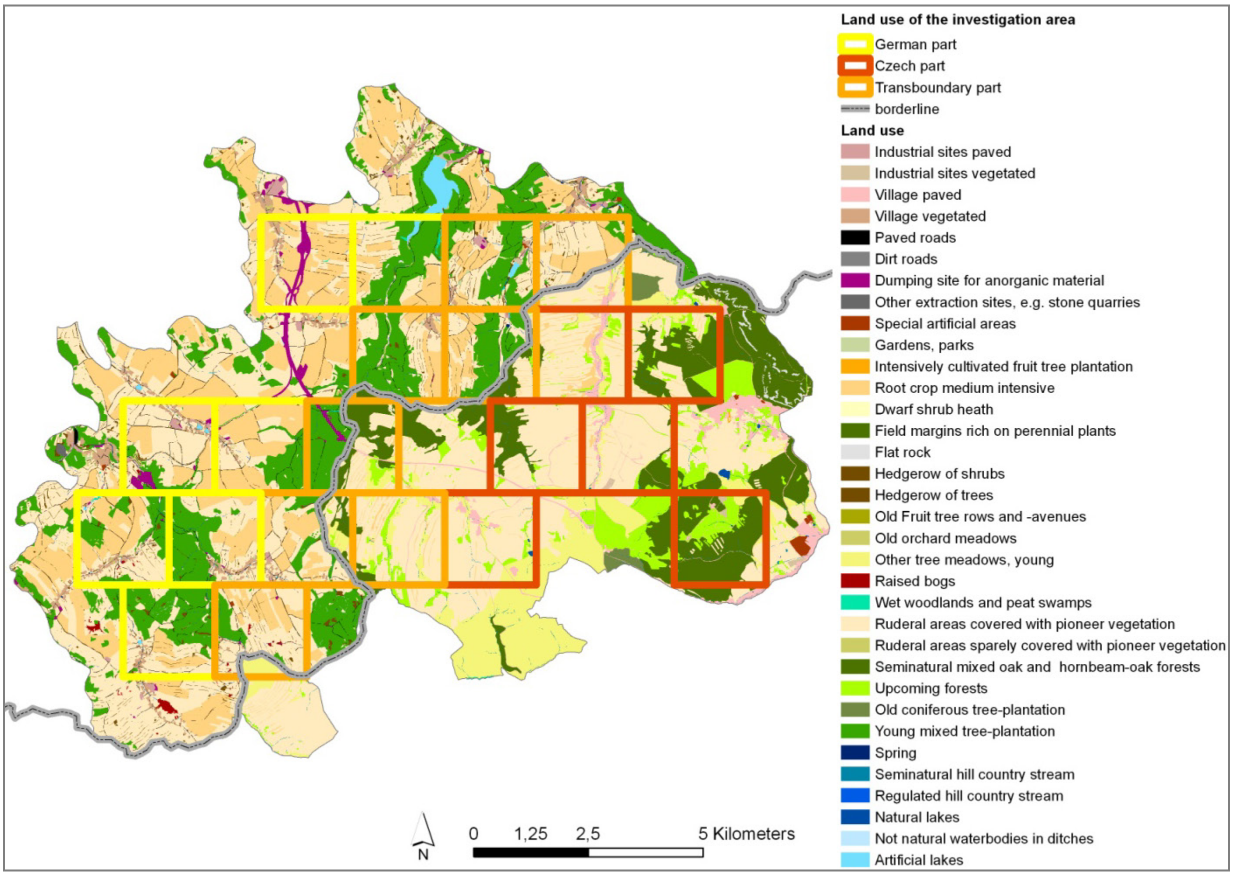


Figure 104: **Biotope types in the investigation area**

2.4.2 *Data and data preparation*

For the German part of the investigation area Erzgebirge and Sandstone mountains border region the BTLNK 2005 (biotope and land use mapping) for Saxony was used. The data is the result of the vectorisation of the aerial photographs from the aerial survey in 2005. Linear objects such as hedgerows, rivers and streets were buffered according to Table 25.

Table 25: Buffer distances for different biotope types (along the buffer distances from Fichtner 2005)

Biotope type	**Total buffer in m**
Row of old trees	5
Row of broad leafed trees	5
Row of coniferous trees	5
Row of broad leafed and coniferous trees	5
Row of fruit trees	5
Alley of fruit trees	5
Row of poplar trees	5
Trees along rivers and streams	5
Pollarded trees	5
Hedgerow	5
Hedgerow in or along agricultural fields	5
Hedgerow along stone ridges	5
Stone ridges	5
Perennial and ruderal herbs	3
Stepped forest edge	5
Creek, stream	3
River	5
Chanel	2
Dam	10
Country road, highway	7
Unpaved road	5
Other roads	5
Railway	6

In a second step the biotope types were assigned to the CORINE classification and functional groups (Table 26) according to the table provided by the work package coordinator University of Vienna.

Table 26: Assignation of CORINE land use codes for the German part

German description	CORINE description	CLC Code	CLC Code Level 3
Residential and mixed used areas	Residential discontinuous sparse urban fabric	1.1.2.2	112
Dams	Industrial or commercial units	1.2.1	121
Dams in and along river courses	Industrial or commercial units	1.2.1	121
Industrial or commercial units	Industrial, commercial, public and private units, partly sealed	1.2.1.2	121
Agricultural business location	Industrial, commercial, public and private units, partly sealed	1.2.1.2	121
Other driveways	Road and rail networks and associated land	1.2.2	122
Other roads	Road network	1.2.2.2	122
Rural and agricultural roads	Road network	1.2.2.2	122
Main road	Main roads	1.2.2.2.1	122
Railways	Other rails	1.2.2.4	122
Excavation site	Mineral extraction sites	1.3.1	131
Dump sites	Dump sites	1.3.2	132
Construction and dump sites	Dump sites	1.3.2	132
Areas with vegetation within urban fabric	Other green, man-made areas	1.4.1.3	141
Sport and leisure facilities	Sport and leisure facilities	1.4.2	142
Arable land	Non-irrigated arable land	2.1.1.1	211
Fruit tree meadows	Fruit tree meadows	2.2.2.1	222
Meadows	Meadows	2.3.1	231
Fruit tree alley	Bosk, grove	2.4.3.1	243
Row of fruit trees	Bosk, grove	2.4.3.1	243
Row of poplar trees	Bosk, grove	2.4.3.1	243
Old trees along field margins	Tree row	2.4.3.2	243
Row of trees along rivers and streams	Tree row	2.4.3.2	243
Row of trees	Tree row	2.4.3.2	243
Row of broad leafed trees (one species)	Tree row	2.4.3.2	243
Row of coniferous trees (one species)	Tree row	2.4.3.2	243
Vegetation along rivers and streams	Tree row	2.4.3.2	243
Trees along rivers and streams	Tree row	2.4.3.2	243
Pollarded trees	Tree row	2.4.3.2	243
Hedgerow in or along agricultural fields	Hedge with distinct proportion of trees	2.4.3.3	243
Hedgerow along stone ridges	Hedge with distinct proportion of trees	2.4.3.3	243
Row of broad leafed trees (several species)	Hedge with distinct proportion of trees	2.4.3.3	243
Row of coniferous trees (several	Hedge with distinct	2.4.3.3	243

species)	proportion of trees		
Row of broad leafed and coniferous trees	Hedge with distinct proportion of trees	2.4.3.3	243
Other hedgerows	Hedge with distinct proportion of trees	2.4.3.3	243
Perennial and ruderal herbs / dry to fresh	Baulks	2.4.5.1	245
Moist forest	Broad-leaved forests	3.1.1	311
Shrubbery	Broad-leaved forests	3.1.1	311
Afforestation	Mixed forests	3.1.3	313
Broad-leaved and mixed forest	Mixed forests	3.1.3	313
Mixed forest	Mixed forests	3.1.3	313
Coniferous and mixed forest	Mixed forests	3.1.3	313
Reafforestation	Mixed forests	3.1.3	313
Humid grasslands	Natural grassland	3.2.1	321
Dry grasslands	Natural grassland	3.2.1	321
Dwarf shrub heathlands and bristle grass lawns	Moors and heathland	3.2.2	322
Stepped forest edge	Transitional woodland shrub	3.2.4	342
Forest edges and pioneer forests	Transitional woodland shrub	3.2.4	324
Bare rock and scree slopes	Bare rock	3.3.2	332
Large stone ridges	Sparely vegetated areas	3.3.3	333
Stone ridges	Sparely vegetated areas	3.3.3	333
Sparely vegetated areas	Sparely vegetated areas	3.3.3	333
Bogs and swamps	Peat bogs	4.1.2	412
Source areas, creeks, small ponds	Inland waters	5.1	51
Creeks	Natural water courses	5.1.1.1	511
Rivers	Natural water courses	5.1.1.1	511
Channels and ditches	Artificial water courses	5.1.1.2	511
Ponds, artificial reservoirs	Artificial reservoirs	5.1.2.2	512

The data for the Czech part of the investigation area was prepared by project partner 7 (University of J. E. Purkyně in Ústí nad Labem, Faculty of the Environment, Department of Geoinformatics). For the Czech part of the investigation area Erzgebirge and Sandstone mountains border region the ZABAGED data (Fundamental Base of Geographic Data/Základní báze geografických dat, scale 1:10.000) was used. The data is the result of the vectorisation of the aerial photographs from the aerial survey in 2007. Main & minor roads and hedgerows were vectorised together. Only linear objects such as small rivers were buffered with 3 m.

Table 27: Assignation of CORINE land use codes for the Czech part

CORINE 2	CORINE 3	LABEL1	LABEL2	LABEL3
31		Forest and semi-natural areas	Forests	
	112	Artificial surfaces	Urban fabric	Discontinuous urban fabric
	121	Artificial surfaces	Industrial	commercial and transport units
	122	Artificial surfaces	Industrial	commercial and transport units
	142	Artificial surfaces	Artificial	non-agricultural vegetated areas
	222	Agricultural areas	Permanent crops	Fruit trees and berry plantations
	243	Agricultural areas	Heterogeneous agricultural areas	Land principally occupied by agriculture
	244	Agricultural areas	Heterogeneous agricultural areas	Agro-forestry areas
	321	Forest and semi-natural areas	Scrub and/or herbaceous vegetation associations	Natural grasslands
	324	Forest and semi-natural areas	Scrub and/or herbaceous vegetation associations	Transitional woodland-shrub
	332	Forest and semi-natural areas	Open spaces with little or no vegetation	Bare rocks
	511	Water bodies	Inland waters	Water courses
	512	Water bodies	Inland waters	Water bodies

By joining the data from the German and Czech side a mismatch along the border was detected regarding the data connection due to unharmonised data sets resulting in gaps and overlaps. Thus, it was necessary to manually shift the Czech data and connect it to Germany.

The whole investigation area was overlaid by a regular raster dividing the surface into squares. We used the official European Grid System (INSPIRE, 2009) based on the ETRS89 Lambert Azimuthal Equal Area coordinate reference system that has its centre of the projection at the point 52º N, 10º E and false northing: Y0 = 3 210 000 m, false easting: X0 = 4 321 000 m. In this study we used a basic grid-size of 1x1 km with a refinement to 500x500 m provided by the work package coordinator University of Vienna. For the calculation four raster cells were combined to one, so that the area of the raster is 2 km² (Figure 105). Overall 22 raster cells were analysed, only raster cells which were completely within the investigation area were selected.

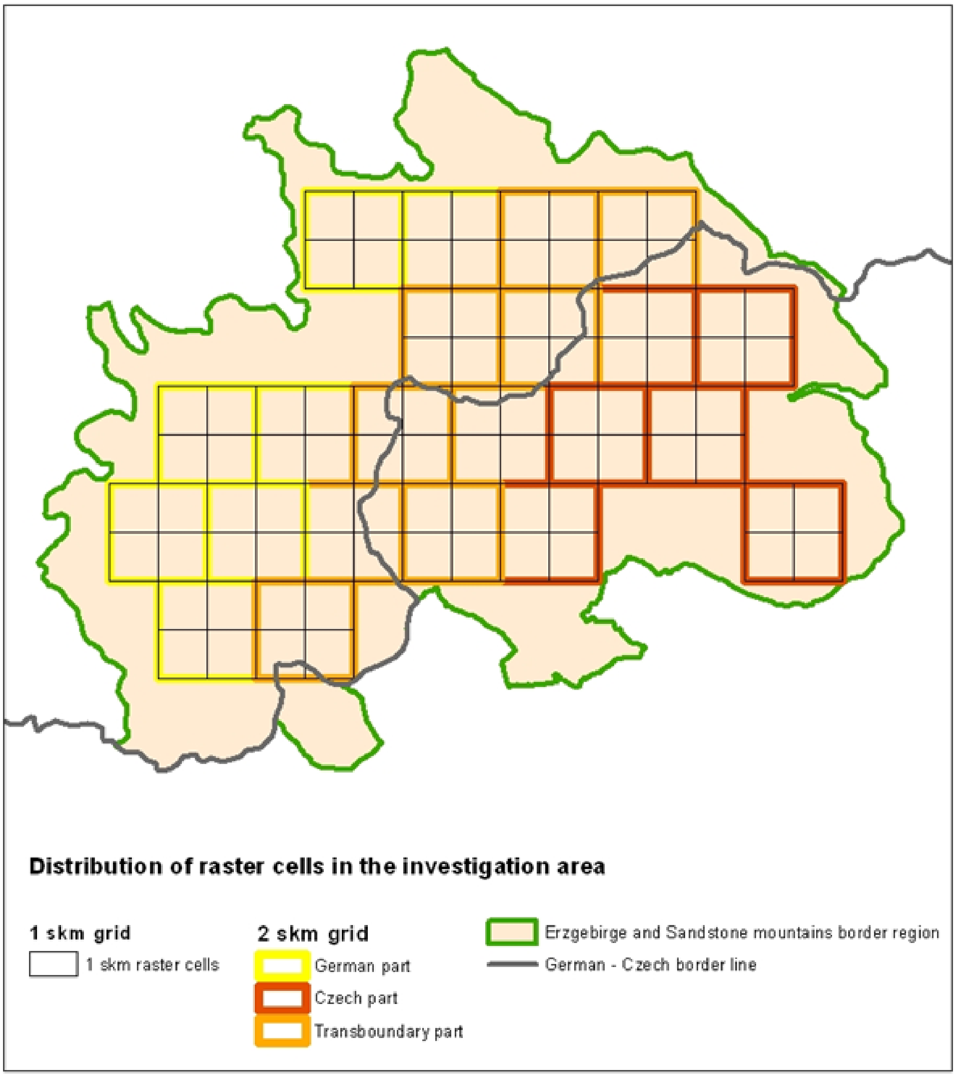


Figure 105: Location of raster cells in the investigation area

Altogether 7 raster cells are totally located in Germany, 6 are totally within the territory of the Czech Republic and 9 cells are transboundary with various percentages of area in Germany and the Czech Republic (Table 28).

Table 28: Transboundary location of the 2 km² raster cells

Raster number	German part in %	Czech part in %
1	100,0	0,0
2	100,0	0,0
3	99,1	0,9
4	66,7	33,3
5	0,0	100,0
6	0,0	100,0
7	73,5	26,5
8	95,7	4,3
9	100,0	0,0
10	100,0	0,0
11	37,6	62,4
12	5,5	94,5
13	0,0	100,0
14	0,0	100,0
15	0,0	100,0
16	0,0	100,0
17	0,1	99,9
18	74,5	25,5
19	100,0	0,0
20	100,0	0,0
21	100,0	0,0
22	90,6	9,4

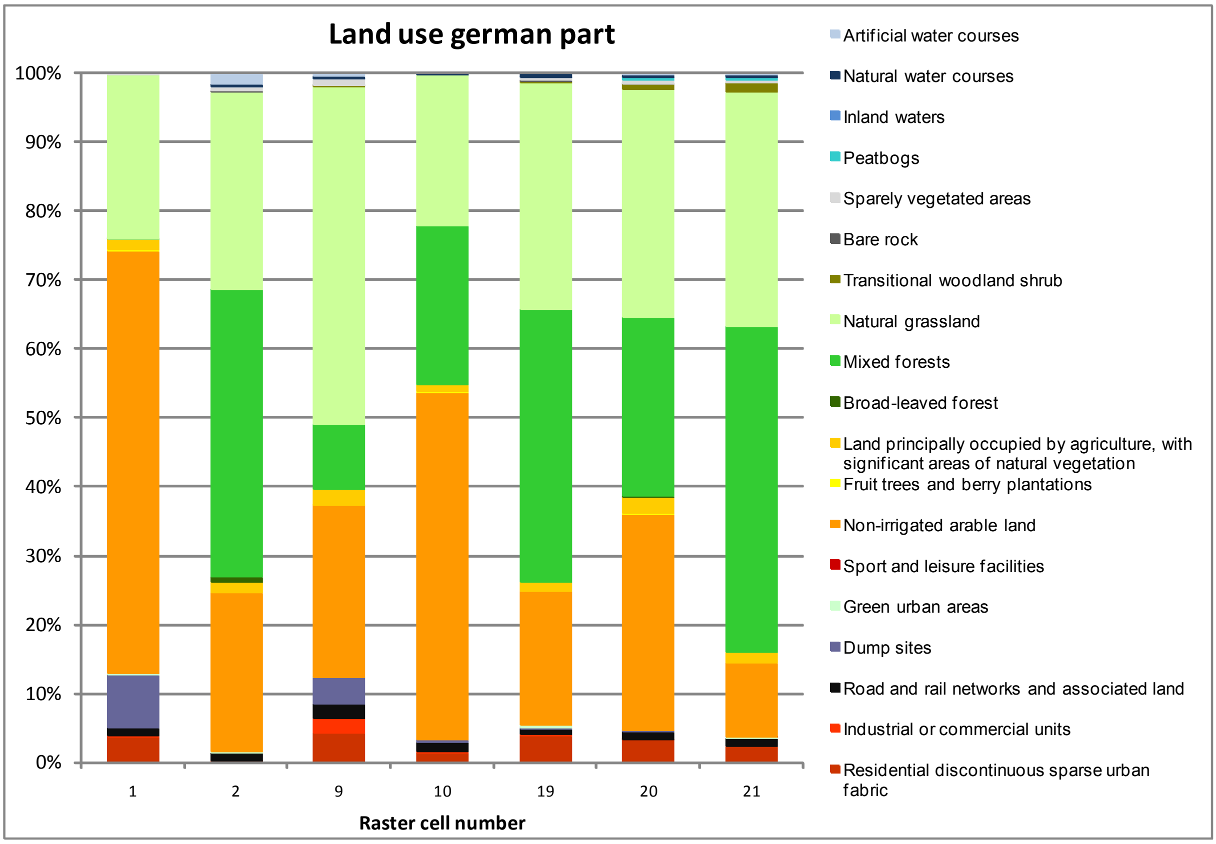


Figure 106: Land use in the German part

The land use in the German part (Figure 106) is a mixture of areas with natural grassland (between 21,8 % and 49,0 %), agricultural use (between 10,9 % and 61,3 %) and mixed forests (between 9,4 % and 47,2 %, except raster cell 1, which does not have any forest areas at all). Artifical surfaces have a low percentage (less than 5 %).

The Czech part of the investigation area is different from the German part (Figure 107). The dominating land use here is forest (broad leaved forest and mixed forest) as well as transitional woodland shrubs and natural grassland. The percentage of arable land is negligible as is the percentage of artificial surfaces.

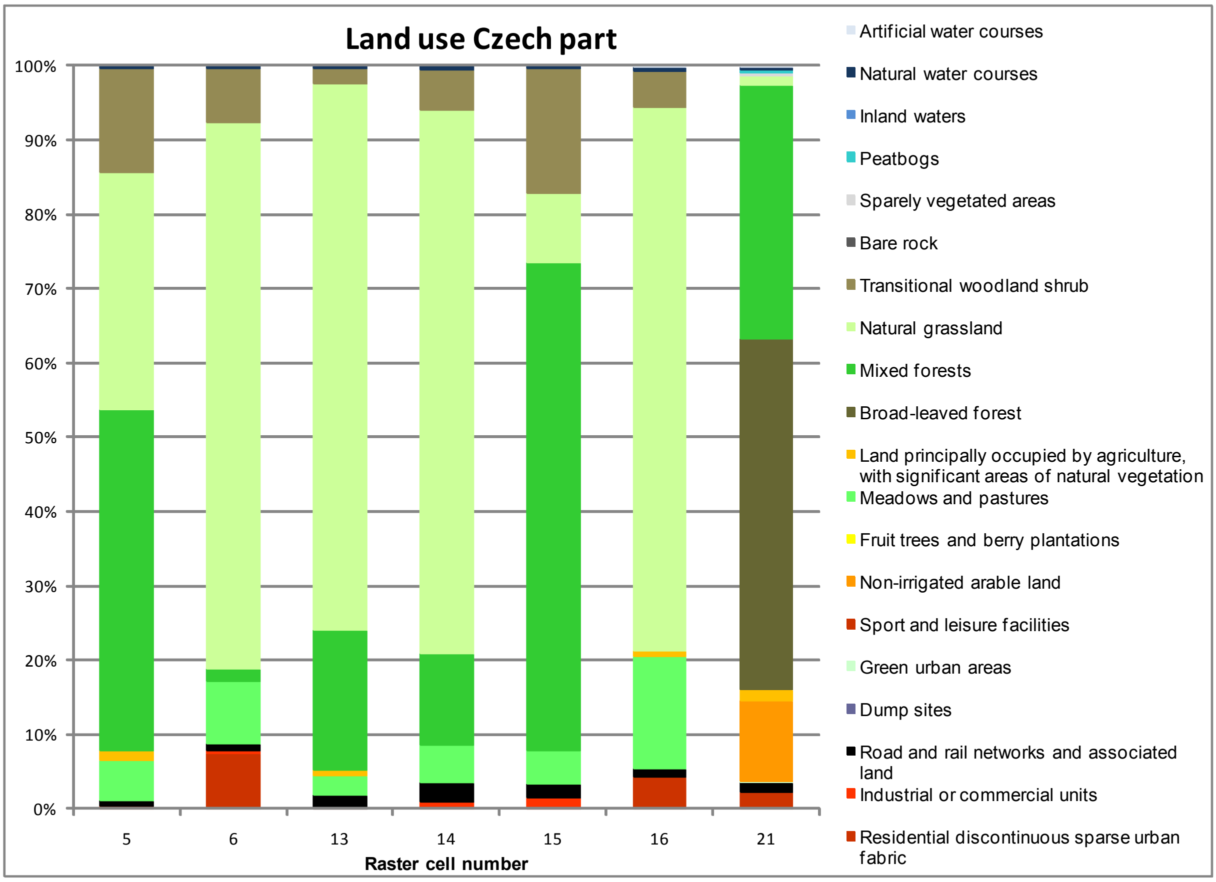


Figure 107: Land use in the Czech part

The land use in the transboundary part is dominated by natural grassland, mixed forest and arable land (Figure 108).

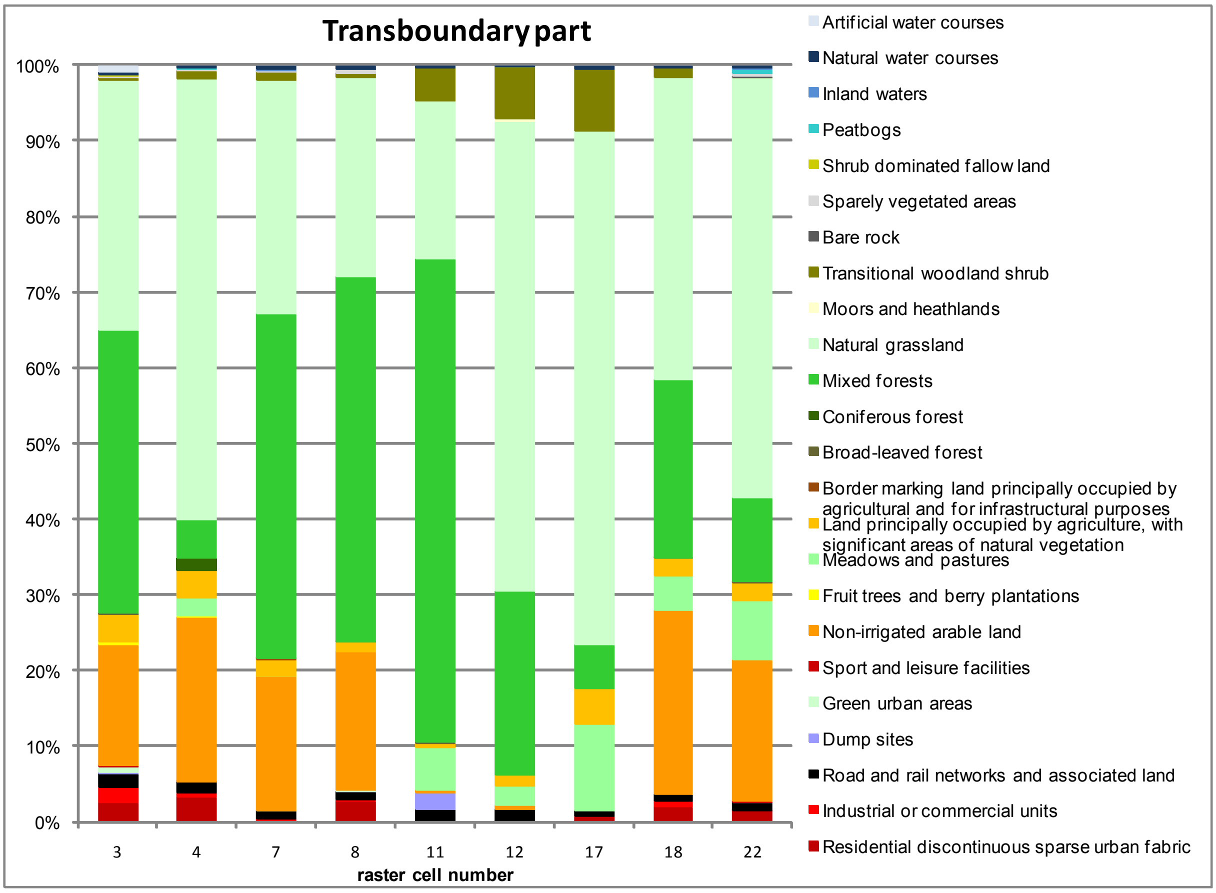


Figure 108: Land use in the transboundary part

2.4.3 *Methodology*

For the investigation area Erzgebirge and Sandstone mountains border region we used the methodology developed by the University of Vienna. We also used the area weighted mean which targets every single sample site as an independent entity and therefore allows to calculate a more realistic value for one single service depending on the distinct local landscape composition.

Table 29 shows the capacity matrix for the assessment of the different links between the biotope type and the related services for all functionality classes for both countries (Germany, Czech Republic).

Table 29: Capacity matrix for the assessment of the different links between the biotope types and the related services for all main service categories (1 = low relevant link, 2 = relevant link, 3 = medium relevant link, 4 = high relevant link, 5 = very high relevant link)

Main services	***Regulation* services**							***Habitat*-services**			***Information* services**	***Carrier* services**						***Provision* services**			
Sub-services	Climate regulation	Disturbance prevention	Water regulation	Water supply	Soil retention	Soil formation	Nutrient regulation	Pollination	Refugium service	Nursery service	Science and education service	Habitation	Cultivation	Energy conversion	Mining	Waste disposal	Transportation	Food	Raw materials	Genetic resources	Medicinal resources
Biotope types in the Czech part																					
Forests	0	1	1	0	1	1	0	2	1	1	0	2	0	0	0	1	3	0	1	0	1
Discontinuous urban fabric	4	1	0	0	0	0	0	0	0	0	0	5	0	0	0	0	3	0	0	0	0
commercial and transport units	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3	0	0	0	0
commercial and transport units	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
non-agricultural vegetated areas	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Fruit trees and berry plantations	0	2	3	2	3	3	2	3	1	0	0	0	5	0	0	0	0	1	1	0	0
Land principally occupied by agriculture	0	0	2	0	0	2	1	0	1	0	0	0	4	0	0	0	0	0	0	0	0
Agro-forestry areas	3	2	3	2	4	3	3	1	2	0	0	0	5	0	0	0	0	1	5	0	0
Natural grasslands	0	3	3	2	2	3	2	2	2	2	1	0	0	0	0	0	0	1	0	1	3
Transitional woodland-shrub	3	4	5	3	5	5	5	2	4	1	2	0	0	0	0	0	0	2	3	0	2

Bare rocks	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Water courses	4	3	4	5	0	0	1	0	3	2	1	0	0	0	0	0	0	3	0	0	0
Water bodies	5	4	5	5	0	0	4	1	3	4	2	0	3	0	0	0	0	3	0	1	0
Biotope types German part																					
Residential and mixed used areas	3	2	0	0	1	0	0	1	1	2	0	5	0	0	0	0	3	0	1	0	1
Dam	0	3	0	5	0	0	0	0	0	0	0	0	0	5	0	1	3	0	0	0	0
Dam in and along river courses	0	3	0	5	0	0	0	0	0	0	0	0	0	5	0	1	3	0	0	0	0
Industrial or commercial units	0	1	1	0	1	1	0	2	1	1	0	2	0	0	0	1	3	0	1	0	1
Agricultural business location	0	1	1	0	1	1	0	2	1	1	0	2	0	0	0	1	3	0	1	0	1
Other driveways	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Other roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Rural and agricultural roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Main road	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Railway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Excavation site	3	2	1	0	1	0	0	1	2	1	1	0	0	0	5	0	0	0	0	0	0
Dump sites	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Construction and dump sites	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Areas with vegetation within urban fabric	2	4	3	3	4	4	2	4	3	2	3	0	0	0	0	0	0	1	1	0	2
Sport and leisure facilities	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Arable land	0	0	2	0	0	2	1	0	1	0	0	0	4	0	0	0	0	0	0	0	0
Fruit tree meadows	1	3	4	3	4	4	3	5	4	3	1	0	3	0	0	0	0	1	2	4	2
Fruit tree alley	0	3	3	2	4	4	2	4	3	3	0	0	0	0	0	0	0	5	1	3	0
Row of fruit trees	0	3	3	2	4	4	2	4	3	3	0	0	0	0	0	0	0	5	1	3	0
Row of poplar trees	0	2	2	1	4	4	1	2	2	3	0	0	0	0	0	0	0	0	1	0	0
Old trees along field margins	3	4	4	3	5	4	4	3	3	3	0	0	0	0	0	0	0	2	2	1	1
Row of trees along rivers and streams	3	4	4	4	5	5	5	2	4	3	3	0	0	0	0	0	0	2	4	2	2
Row of trees	0	3	3	2	4	4	2	2	3	3	0	0	0	0	0	0	0	0	1	0	0
Row of broad leafed trees (one species)	0	2	2	1	4	4	1	2	2	3	0	0	0	0	0	0	0	0	1	0	0
row of coniferous trees (one species)	0	3	3	2	4	4	2	1	3	2	0	0	0	0	0	0	0	0	1	0	0
Vegetation along rivers and streams	0	2	3	2	4	4	3	2	2	2	0	0	0	0	0	0	0	1	0	0	1
Trees along rivers and streams	3	4	4	4	5	5	5	2	4	3	3	0	0	0	0	0	0	2	4	2	2
Pollarded trees	0	2	2	1	4	4	1	2	2	3	0	0	0	0	0	0	0	0	1	0	0
Hedgerow in or along agricultural fields	2	3	3	2	5	4	4	3	3	3	0	0	0	0	0	0	0	2	2	1	1
Hedgerow along stone ridges	2	3	3	2	5	4	4	3	3	3	0	0	0	0	0	0	0	2	2	1	1
Row of broad leafed trees (several species)	0	2	2	1	4	4	1	2	2	3	0	0	0	0	0	0	0	0	1	0	0
Row of coniferous trees (several species)	0	3	3	2	4	4	2	1	3	2	0	0	0	0	0	0	0	0	1	0	0
Row of broad leafed and coniferous trees	0	3	3	2	4	4	2	2	3	3	0	0	0	0	0	0	0	0	1	0	0
Other hedgerows	2	3	3	2	5	4	4	3	3	3	0	0	0	0	0	0	0	2	2	1	1

Perennial and ruderal herbs/ dry to fresh	0	1	3	2	3	4	2	2	2	2	0	0	0	0	0	0	0	2	0	0	2
Moist forest	5	5	5	4	4	5	5	2	5	5	3	0	0	0	0	0	0	2	2	0	2
Shrubbery	3	3	4	2	5	4	4	3	3	2	0	0	0	0	0	0	0	2	3	0	1
Afforestation	5	3	3	2	4	4	3	1	2	1	0	0	4	0	0	0	0	1	4	0	0
Broad-leaved and mixed forest	5	5	5	3	5	5	5	2	4	4	2	0	0	0	0	0	0	3	5	1	3
Mixed forest	5	4	4	3	4	4	4	1	3	3	0	0	4	0	0	0	0	2	5	0	0
Coniferous and mixed forest	5	4	4	3	4	4	4	1	3	3	0	0	4	0	0	0	0	2	5	0	0
Reafforestation	5	3	3	2	4	4	3	1	2	1	0	0	4	0	0	0	0	1	4	0	0
Humid grasslands	0	3	3	2	2	3	2	2	2	2	1	0	0	0	0	0	0	1	0	1	3
Dry grasslands	0	3	3	2	2	3	2	2	2	2	1	0	0	0	0	0	0	1	0	1	3
Dwarf shrub heath lands and bristle grass lawns	0	2	3	2	3	4	3	2	4	2	1	0	0	0	0	0	0	1	0	0	1
Stepped forest edge	3	4	4	3	5	4	4	3	3	3	0	0	0	0	0	0	0	2	2	1	1
Forest edges and pioneer forests	3	4	5	3	5	5	5	2	4	1	2	0	0	0	0	0	0	2	3	0	2
Bare rock and scree slopes	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Large stone ridges	0	2	2	1	2	3	1	2	2	1	0	0	0	0	0	0	0	1	0	0	3
Stone ridges	0	2	2	1	2	3	1	2	2	1	0	0	0	0	0	0	0	1	0	0	3
Sparely vegetated areas	0	2	2	1	2	3	1	2	2	1	0	0	0	0	0	0	0	1	0	0	3
Bogs and swamps	3	5	5	5	3	5	5	1	5	3	3	0	0	0	0	0	0	2	4	0	3
Source areas, creeks, small ponds	0	1	4	5	1	3	2	1	4	1	2	0	0	0	0	0	0	0	0	0	0
Creeks	4	2	1	5	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Rivers	4	3	4	5	0	0	3	1	3	2	1	0	0	0	0	0	4	3	0	0	0
Channels and ditches	3	4	2	4	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Ponds, artificial reservoirs	5	3	3	5	0	0	0	1	1	4	0	0	4	0	0	0	0	1	0	0	0

2.4.3.1.1 Results

The maps (Figure 109, Figure 110, Figure 111, Figure 112 and Figure 113) illustrate the distribution of the different main services (*Regulation*, *Habitat*, *Provision*, *Information* and *Carrier*) in the investigation area.

The highest functionality occurs within the *Regulation* service mainly in the Czech part of the investigation area especially where the percentage of broad-leaved and mixed forest is high (see Figure 104). The lowest value for the *Regulation* service is in the areas where the settlements and the agricultural fields are located, which is mostly in the north- and south-western area of the German part.

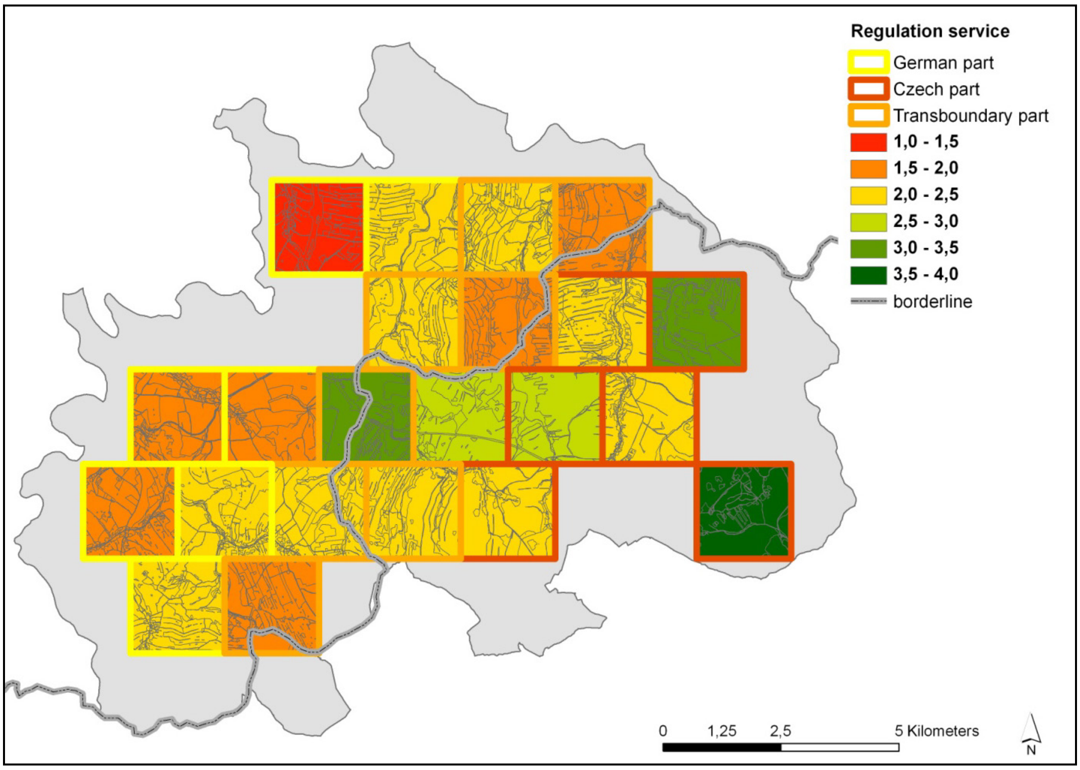


Figure 109: *Regulation* service of all 22 cells in the investigation area Erzgebirge and Sandstone mountains border region (*Regulation* service categories: 0 = low functionality to 5 = high functionality)

The *Habitat* service reaches the highest results in the north-eastern parts of the Czech part of the investigation area (Figure 110). The lowest value occurs in the north-western part on the German side.

The *Provision* service is again higher on the Czech side than it is on the German side (Figure 111).

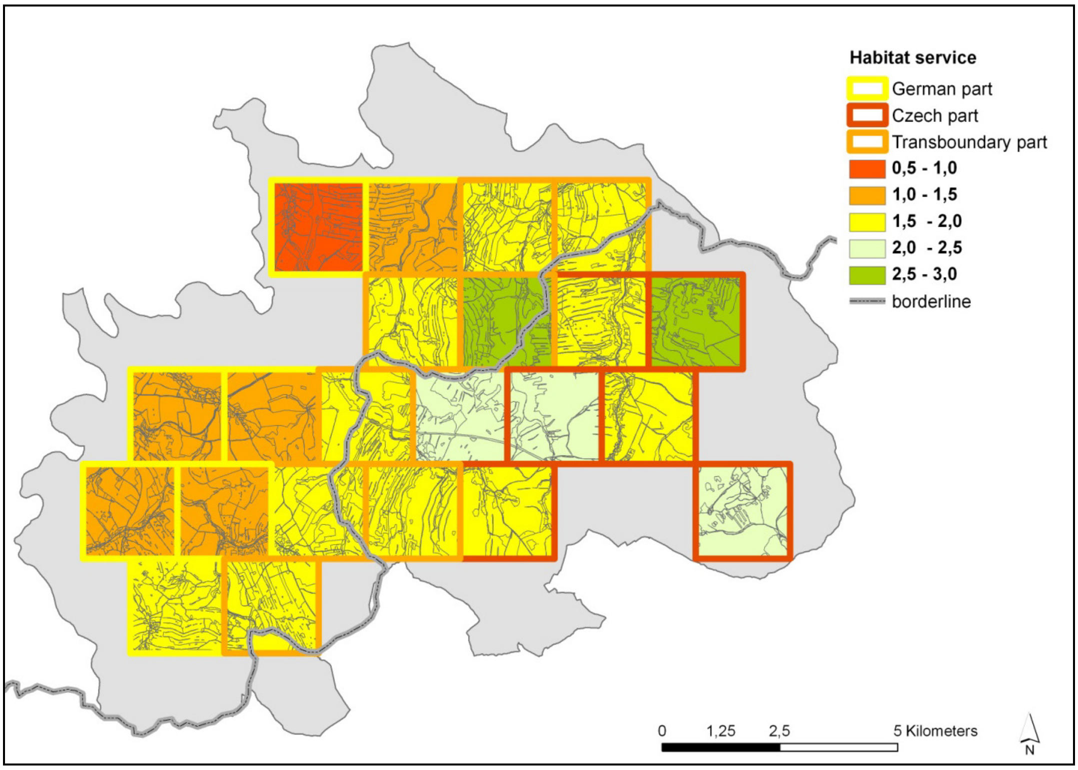


Figure 110: ***Habitat*** **service of all 22 cells in the investigation area Erzgebirge and Sandstone mountain border region (*Habitat* service categories: 0 = low functionality to 5 = high functionality)**

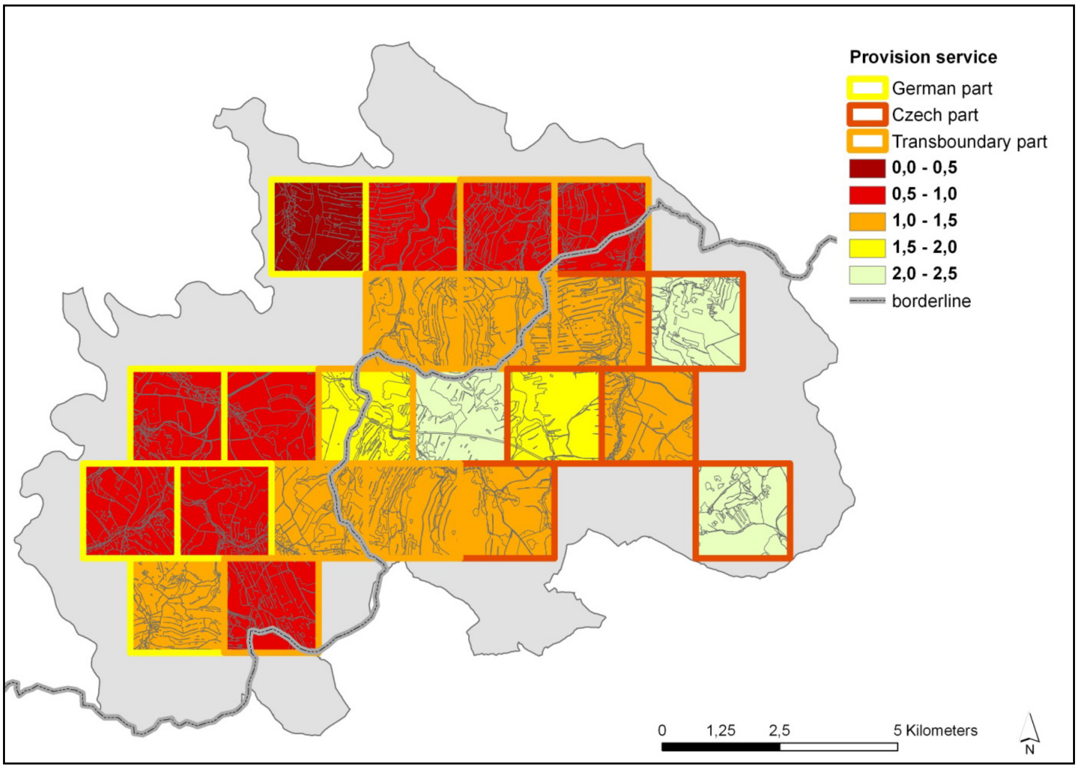


Figure 111: ***Provision*** **service of all 22 cells in the investigation area Erzgebirge and Sandstone mountains border region (*Provision* service categories: 0 = low functionality to 5 = high functionality)**

Overall, the *Information* service is low in the whole investigation area (Figure 112). It is based only on one sub- service, the 'science and education' service. Again the German part shows lower values than does the Czech part.

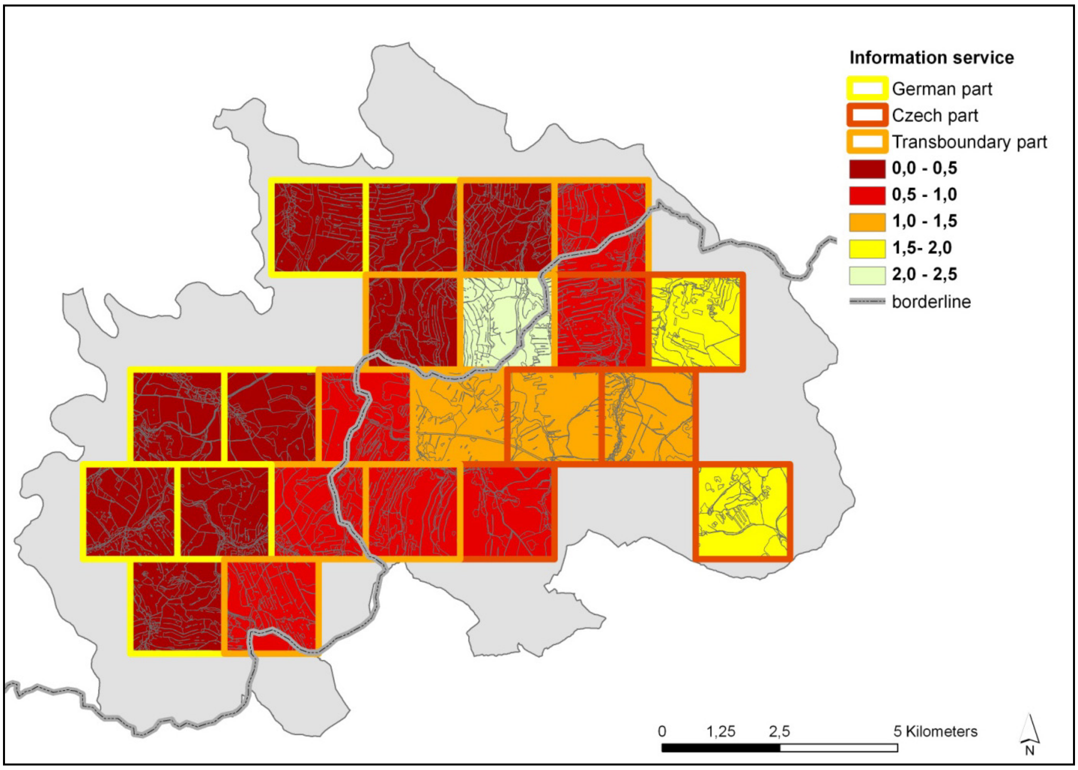


Figure 112: *Information* service of all 22 cells in the investigation area Erzgebirge and Sandstone mountains border region (*Information* service categories: 0 = low functionality to 5 = high functionality)

For the whole investigation area the *Carrier* service shows the lowest values (Figure 113). But the German part has in some areas higher values than does the Czech part.

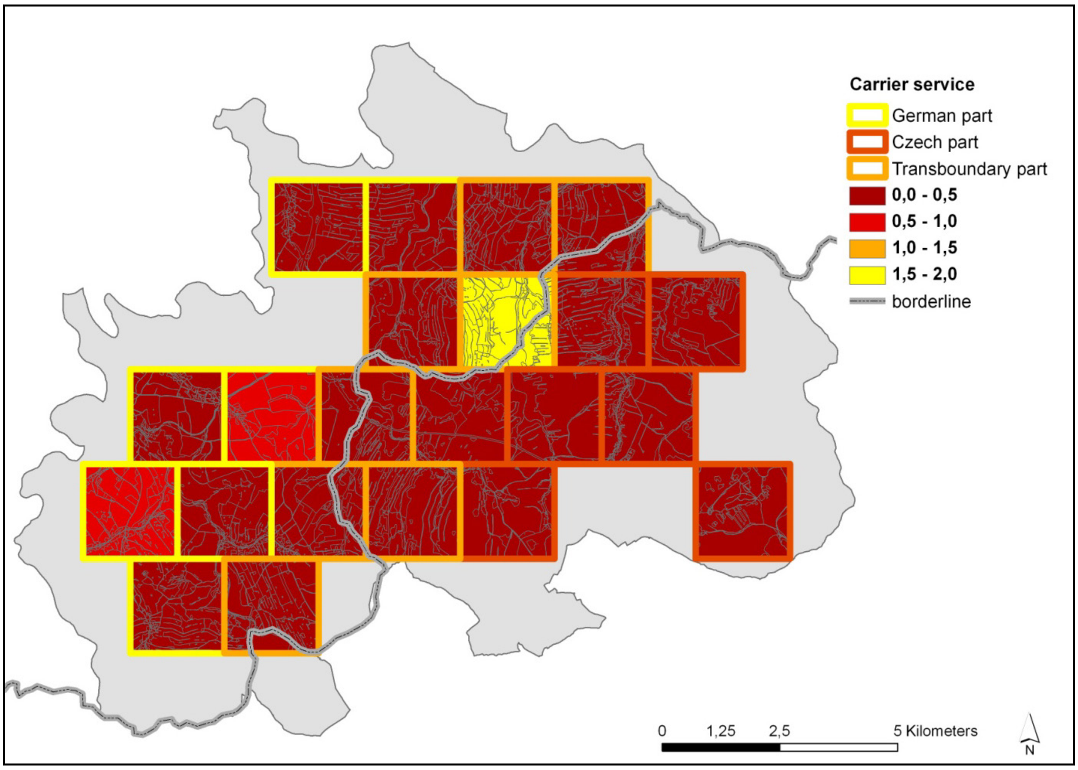


Figure 113: *Carrier* service of all 22 cells in the investigation area Erzgebirge and Sandstone mountains border region (*Carrier* service categories: 0 = low functionality to 5 = high functionality)

In the transboundary part the results of the functionality analysis, using the landscape service approach, are different from the results in the German and Czech part alone (Figure 114, Figure 115, Figure 116 and Figure 117). Overall, the Czech part shows higher functionality in nearly all mean services except for the *Carrier* service.

The land use of the German and Czech part differs substantially (see Figure 104). The land use in the German part is a mixture of areas with natural grassland agricultural use and mixed forests, artifical surfaces have a very low percentage. The Czech part is dominated by forests (broad leaved forest and mixed forest) as well as transitional woodland shrubs and natural grassland. The percentage of arable land is negligible as is the percentage of artificial surfaces. Land use in the transboundary part is dominated by natural grassland, mixed forest and arable land. Since the functionality analysis mainly depends on the land use the results of the functionality analysis differ as well.

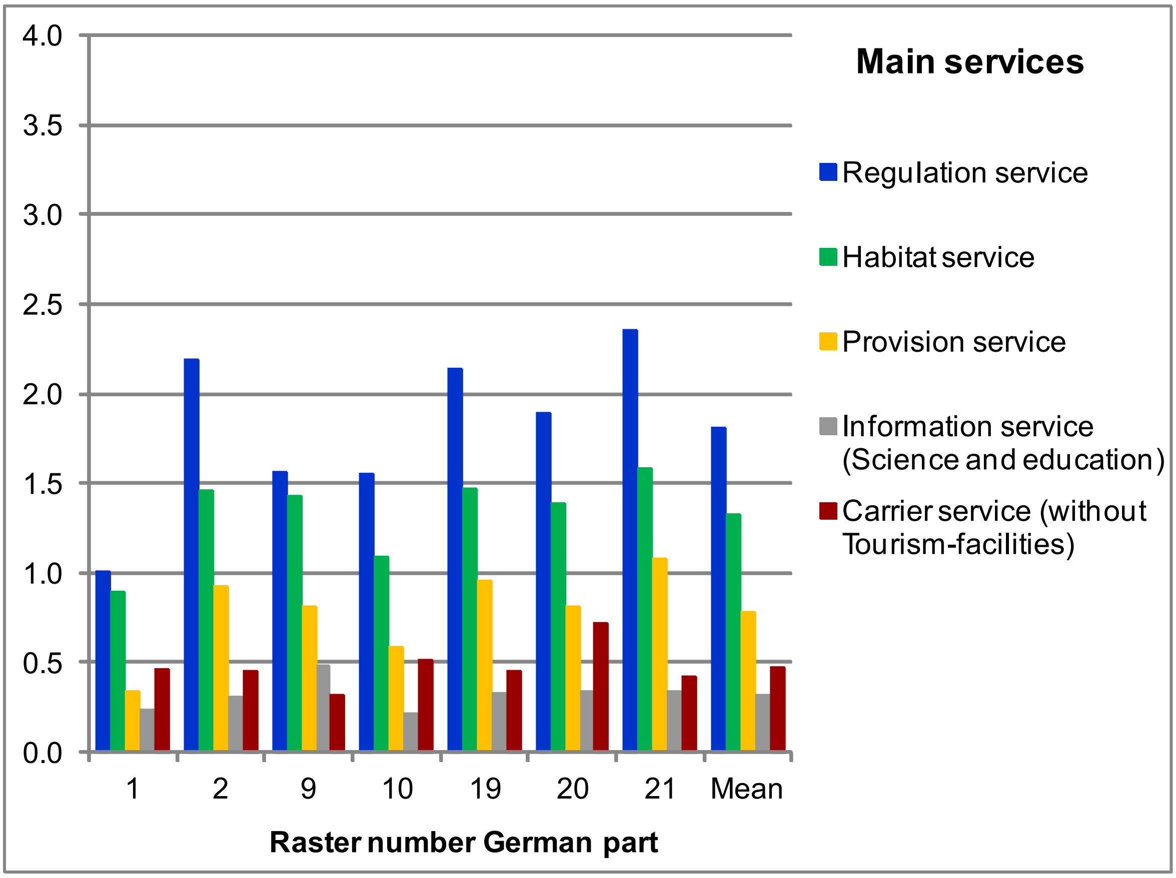


Figure 114: Distribution of the main services in the German part

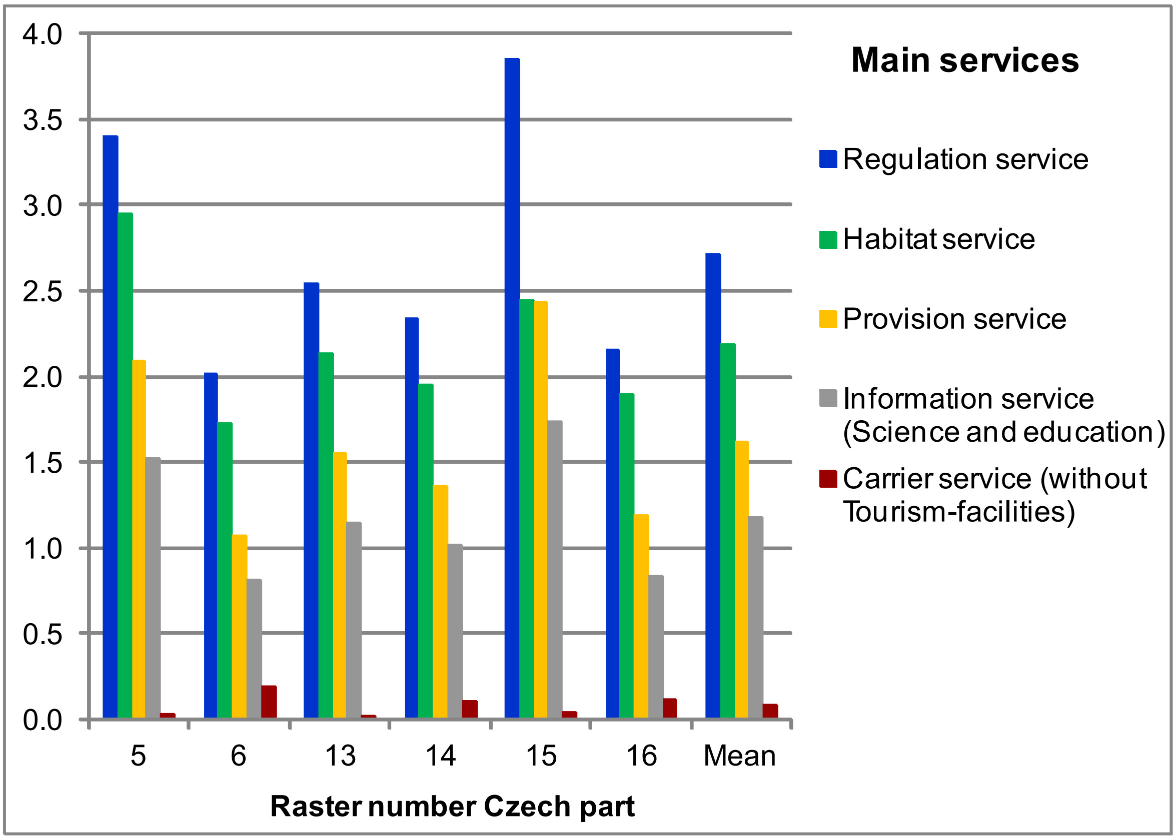


Figure 115: Distribution of the main services in the Czech part

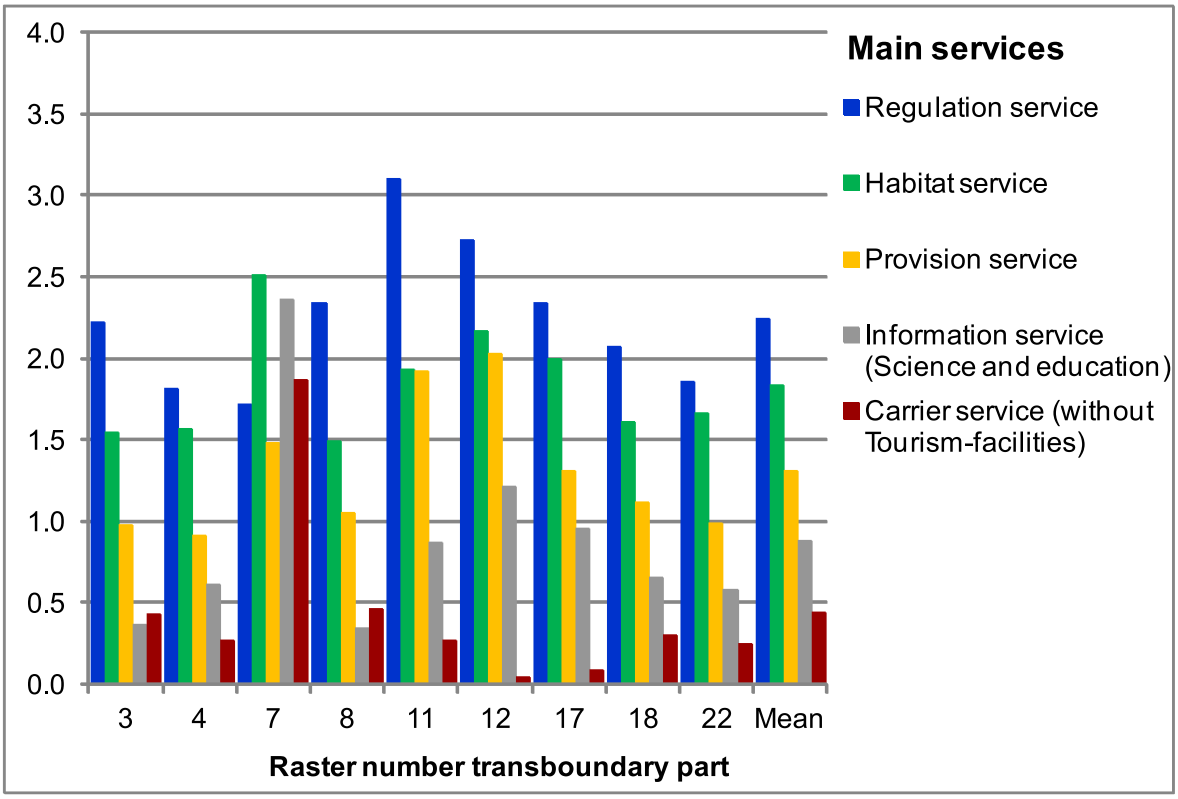


Figure 116: Distribution of the main services in the transboundary part

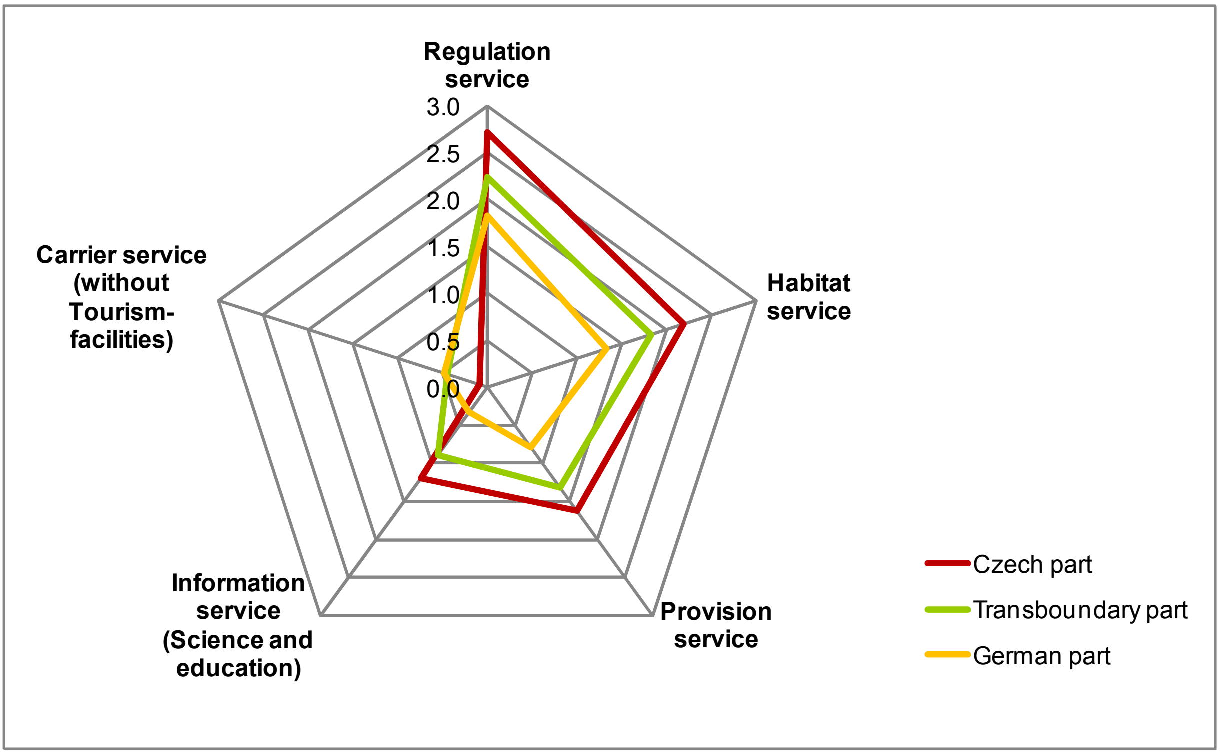


Figure 117: Overview of all services (mean) for the whole investigation area

3 Catalogue of planning measures

Action 5.5.2

CATALOGUE OF PLANNING MEASURES FOR THE PROJECT REGION CENTRAL SOUTH

Authors:

Anna Hermann, Michael Kuttner, Christa Hainz-Renetzeder, Sonja Völler, Thomas Wrbka, Tamara Zhuber, Katharina Zmelik (authors are listed alphabetically)

PP05 – Dept. of Conservation Biology, Landscape- and Vegetation Ecology, University of Vienna, Vienna, Austria

With contributions of:

PP09 - Institute of Forest resource Management and Rural Development, The University of West Hungary, Sopron/Hungary

3.1 Introduction

This catalogue of planning measures bases on the general guidelines of a strategy and action plan for sustainable management of ecological networks analysed in Action 5.4.3. Since the establishment of ecological networks presents a substantial contribution to the conservation of biodiversity the following principles concerning the structure of the planning process seem likely to apply: (i) Getting organized, (ii) Status review and assessment, (iii) Strategy and action plan, (iii) Implementation, (iiii) Monitoring system and (iiiii) Reporting. Implementing these rules it was possible to develop guidelines for the setup of an action plan tailored to the needs of transnational ecological networks (Figure 118, for detailed information see Action 5.4.3).

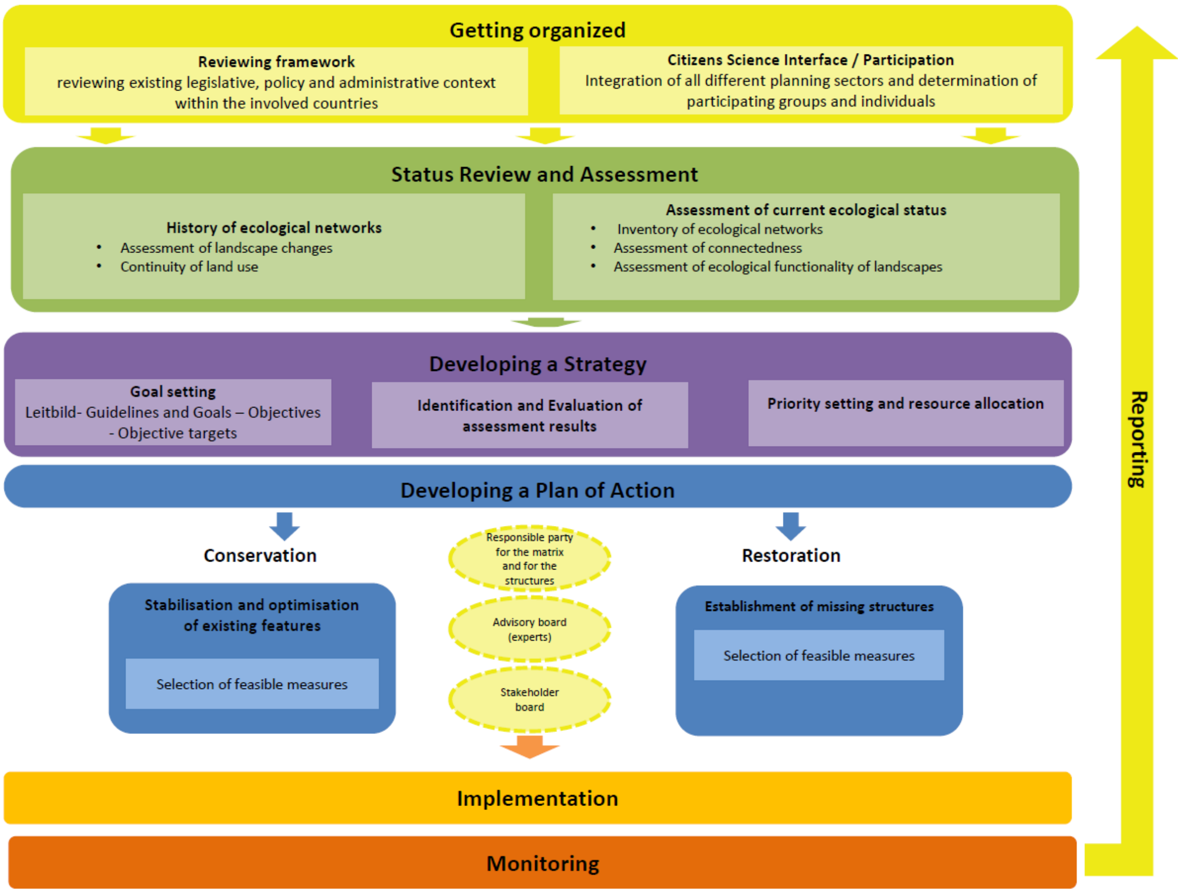


Figure 118: Set-up of an action plan for sustainable management in transnational ecological networks (source: Action 5.4.3)

The idea of the present report is to apply the action plan to the case study Biosphere Reserve Neusiedler See. Biosphere Reserves (BR) are initiated within the UNESCO's Man and the Biosphere (MAB) Programme and should nowadays follow the Seville strategy drawn up in 1995. This framework includes basic ecological and socio-economic assessments for zoning and defining conservation, reinforce scientific research and initiate development tasks. Biosphere Reserves following the Seville strategy are aiming at fulfilling the needs of human beings as well as nature by involving all interest groups and contributing to conservation, sustainable development and scientific understanding. Due to this bottom-up and integrating approach Biosphere Reserves offer promising possibilities for research on ecosystem functions and services. Founded in 1977 the current Austrian BR Neusiedler See consists only of a core zone and mainly covers the reed belt and the lake Neusiedl. This rather restrictive designation is excluding large tracts of land with smaller remnants of natural and semi-natural habitats interspersed with the surrounding agricultural landscape matrix. According to Jungmeier & Zollner (2005) especially within the criteria *zonation*, *administrative structure* and *conceptual framework* the actual BR is not meeting the demands of the Seville strategy. So for preventing the withdrawal of the label a redesigning of the BR is inevitable. Due to the fact that the BR lies inside the Project region Central South a redesigning offers the possibility to apply the concept of ecosystem services and the structural action plan above to a concrete case study and provide a catalogue of planning measures. Results can be implemented into regional and local landscape planning processes.

3.2 Catalogue of planning measures for BR Neusiedler See

The detailed action plan shown in **Figure 119** provides a catalogue of planning measures for sustainable implementation and management of ecological networks and nature conservation projects on the basis of the case study BR Neusiedler See. Referring to PP05's expertise and defined work packages our approach focuses on the comprehensive part "*Status Review and Assessment*" while taking also related process steps into considerations.

- *Getting organized* (Box 1)

On the one hand this action consists of the "*legal and administrative frameworks and policies"* for which a short review for the BR is given. On the other hand it contains the important step of citizen participation which includes the integration of all different planning sectors and determination of participating groups and institutions. This process of "*Citizen Science Interface /Participation*" is also integrated in further actions of the catalogue.

- *Status Review and Assessment* (Box 2)

Basing on approaches of work packages 3, 4, 5 and 6 a comprehensive review of history and actual status of ecological networks in the investigation area can be given, including inventory of ecological networks, ecological functionality and landscape changes. Future sustainable development will be analysed in Action 5.5.3 by the assessment of a sustainable Leitbild. By applying an adapted concept of ecosystem services and implementing local stakeholders a detailed structural framework of planning measures for the case study BR Neusiedler See will be generated.

- *Citizens Science Interface / Participation* (Box 3)

This important process should be integrated at different levels of the action plan (see **Figure 119**). In our approach it consisted of public communication tools (Information meeting, International Conference, folder), a stakeholder workshop and continuing communication with decision makers of the authorities of the federal province Burgenland and spatial planning authorities.

Summing up a list of recommendations for BR Neusiedler See resulting from Action 5.5.3 is given and integrated into the action plan (see Box 4).

Case study Biosphere Reserve Neusiedler See

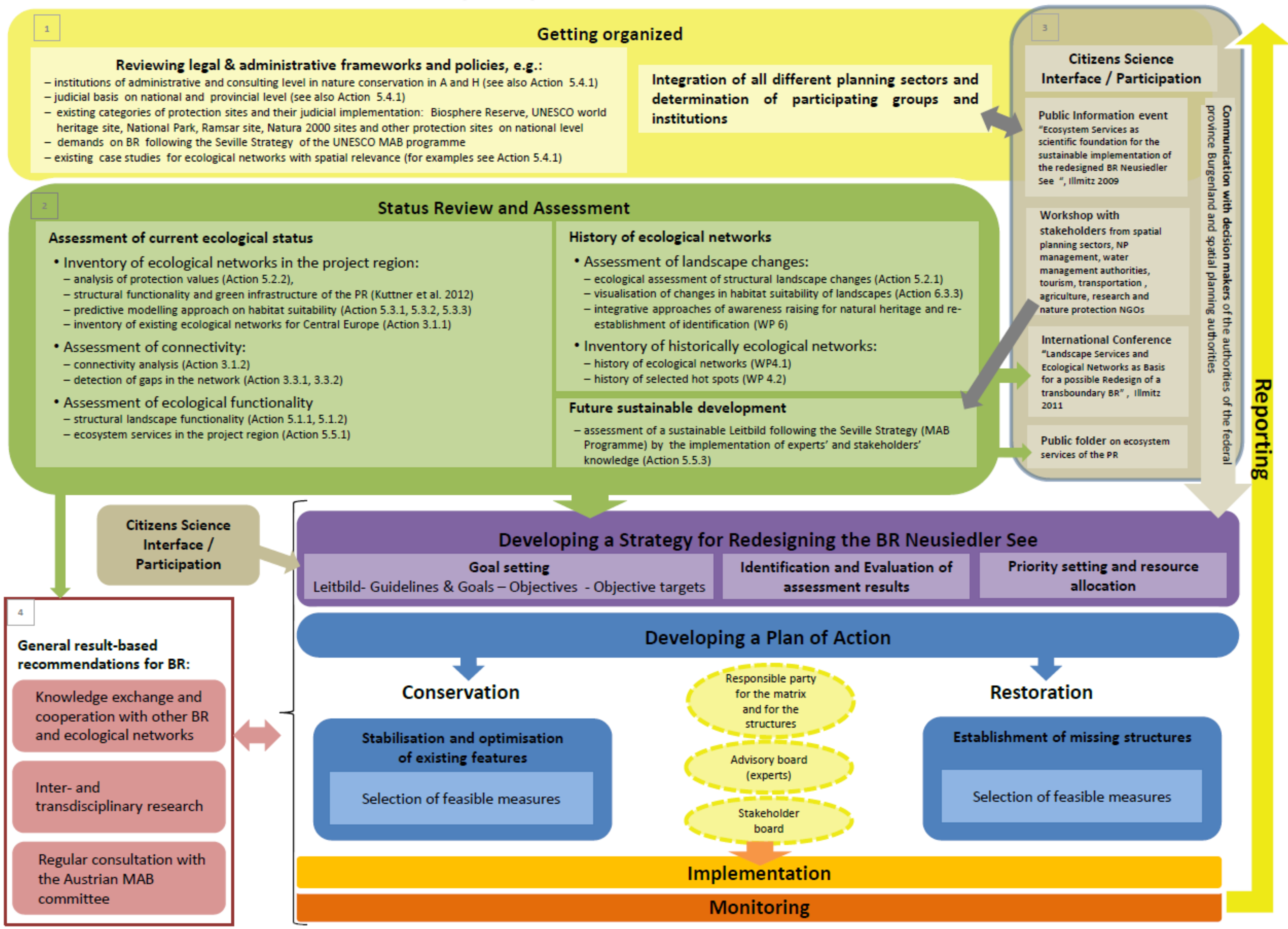


Figure 119: Catalogue of planning measures for case study Biosphere Reserve Neusiedler See (for abbreviations see next page)

Ad Figure 2 / abbreviations:

PR…Project region
BR…Biosphere Reserve
A…..Austria
H…..Hungary

4 Structural framework of planning measures

Action 5.5.3

STRUCTURAL FRAMEWORK OF PLANNING MEASURES FOR THE PROJECT REGION CENTRAL SOUTH

Authors:

Anna Hermann, Michael Kuttner, Christa Hainz-Renetzeder, Thomas Wrbka, Tamara Zhuber, Katharina Zmelik (authors are listed alphabetically)

PP05 – Dept. of Conservation Biology, Landscape- and Vegetation Ecology, University of Vienna, Vienna, Austria

With contributions of:

PP09 - Institute of Forest resource Management and Rural Development, The University of West Hungary, Sopron/Hungary

University of Natural Resources and Life Sciences, Vienna, Department of Landscape, Spatial and Infrastructure Sciences, Institute of Landscape Development, Recreation and Conservation Planning

4.1 Abstract: Structural framework of planning measures

Introduction: The establishment of ecological networks preserving biodiversity and cultural heritage across borders requires appropriate instruments in landscape planning. The concept of ecosystem functions and services basing on the Millennium Ecosystem Assessment (2003) and de Groot (2006) lends itself to a promising tool in frameworks for landscape planning and providing basis for necessary conditions in establishing ecological networks. Ecological connectivity is based to a large extent on a widespread network of conservation areas of all kinds of protection categories and different emphases. Biosphere Reserves following the Seville Strategy of the UNESCO's Man and the Biosphere (MAB) Programme are aiming to fulfil the needs of human beings as well as nature by involving all interest groups and contributing to conservation, sustainable development and scientific understanding. Due to this bottom-up and integrating approach Biosphere Reserves offer promising possibilities for research on ecosystem functions and services.

Objectives: The main objective of this action is the creation of a structural framework of planning measures for the case study Biosphere Reserve "Neusiedler See" by applying an adapted concept of ecosystem services and integrating local stakeholders. In detail, analyses are aiming at the identification, measuring and communication of the ecological and socio-cultural values of the region for the implementation of a redesigned Biosphere Reserve following Seville standards.

Methods: The investigation area consisting of the current Biosphere Reserve "Neusiedler See" and its surrounding landscapes is situated on both sides of the border of Hungary and Austria and is part of the Small Hungarian Plain in Central Europe representing the westernmost extension of the Pannonian Basin. The process of integrating the concept of ecosystem services into landscape planning is based on a structural framework developed by the project partners. In former actions a set of landscape services has been developed, analysed, pooled into 5 main groups and extrapolated to different Landform Types within the wider investigation area to illustrate the actual state of service provision of the landscapes around Neusiedler See. Creating a Seville conform Leitbild for a redesigned Biosphere Reserve within the region had to be estimated by analysis and consulting local experts on landscape planning, nature conservation and tourism. Combined results on landscape services from expert's analyses and stakeholders input are displayed in spiderweb diagrams.

Results and Conclusions: According to the results of this study a redesign of the Biosphere Reserve "Neusiedler See" is possible and the existing BR provides a good basis on which the redesign could build upon. In detail, our results showed different potential and actual landscape services in the individual Landform Types. Therefore, we would recommend that especially in the Austrian part of the BR the umbrella and regional development function should be stressed more. Furthermore, the future BR should integrate parts of the region which are not in any protection category yet. Our analyses confirm that the concept of the Landscape functions and services can provide a detailed scientific basis for planning measures and therefore lends itself to be an appropriate instrument for landscape planning.

It can be said that this evaluation has been a first step of stakeholders' knowledge implementation into our structural framework for the BR „Neusiedler See" and also the first interaction concerning the issue of its ecosystem service provision between project partners and stakeholders. Therefore, points of criticism and experiences from the workshop should be integrated in further analyses concerning this issue.

4.2 Introduction

The establishment of ecological networks preserving biodiversity and cultural heritage across borders requires appropriate instruments in landscape planning. The concept of ecosystem functions and services (Millennium Ecosystem Assessment, 2003, de Groot et al., 2002; de Groot, 2006) lends itself to a promising tool for landscape planning and for a basis establishing ecological networks. Ecological connectivity is based on a large extent on a widespread network of conservation areas of all kinds of protection categories with different emphases. Biosphere Reserves following the Seville Strategy of the UNESCO's Man and the Biosphere (MAB) Programme are aiming at fulfilling the needs of human beings as well as nature by involving all interest groups and contributing to conservation, sustainable development and scientific understanding. Due to this integrated and bottom-up approach of Biosphere Reserves we chose the case study Biosphere Reserve “Neusiedler See” for our studies applying the concept of ecosystem services as a framework of landscape planning. The results are basis for recommendations concerning the process of sustainable enlargement/redesigning of the BR as an important building stone of ecological networks in the transboundary region of Hungary and Austria.

4.2.1 Problem identification

The whole Biosphere Reserve “Neusiedler See“ with a total area of 25 000 ha lies inside the investigation area Neusiedler See/Fertő. It was founded in 1977, three years after the concept of Biosphere Reserves was initiated by a Task Force of UNESCO's Man and the Biosphere (MAB) Programme in 1974. Currently the Biosphere Reserve covers only the lake basin, in particular the reed belt and the lake itself. This rather restrictive designation is excluding large tracts of land with smaller remnants of natural and semi-natural habitats interspersed with the surrounding agricultural landscape matrix. The small-scale cultural landscape types situated at the western lakeshore are completely excluded. This delineation is reflecting the ideas of the MAB-programme in the concept of the 1970s. But it is not congruent with the criteria of the Seville Strategy as outlined in 1995. Many other Biosphere Reserves in the world encounter similar problems, so that the MAB committee decided to withdraw the label of Biosphere Reserve by 2013 if a re-implementation will not have been applied for.

While the objective for achieving a sustainable balance between the sometimes conflicting goals of Biosphere Reserves is still the same, the context in which Biosphere Reserves operate has changed considerably. In 1991 the Convention on Biological Diversity has led to establish an Advisory Committee for Biosphere Reserves. This Advisory Board developed a strategy for a modern kind of Biosphere Reserves and drew up the so called “Seville Strategy”. This broaden strategy tries to contribute to those changed frameworks. This means to include basic ecological and socio-economic assessments for zoning and defining conservation, reinforce scientific research and initiate development tasks (UNESCO, 1996).

Besides the foundation of the Biosphere Reserve “Neusiedler See” in 1977, substantial progress in conservation efforts has been achieved by the designation of a RAMSAR site in 1982 and the successful establishment of Austria’s first national park in 1992. Both conservation areas are much larger than the Biosphere Reserve and complementing each other in area and management objectives. In addition, a large area of the whole region – including the western lakeshore and its surroundings – has been officially listed by UNESCO as world heritage site for cultural landscape in 2001.

Preventing the withdraw of the label Biosphere Reserve and following previous considerations a Seville conform redesigning of the actual Biosphere Reserve “Neusiedler See” is necessary and inevitable.

One possibility to provide the knowledge basis to meet the needs of the Seville Strategy can be the concept of ecosystem functions, goods and services. This scientific concept has experienced increasing attention in the last years as it provides the means of documenting the importance and benefits of ecosystems and landscape for human society. One of the most relevant publications is the Millennium Ecosystem Assessment (2003) which provides the basic framework for assessing the interactions between ecosystems and humans, how these can be measured, evaluated and strengthened for future human well-being.

In our project the classification of landscape services is mainly based on de Groot (2006) and has been adapted to our research issues, see previous studies on the assessment of landscape services (Action 5.5.1). In this present action the project team PP05 made use of and developed this approach in a way to display possibilities for a redesigned Biosphere Reserve in the region of Neusiedler See in trade-offs with local people and other stakeholders and to provide a structural framework for planning measures and nature conservation issues.

4.2.2 Research questions

The overall research objective of the present study is the establishment of a structural framework of planning measures for the case study Biosphere Reserve “Neusiedler See“ by applying an adapted concept of ecosystem services. In detail, analyses are aiming at the identification, measuring and communication of the ecological and socio-cultural values of the region for the implementation of a redesigned Biosphere Reserve following Seville standards.

To allow a thorough function-analysis, data on landscape, land use and regional socio-economic data were used to answer the following research questions linked to the described background:

- → In which way is it necessary to adapt the basic concept of ecosystem functions, goods and services for acknowledging the bio-physical and socio-economic situation of the Neusiedler See/Fertő region?
- → What are the potential landscape services of the Neusiedler See region following the Seville Strategy and how do they differ from the actual ones?
- → To what extent is it possible to communicate the applicability of landscape functions and ecosystem services to the residents and stakeholders of the Neusiedler See region in order to promote a sustainable development in the region and to have a bottom up-support during development?
- → How can the expected benefit of a new generation Biosphere Reserve for natural and cultural values of the region be measured and communicated in order to facilitate the implementation-process of a redesigned Biosphere Reserve?
- → How can the redesigned Biosphere Reserve “Neusiedler See” become part of an international network of Biosphere Reserves, where are potential partners and what would be the issues for specific co-operation and exchange programmes?
- → How can results be outlined to general recommendations for Biosphere Reserves and for instruments of landscape planning

4.3 Material and Methods

4.3.1 UNESCO's Man and the Biosphere Programme: description of Seville strategy

The Seville Strategy for BR has transformed the original focus of BR as areas for research on ecosystems, monitoring and environmental conservation (Man and Biosphere Programme). During the 1970ies and 1980ies several national parks were recognized as BR. The second World Congress of BR held in Seville 1995 defined a set of (new) objectives and procedures governing the recognition of potential BR: Seville Strategy and the International Guidelines. According to the Seville Strategy BR are terrestrial or coastal/marine ecosystems which are internationally recognized and integrated into the framework of UNESCO's Man and the Biosphere Programme and the Network of Biosphere Reserves. Each BR is intended to fulfil three complementary functions: a conservation function, a development function and a logistic support function. It consists of three different zones with different aims of protection and impact of uses:

- Core area: for conservation, monitoring and non-destructive research
- Buffer zone surrounding or adjoining core area(s): for activities compatible with sound ecological practices
- Transition area: for activities where stakeholders work together to sustainably manage the area's resources (UNESCO – MAB Secretariat, 2010)

Based on the past experience in implementing the innovative concept of BR and the emphases to the three functions a couple of key directions were identified. Among others it is emphasized, that all zones of BR contribute to conservation, sustainable development and scientific understanding. The human dimensions get more importance. The management should be open, evolving and adaptive and bring together all interested groups and sectors in a partnership approach. Biosphere Reserves should be used to further our understanding of humanity's relationship with the natural world. "In sum, BR should preserve and generate natural and cultural values, through management that is scientifically correct, culturally creative and operationally sustainable." (UNESCO, 1996, p. 3-4).

4.3.2 Seville conform Leitbild creation

A set of 19 single landscape sub-services were defined, assessed, pooled into 5 main groups (*Provision, Regulation, Habitat, Carrier* and *Information* services) and finally extrapolated to the seven Landform Types within the investigation area of the project region Central South in order to illustrate the **actual state** of service provision of the different landscapes around Neusiedler See (see chapter 2.2). To create a Seville conform Leitbild the **potential** service fulfilment along a required zoning for a redesigned BR had to be assessed by analyses and by consulting local experts on landscape planning, nature conservation and tourism.

The Seville strategy determines that within the Biosphere Reserve´s **core zone** nature protection has priority. To predict the optimal supply of *Provision, Regulation* and *Habitat* services within the core zone potential landscape services previously derived from the project BIOSERV (Wrbka et al., 2012) have been taken as a proxy. In the course of this project maps of the potential vegetation types within the investigation area were identified by merging a list of potential vegetation types (based on Bohn et al., 2002/2003 and Niklfeld 1970/1989), their specific site conditions and spatial geodata on soil, geology and elevation of the region. In further analyses the new constructed vegetation types were linked by expert knowledge about the different types´ capacities to provide various landscape services. For receiving the final potential landscape service values, we calculated the area-weighted mean of the vegetation type values within each Landform. Finally the mean value of the sub-services within each main service was taken in order to plot the main potential services *Provision, Regulation* and *Habitat* onto a 3-axes spider web diagram. The remaining *Carrier* and *Information* service values could be estimated by referring to the respects of the Seville-criteria. They were set to “0” concerning the *Carrier* service and “2.5” concerning the *Information* service for all Landform Types (LFT´s), after consulting the Seville-criteria handbook (UNESCO 1996) and internal discussions.

In terms of potential Seville-conform service provision for the **buffer** and **transition zones** values for *Habitat, Regulation* and *Provision* services were again determined following the guidelines of the Seville-criteria and the actual state of service provision within the single LFT´s derived by analyses in action 5.5.1 (chapter 2.2). As specific values could be hardly defined, the values span a domain and therefore are visualized as blurred bands within the final spiderweb diagrams (see Figure 120) rather than concrete lines. As *Carrier* and *Information* services are strongly influenced by regional and local activities the potential service provision values for the buffer and transition zones had to be assessed with consultation of regional planning authorities and stakeholders.

For this reason Seville conform goals differ between the single LFT´s and in this sense no general guidelines could be defined due to cultural and socioeconomic disparities within the LFT´s. To resolve this issue a regional expert meeting was organized at the 3rd of November 2011, involving regional stakeholders to jointly develop and discuss the potential target values, especially focussing on the *Carrier* and *Information* services for designated buffer and transition zones. Due to lack of time the evaluation was only carried out for the three most representative LFT´s of the investigation area: LFT 2 (Marshland and reclaimed marshland), LFT 4 (Low lying terrace) and LFT 7 (Hilly area and hill range).

Implementation of the stakeholders’ knowledge and demands

First of all, the participating stakeholders were briefed up on the general concept of ecosystem service evaluation and the particular method applied in the framework of TransEcoNet. Then a series of hand-outs, encompassing 5-axis spiderweb diagrams illustrating the actual state of ecosystem service provision and the potential Seville conform services of the environmental services throughout each Landform of interest to be discussed during the meeting were distributed to the experts (see Figure 120 and Figure 121). Within the spiderweb diagrams also predefined potential value ranges of *Habitat, Regulation* and *Provision* services were illustrated. Additionally, a table including target sub-services, framing the *Carrier* and the *Information* main service and associating rating schemes were supplied to the committee. The rating scheme contains five categories such as “substantial increase (+50%)”; “moderate increase (+25%)”; “stagnation (+/- 0%)”; “moderate decrease (-25%)” and “substantial decrease (-50%)”. With the help of this categorization the expert committee could estimate potential adaptation possibilities for designated sub-service provision within the LFT´s of interest.

In case of the *Carrier* main service, the actual service assessment was carried out on LCT-level first and then subtotals were extrapolated on LFT-level. The same was true for the stakeholder driven assessment of potential Seville conform service provision: First the stakeholders discussed about which of the proposed categories would either be desirable, appropriate and feasible for each service in each LCT targeting the two strata of transition and buffer zone. E.g. in ”LCT 1d” which has a 35% share of “LFT 2” experts plead for a moderate increase in “cultivation” within the transition zone and a stagnation of “cultivation” in the buffer zone. In some cases the stakeholders could not agree on one category, therefore intermediate values were assumed, for example 37.5% increase. This procedure was carried out for all *Carrier* sub-services and all LCTs within the LFTs of interest. Finally, potential main service values were calculated by summing up the proposed increased or decreased area weighted sub-service values. Consequently, the ratios between the Seville potential and actual service values were calculated. E.g., in LFT 2 the stakeholders opted for an up to 30%-increase of the

Carrier service if a transition zone would be established therein and for a 10% increase in a buffer zone.

The Seville potential *Information* main service could only be roughly estimated on the spatial level of the whole LFT´s, though the evaluation of the actual *Information* service has also been derived on LCT-level first and then extrapolated for the single LFT´s. This is due to the fact that the *Information* service consists of several sub services that either affects the target landscape on local up to regional level in different proportions.

Finally, the spiderweb diagrams expressing the landscape´s potential of possible transition and buffer zones were complemented by former missing values for *Information* and *Carrier* services gathered by the stakeholder implementation process.

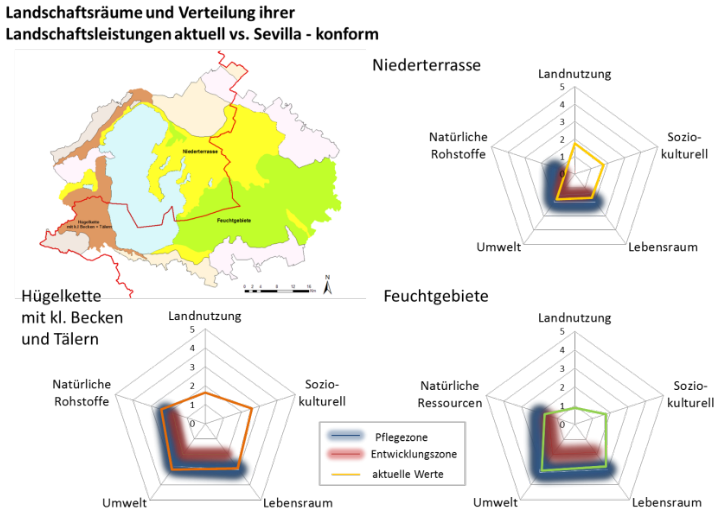


Figure 120: Handout for the stakeholders illustrating the actual landscape service provision as well as the Seville conform services for *the Habitat, Provision* and *Regulation* categories within the Landforms 'Low lying terrace', 'Hilly area and hill range' and 'Marshlands'.

Sevilla-konforme Einstufung der Landschaftsleistungen im Landschaftsraum **„Feuchtgebiete“**

Sozio-kulturelle Funktion

Teilfunktionen	Pflegezone	Entwicklungszone
Bebauungsgebiete		
Landwirtschaft		
Wind- und Kleinwasserkraftwerke		
Müllablagerungsplätze		
Verkehr (Straßen und Wegenetze)		
Tourismusinfrastruktur		

Bewertungsschema

+ +	• starke Zunahme
+	• mäßig Zunahme
~	• Gleichstand
-	• mäßig Abnahme
- -	• starke Abnahme

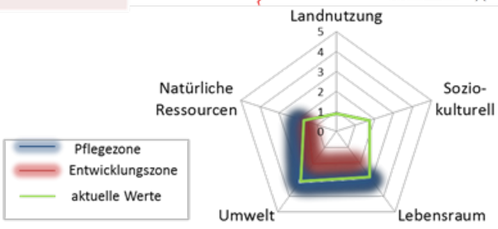


Figure 121: Form to be filled in during the stakeholder workshop in Rust focusing on the *Information* services

4.4 Results

In general, our analyses focused on the three most representative Landform Types (‘Marshlands’, ‘Low lying terraces’ and ‘Elevated terraces’) within the investigation area. All three Landforms can be found in Austria as well as in Hungary.

4.4.1 Actual services

Actual service provision (*Habitat, Regulation, Provision, Carrier* and *Information*) of the different Landforms within the investigation area have been displayed in detail in (see chapter 2.2). The Seville conform Leitbild creation (see chapter 4.3.2) is based on these results and differences between both can be detected.

4.4.2 Potential Seville conform services

4.4.2.1 Core area of the BR

Nature protection has priority in the core areas of BR. Therefore, values of the Seville conform provision of *Habitat, Regulation* and *Provision* services for this category are based on the potential natural vegetation types. Detailed analyses were carried out in the project BIOSERV (Wrbka et al., 2012) and are used as a basis for this approach (Figure 122).

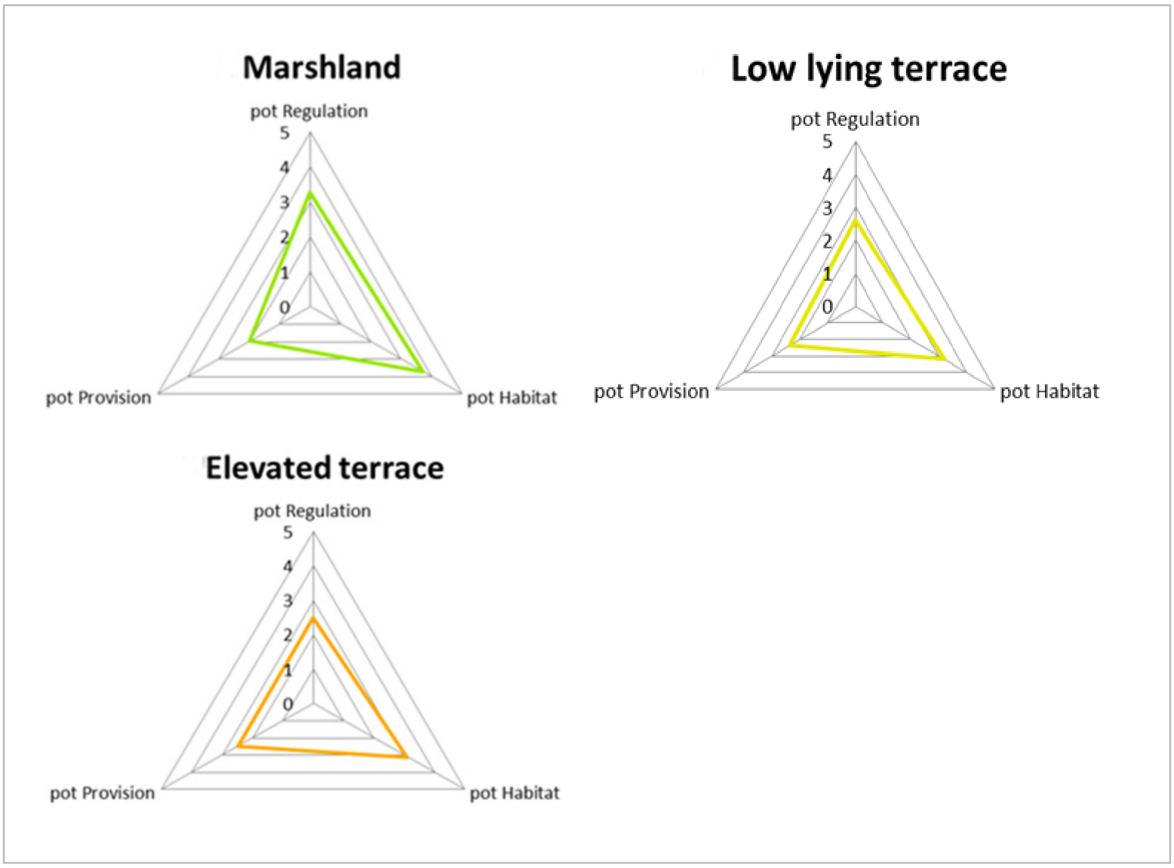


Figure 122: Spiderweb diagrams of the potential Seville-conform service provision of different Landforms for the BR zone category “core area”

4.4.2.2 Buffer and Transition zone of the BR

Values of the Seville-conform service provision concerning *Habitat, Regulation* and *Provision* services were defined by expert knowledge of the PP05. This process is based on previous results of the actual service provision of the BR (see Action 5.5.1, chapter 2.3) as well as on expert discussions. The results are displayed in the spiderweb diagrams (Figure 126, Figure 127 and Figure 128).

4.4.2.2.1 Stakeholder participation process: Information and Carrier Services

The following chapter gives an overview of the results of the participation process. During the expert workshop in Rust stakeholders from different sections (politics, tourism, nature protection,…) were asked to take part in the implementation process of an overall concept for a new BR "Neusiedler See".

Stakeholder Workshop for evaluation of landscape services in Rust

The workshop on the subject of "Ecosystem Services of the BR Neusiedler See" took place on November 3rd 2011 in Rust, Austria. Eleven experts from different disciplines and both countries participated in the workshop, which was held in German. Representatives from Hungary were able to speak German.

After an **official welcome** by the project team the experts were asked to introduce themselves (name and institution) and to name one word they associate with the term Biosphere Reserve. Most of the participants associated the term with 'nature protection', an 'unique natural and cultural landscape', 'birds' or 'development', but also terms like 'UNESCO', 'cooperation' or 'integrative' were mentioned.

In the **presentation part** of the workshop, basic knowledge on the endangerment of the natural and cultural landscape as well as the on the current situation of the Biosphere Reserve „Neusiedler See" was introduced by the project team. Moreover, the chances for the region in consequence of a new BR „Neusiedler See" were presented. In the second part of the presentation the current results of the TransEcoNet project were outlined.

In the "***World Café***" the stakeholders were asked to evaluate the related sub-services of the *Carrier* service and *Information* service with regard to the three different Landform Types: Marshland, 'Low lying terraces' and 'Elevated terraces'. The evaluation was based on a given evaluation scheme (Figure 123). These three Landforms were chosen because they are representative of the whole region and can be found in Austria as well as in Hungary. Because of the fact that nature protection has priority in the core area, this zone was not valued. The stakeholders were asked to evaluate the current situation of the region as well as the desired future Seville conform development.

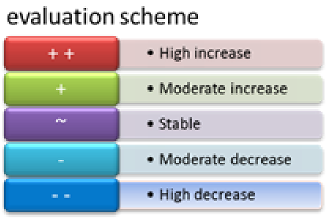


Figure 123: Evaluation Scheme, Stakeholder Workshop Rust

Discussion of the Seville conform sub-services of the *Carrier* service for 3 Landforms

Table 30: Evaluation results of the *Carrier* service concerning a Seville-conform development

Results –*Carrier* service						
	marshland		low lying terraces		elevated terrace	
Related sub-services	buffer zone	transition area	buffer zone	transition area	buffer zone	transition area
Habitation	~	+	~ / +	+ / ++	+ (1 for ~)	+ / ++
Cultivation	~ / -	+ (1 for ++)	~	+	+ (H ~)	+ (H ~)
Energy conversion	~ (H -)	~	~ (1 for -)	+ / ~	~	~
Waste disposal	~	+	~	~ / +[1] (H +)	~	+
Transportation	~ (H +)	+ (H ++)	~	+	~	+
Tourism facilities	+	++	+	++	+	++

Notes:
H = Hungary

[1] lop / garden waste

The table above (

Table **30**) shows the results of the discussion on *Carrier* services for the Marshland, 'Low lying terraces' and Elevated terrace. According to the stakeholders the intensity of habitation in the Landform Marshland deserves the evaluation "moderate decrease (-)" for the buffer zone. The fact that a deconstruction of buildings is impossible prompted them to vote with "stable (~)". Concerning cultivation (agriculture) in the buffer zone of the Landform Marshland, experts argued that it makes a big difference whether, for example, one speaks of intensive or extensive agriculture. Intensive use would mean a moderate decrease, whereas an extensive use would cause abandonment or grazing. Further evaluation results show that stakeholders would desire a moderate economic development within a transition zone for all Landforms. Concerning 'waste disposal' within the transition zones of the three Landforms experts see a moderate increase, for example for lop or garden waste in the Landform 'Low lying terraces', which could cause a win-win situation for all. It was also said that 'energy conversion' stays more or less "stable" for all 3 Landforms because the number of wind generators could not be increased (because of UNESCO label "World Heritage") and, as things stand at present, there seems to be no possibility for a decrease. Discussing the subject 'transportation', the panellists agreed that it is necessary to differentiate between the situation in the Marshland of Austria and Hungary. In their opinion Hungarian infrastructure in the respective region is badly established and therefore needs to be strengthened. All experts recommended a development and improvement of the sub-service 'tourism facilities' for all 3 Landforms and both zones.

Discussion on the Seville conform sub-services of the *Information* service for 3 Landforms

Table 31: Evaluation results of the *Information* service concerning a Seville-conform development

Results – *Information* service						
	marshland		**low lying terraces**		**elevated terrace**	
related sub-services	**buffer zone**	**transition area**	**buffer zone**	**transition area**	**buffer zone**	**transition area**
Aesthetic information	++ (H +)	~ (1 for - / 1 for +)	++ (H ~)	+ (H ~)	+	+
Recreation	+	+	+	++	++	++
Cultural & artistic information	+ (1 for ++ / H ~)	+ (H ++)	+	+	+	+
Science & education	++	++	++	++	++	++

Notes: H = Hungary

Stakeholders generally recommend an increase of most *Information* sub-services for both BR zones in all 3 Landforms, with some exceptions concerning the Hungarian investigation area (Table 31). According to the panellists, disused or constantly uncultivated land could be a problematic factor for landscape aesthetics especially in ‘Low lying terraces’. For ‘recreation’ stakeholders see a high increase in both zones of the ‘Elevated terraces’ and in the transition area of ‘Low lying terraces’. For the Marshland they evaluated ‘recreation’ with “moderate increase (+)”, within the buffer zone as well as the transition area. A “moderate increase” was also seen for ‘cultural & artistic information’ for all 3 Landforms except for the Hungarian part of ‘Marshlands’. Concerning ‘science & education’ all experts agreed that there is need of transmitting knowledge about the importance of the habitat “Neusiedler See” which led them to evaluate it with “high increase (++)” for both zones.

Figure 124: Stakeholder workshop Rust

Figure 125: Stakeholder workshop Rust

4.4.2.2.2 Combined results of stakeholder participation and expert evaluation

The spider web diagrams below (Figure 126, Figure 127 and Figure 128) show the results of the World Café for the discussed Landforms including *Habitat, Regulation* and *Provision* services resulting from previous evaluations by expert knowledge, see chapter 4.2.2.1). The axes of the graphs represent the services provsion of the cultural landscape. The purple broken line shows the actual allocation of the different services represented in the Neusiedler See region (see output 5.5.1, chapter 2). The blue and red lines show the potential Seville conform landscape services based on experts' and stakeholders' evaluations. The ratings reflect the desired or imaginable development of the region in the fictitious buffer zone and transition area discussed in the World Café.

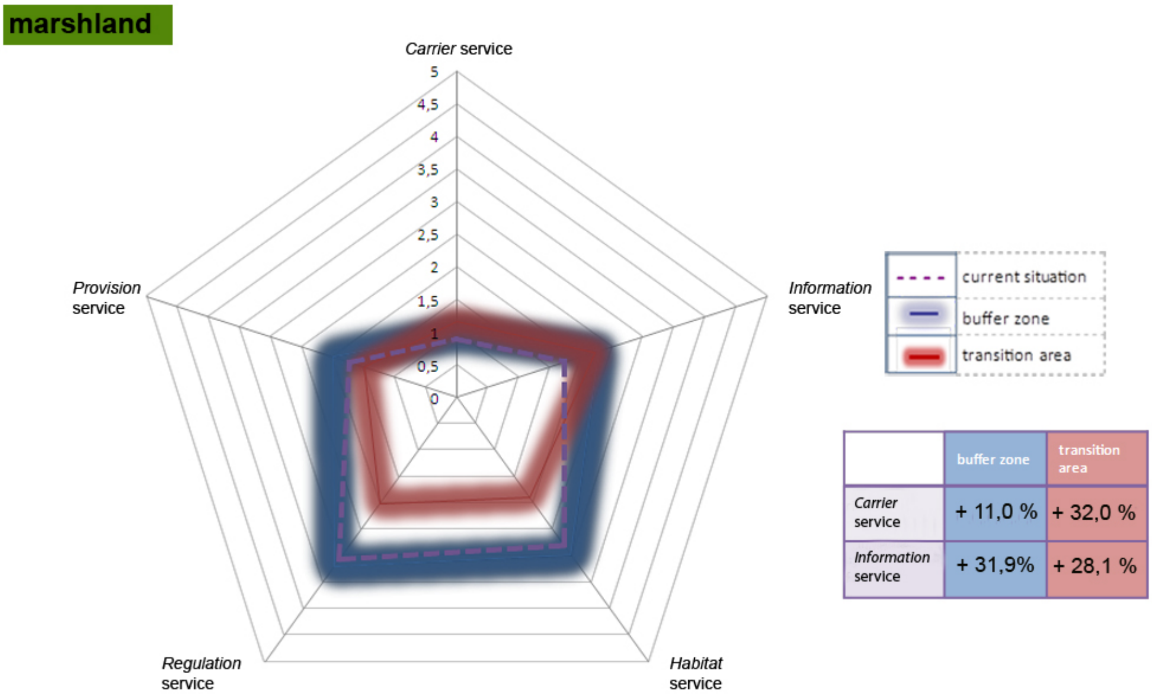


Figure 126: Potential Seville conform services of the Landform Marshland - results of the World Café (*Carrier* and *Information* service) and expert's evaluation (*Habitat, Regulation* and *Provision* services)

As shown in Figure 126, the stakeholders see a huge potential in the development of the *Information* service in 'Marshlands'. The same can be predicted for to the development of the buffer zone (31.9%) as well as the transition area (28.1%). In the opinion of the stakeholders, also an increase up to 32% for the *Carrier* service in the transition area is possible and preferable, which can especially be reached by increasing the 'transport', 'tourism' and 'agriculture' service. Regarding *Habitat* and *Regulation* services within a fictitious buffer zone the current service provision of 'Marshlands' is similar to what experts expect from a Seville conform one.

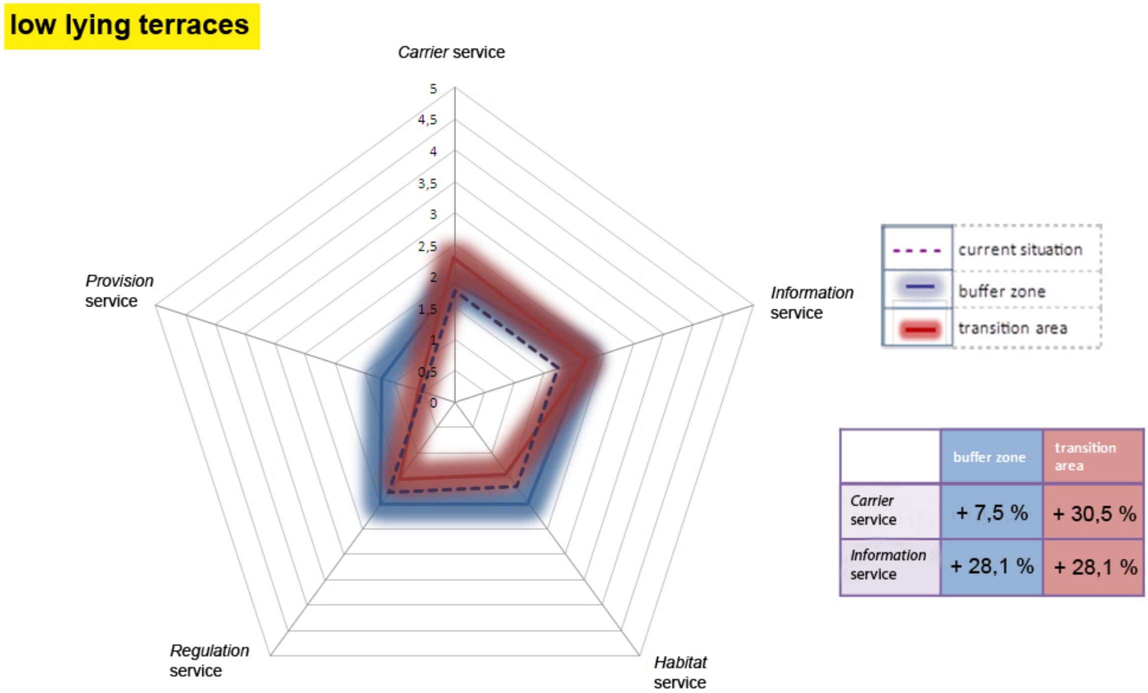
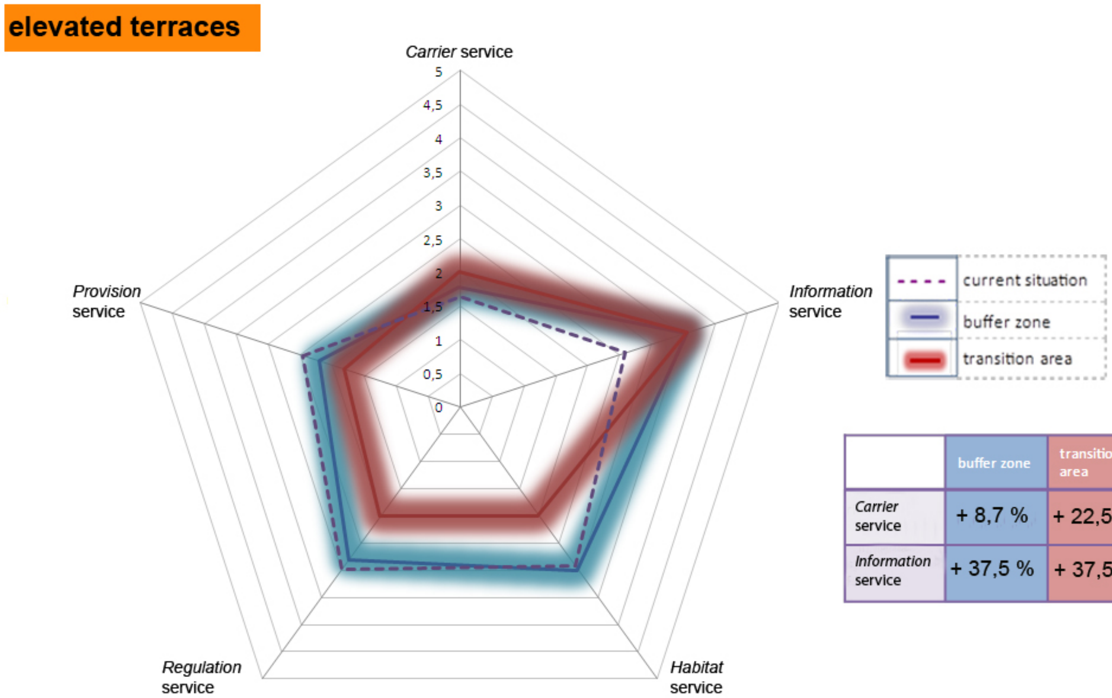


Figure 127: Potential Seville conform services of the Landform 'Low lying terraces' - results of the World Café (*Carrier* and *Information* service) and the previous experts evaluation (*Habitat, Regulation* and *Provision* services)

The results for the LFT 'Low lying terraces' (Figure 127) look similar to those for 'Marshlands'. In both LFTs stakeholders see a huge potential in the development of the *Information* services within the buffer and transition zone (28.1%) as well as of the *Carrier* services in the transition area (30.5%). On the contrary, the buffer zone offers less development potential for the *Carrier* services (7.5%). For a fictitious buffer zone it is obvious that there are still some needs to improve *Provision, Habitat* and *Regulation* service provision for meeting the aims of the Seville strategy. But results show also that the actual *Provision* services in the 'Low lying terraces' conform more or less to what experts expects for a BR transition area. Also the actual *Habitat* and *Regulation* service provision fulfil the Seville conform needs within that zone.



	buffer zone	transition area
Carrier service	+ 8,7 %	+ 22,5 %
Information service	+ 37,5 %	+ 37,5 %

Figure 128: Potential Seville conform services of the Landform 'Elevated terrace' - results of the World Café (*Carrier* and *Information* service) and previous experts evaluation (*Habitat, Regulation* and *Provision* services)

Even for the Landform 'Elevated terraces' (Figure 128) the evaluation of the stakeholders shows a similar distribution of the potential Seville conform services. Compared to the Landforms shown before, the development of the *Information* services for the Landform "Elevated terraces" represents the highest potential of all discussed Landforms. Stakeholders see a potential of development for the *Information* services in the buffer zone as well as transition area of up to 37.5%. Regarding *Habitat* service provision results show that within the buffer zone the current situation is similar to what experts expect for a Seville conform one. In contrast, in the transition zone service provision of *Habitat, Provision* and *Regulation* is even higher than recommended.

To sum up, it can be said that the stakeholders see the highest potential of development in the *Information* services ('aesthetic' information, 'recreation', 'cultural and artistic' information as well as 'science and education'), regardless of whether they talk about 'Marshland', 'Low lying terraces' or 'Elevated terraces' of the region Neusiedler See. Concerning the transition zone for all three Landforms the actual *Habitat, Provision* and *Regulation* service provision is even better than recommended by experts following the Seville strategy (except only *Provision* service in 'Low lying terraces'). Regarding a Seville conform buffer zone it can be outlined that *Provision*, *Habitat* and *Regulation* service provision should be improved for the 'Low lying terraces'. For the LFT 'Marshlands' the actual *Habitat* and *Regulation* service provision is similar to what experts expect from a fictitious buffer zone and also for the LFT 'Elevated terraces' the actual *Habitat, Provision* and *Regulation* services fulfil the Seville conform needs.

4.4.3 Communication

4.4.3.1 Information workshops in Illmitz 2009 and 2011

In the framework of the TransEcoNet project two information events were held in the information centre of the national park in Illmitz.

Kick-off information event in Illmitz 2009

The informative meeting on the subject of “Ecosystem Services as scientific foundation for the sustainable implementation of the redesigned Biosphere Reserve Neusiedler See” took place on Oct. 9th 2009 in the information centre of the Neusiedler See National Park in Illmitz, Austria.

Approximately 40 participants from different departments (Figure 130 and Figure 131) took part in the meeting. Among others the mayors of several municipalities of the region Neusiedler See, members of the Provincial Government of Burgenland, representatives of the tourist board and the association “World Heritage Neusiedler See” as well as the governor of the province of Burgenland and Burgenland’s environmental ombudsman attended the meeting (Figure 129). Representatives of the University of Western Hungary and of the Fertő-Hansag National Park attended as well. The meeting was held in German and lasted for about three hours.

Figure 129: Audience of the meeting on October 9th 2009, Source: Allex

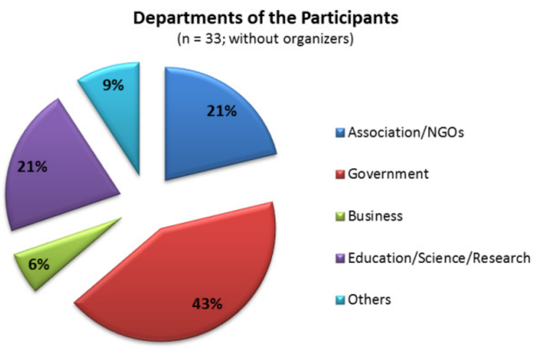


Figure 130: Departments of the participants of the informative meeting in Illmitz

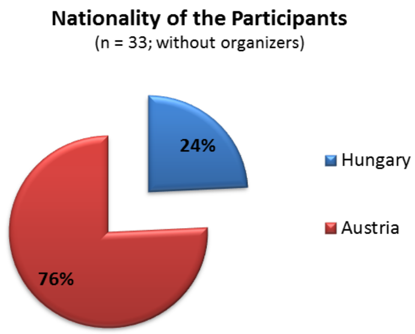


Figure 131: Nationality of the participants of the informative meeting in Illmitz

After an official welcome, Univ. Prof. Dr. Alois Herzig (Biological Station Neusiedler See) talked about “*The Biosphere Reserve Neusiedler See from the manager’s point of view*”. In this talk he presented the history of the development of the BR “Neusiedler See” (Figure 132).

In the second presentation "*Biosphere Reserves in Austria: an overview*" Ass. Prof. Mag. Dr. Karl Reiter (University of Vienna) gave an overview of the current situation of BR in Austria and the intent of the label "Biosphere Reserve" itself.

The cross-border landscape types of the region Neusiedler See were clearly illustrated by Dr. Éva Konkoly-Gyuró (University of Western Hungary in Sopron) in her speech on "*Different types of landscapes in the region of Fertő – Neusiedler See – Hanság*" .

In the next part of the presentation block Dr. habil. Karen Ziener (University of Klagenfurt) presented the results of a completed MAB pre-project "Redesigning the Biosphere Reserve Neusiedler See", which was aiming at developing options for a realignment of the BR „Neusiedler See" by an integrated landscape- and regional development and the initiation of a concept for the continuation of systematic ecological and socio-economic research.

After the presentation block, there was a panel discussion, in which Dr. Herzig, Dr. Reiter, Dr. Konkoly-Gyuró, Dr. Ziener and Dr. Wrbka answered and discussed questions of the audience.

Figure 132: Presentation of Prof. Herzig on 9th October 2009, Source: Allex

<u>International Post Conference Report in Illmitz 2011</u>

The conference on *"Landscape Services and Ecological Networks as Basis for a possible Redesign of a transboundary Biosphere Reserve"* took place on Nov. 25th 2011 at the Information Centre in the Austrian part of the National Park Neusiedler See – Seewinkel (Figure 133).

Figure 133: Conference at the Information Centre of the National Park Neusiedler See – Seewinkel in Illmitz, Source: Czachs

During the conference, options for a sustainable redesign and transboundary enlargement of the Biosphere Reserve „Neusiedler See", which were elaborated in the course of the international projects TransEcoNet (Central Europe) and BIOSERV (MAB), were presented and discussed.

The conference was held in German (partly in English) with simultaneous translation into Hungarian.

Overall, 62 experts from different departments (see Figure 134 and Figure 135) took part in the conference. As a representative from politics, Andreas Liegenfeld, Member of the Provincial Government of Burgenland, attended the conference.

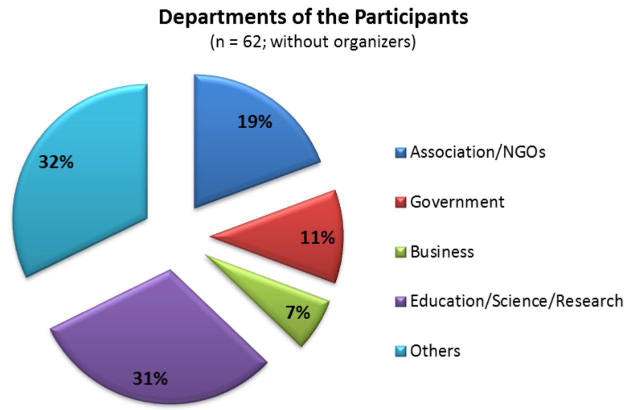


Figure 134: Departments of the participants of the conference in Illmitz

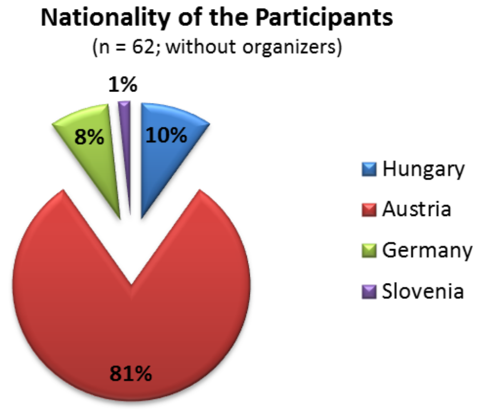


Figure 135: Nationality of the participants of the conference in Illmitz

The opening plenary speaker Univ. Prof. Dr. Elmar Csaplovics (Dresden University of Technology, project manager of TransEcoNet) presented the project "TransEcoNet" in Central Europe and current projects with Austrian attendance.

In the first presentation ***"Ecosystem services – current research in Europe"*** an overview of ecosystem functions and services in a multifunctional landscape was given by Dr. Benjamin Burkhard, (Christian-Albrechts-Universität Kiel), and an integrative valuation concept was presented that allows a comparison of different types of landscapes based on the services they offer. The results of these evaluations could be used to make trade-offs between different land using interests and to facilitate suitable and sustainable land-using decisions. In addition, an overview of the currently numerous landscape ecology activities across Europe was given.

In the second presentation ***"Biosphere Reserves as a motor for regional development"*** Univ. Prof. Mag. Dr. Georg Grabherr, Austrian Academy of Sciences, gave an overview of the history of BR. Given arguments indicated that BR are a good motor for regional development provided that the parties involved are motivated to take action because the concept of BR depends on bottom-up initiative.

Ass. Prof. Dr. Thomas Wrbka (University of Vienna), head of the PP05-team, spoke about ***"Landscape as basis of life and living space– What do landscapes provide for human society?".*** This presentation gave an overview of the current situation of the Neusiedler See region, focusing on the existing natural and cultural landscapes as well as the various categories of protected areas. In addition, the ecosystem service provision of the BR „Neusiedler See" was presented. Thanks to its umbrella function the label "Biosphere Reserve" provides a new chance to coordinate the different forms of land use and the various categories of protected areas to allow a sustainable development of the region. Moreover, a redesigned BR „Neusiedler See" was drafted, which was defined by using an evaluation system, established during previous projects, considering the results of the stakeholder workshop in Rust (November 3rd 2011). These results could form the basis of future regional development strategies.

After the first presentation block there was a **panel discussion** on: *"Biosphere Reserve Neusiedler See – a label with future?"*. The panel, moderated by Alois Lang (National Park Neusiedler See – Seewinkel) consisted of Univ. Prof. Dr. Alois Herzig (Biological Station Neusiedler See), Andrea Szucsich (ARGE Naturparke Burgenland), DI Dorothea Jagschitz (chairwoman of farm holidays), Klaus Hofmann (Manager of the St. Martins Therme) and Alois Lang himself. The panel discussed the future prospective of the BR „Neusiedler See" and the importance of the label for several sections.

The last presentation was titled ***"Place and Identity in Borderlands"***. In this poetic talk on her work Univ. Prof. Dr. Julia Ellis Burnet (University of Nova Gorica) gave an insight into the relationship between humans and their personal place, which is affected by the story of someone´s life, local environment and geographical location as well as ethic tradition, religion and family.

At the end of the official part of the conference the **film *"Borders and Humans around the Neusiedler See"*** was presented. The film was produced during several years in the course of TransEcoNet and shows how the residents perceive their own landscape.

4.4.3.2 Communication with decision makers

As the elaboration of strategies for sustainable management of ecological networks was one of the major goals of TransEcoNet, communication with key-stakeholders and decision makers was decisive. In Austria, nature conservation and territorial planning is in the responsibility of the regional governments. Therefore, the relevant authorities of the federal province Burgenland have been informed regularly about aims, methods and preliminary results. As two politicians held the office of State Councillor during the working period of TransEcoNet, both had to be informed individually. This was done in the format of separate briefings with 1-2 hours duration, including a presentation by the project team and a short discussion afterwards. These briefings were conducted in the following sequence:

- LR W. Falb-Meixner (Sept.2009)
- LR A. Liegenfeld (Nov.2011, Feb.2012)

As a result, the State Councillor of Burgenland recognised the importance of a redesigning of the existing pre-Seville BR. Although the scientific considerations for a large-scale approach were acknowledged in the political arena, a final decision was not taken so far. Alternatively a small-scale approach has been brought up by local decision makers, focussing on the inclusion of the existing world heritage site. Such a solution is not optimal from conservation and landscape ecological point of view, but has some advantages with respect to administrative and financial issues.

In addition, a consultation process has been launched with WHR Dipl.-Ing. R. Schatovich the representative of the spatial planning authorities in the federal province of Burgenland. This was initiated at an early stage of the project on March 18th 2010, when a longer discussion was conducted, followed by regular consultations and exchange of results and planning documents. This communication resulted in a very active participation of relevant key-stakeholders and regional experts during the ecosystem services-assessment workshop in Rust in 2011.

4.5 Conclusions

4.5.1 Discussion and recommendations for Biosphere Reserve Neusiedler See

The TransEcoNet approach on ecological networks and related ecosystem services includes elements of participatory planning and transdisciplinarity. Regarding the case study BR „Neusiedler See" this can be documented by the results of the stakeholder and expert consultation process as well as the feed-back from participants at the public presentations.

Nevertheless the implementation of scientific results into the political decision making seems to be unsatisfactory. Mainly the adoption of appropriate enlargement options of the existing pre-Seville BR failed to some extent. We suppose that this can be explained by a lack of knowledge about the Seville strategy and its potential benefit for regional development. Furthermore some key-stakeholders, namely from nature conservation authorities and the National Park Neusiedler See – Seewinkel, appeared to be reluctant to accept a more integrated approach concerning nature conservation. In addition the concept of BR was not seen as a desirable option for transboundary cooperation by Hungarian representatives.

4.5.1.1 General feedback on the label "Biosphere Reserve"

During the stakeholder workshop in Rust, one of the main questions concerned the added value of the label "Biosphere Reserve" considering that the Neusiedler See region is currently protected by several categories of protection. Some stakeholders see one of the most important added values of the label in the umbrella function, which could be a new chance to coordinate the different forms of land use and the various categories of protected areas to allow a sustainable development of the region. In contrast to other categories of protection the label "Biosphere Reserve" leaves room for recreation and tourism as well as regional development in addition to environmental protection, nature conservation, research and education. Thus for example, especially the tourism sector could benefit from the BR and its umbrella function. This reasoning is based on the grounds (i) that nature value /conservation plays also an important role for tourism and (ii) that the various categories of protected areas are very hard to communicate to residents and tourists. They also agreed that the BR could help to communicate the concept of the Neusiedler See as one uniform region. The enlargement of the BR would also mean an enlargement of the whole (tourist) region Neusiedler See, including for example the west bank with its small-scale cultural landscapes.

A BR could (more or less) help to expand the borders and include some more areas (or municipalities). In addition, some stakeholders cast doubt on the compatibility of the BR with the aims of a National Park, which in our opinion is arbitrary because since BR are based on a very flexible concept no conflicts of interest are to be expected. Another important aspect was that tourism needs space to develop and that there has to be enough room for building activities (e.g. housing development) in the region.

During the panel discussion at Illmitz all attendant parties considered in substance that the National Park as well as the BR are important institutions for the region. Especially the tourist sector implements marketing concepts to promote regional tourism using the label "Biosphere Reserve". A loss of this label could have fatal consequences for both economy and nature and therefore needs to be avoided. Furthermore, they agreed that only a sustainable all-over concept could secure the future of the region.

4.5.1.2 Project team´s opinion (based on our results)

According to the results of this study a redesign of the BR "Neusiedler See" seems to be possible. The existing BR provides a good basis on which the redesign could build upon. The concept of Landscape functions and services was an appropriate instrument to display the umbrella function and the conservation effectiveness of a potential redesigned BR.

In our analysis we could identify some differences in the investigation areas of Austria and Hungary. Based on the larger sizes of conservation areas (especially of National Park) conservation issues are more important in Hungary, whereas the sustainable development function of the BR is not acknowledged by Hungarian stakeholders. However, the participation of the Hungarian stakeholders is much lower in workshops and the interest is marginal. The umbrella function of the BR pooling various areas of different protection categories is neither acknowledged.

Our results showed differences between the potential and actual landscape service provision in the individual Landforms. Therefore, we recommend that the different landscape types should play a role in the future identification of the BR and that in the Austrian part of the BR umbrella function and regional development function should be stressed more. Furthermore the future BR should integrate parts of the region which are not in any protection category yet.

4.5.1.3 Outsiders view (reflection on the newspapers)

The press also has published reports on the imminent withdrawal of the UNESCO label "Biosphere Reserve" and the possible consequences on the region (Kronen Zeitung, December 13th 2011; Krutzler, 2012 in Standard, January 18th 2012). Criticism was passed especially on politics, which has so far delayed a decision. At the moment responsible politicians believe that the label "National Park" is the highest award, so they disbelieve that there is need for a BR.

Also the reader feedback on Krutzler (2012) indicates that the Neusiedler See region is currently protected by several categories of protection, outsiders do not see any disadvantages for the region by the loss of the label "Biosphere Reserve".

This reveals that further investigation and communication is required concerning the added value of the label "Biosphere Reserve" and its benefits for the region Neusiedler See.

4.5.1.4 Possibilities of Cooperation

Following the UNESCO guidelines for the World Network of Biosphere Reserves (WNBR) of the MAB Programme the concept of BRs represents a unique tool for international co-operation through sharing knowledge, exchanging experiences, building capacity and promoting best practices, focusing especially on North-South collaboration (website: World Network (WNBR) I United Nations Educational, Scientific and Cultural Organization). In further steps communication and exchange of scientific concepts, expert knowledge and experiences from practical BR management with other BRs would be useful. Based on our analysis especially research issues concerning the concept of ecosystem services could provide knowledge exchange and capacity building, so for example with BR Oberlausitzer Heide- und Teichlandschaft or BR Schwäbische Alb in Germany which are study areas of the research project "Market-Based Instruments for Ecosystem Services" (website: Market-based instruments for ecosystem services). Also a cooperation with BR in Austria (Gross-Walsertal, Wienerwald) and neighbouring countries (e.g. Spreewald, Rhön, Schorfheide, Schaalsee in Germany) could offer opportunities for experience exchange concerning different issues for example development concepts, tourism, education and management. Furthermore a high level of input for issues of nature conservation including conflict management between nature protection and humane use could be provided for all partners by knowledge exchange with BRs containing similar ecosystems and biotopes, such as the BR Danube Delta (Romania/Ukraine) with its reed belts and high abundance of birdlife.

4.5.1.5 Recommendations for Biosphere Reserve „Neusiedler See“

Based on experiences from this study the PP05-team concludes with the following recommendations for the BR Neusiedler See:

- → a regular consultation process about existing pre-Seville BR between the responsible authorities and the Austrian MAB-committee should be established
- → knowledge about the Seville strategy and its potential benefit for regional development should be promoted by an information campaign, jointly organized by the federal province and the Austrian MAB-committee
- → a label for regional marketing of sustainably produced goods from the proposed BR should be developed under the umbrella of UNESCO and the Austrian MAB-committee respectively
- → promoting the BR-concept by organizing excursions and other Twinning-activities to best practice examples in Austria (Gross-Walsertal, Wienerwald) and neighbouring countries (e.g. Spreewald, Rhön, Schorfheide, Schaalsee in Germany)
- → strengthen the role of existing nature reserves as core areas for the future BR by ensuring sufficient financial resources and optimal management
- → promote the concept and underlying philosophy of BRs in Hungary and foster transboundary cooperation in this respect
- → further develop inter- and transdisciplinary research on the integration of nature conservation into economic activities as a stimulus for sustainable regional development

4.5.2 The ecosystem service concept as a structural framework of planning measures

4.5.2.1 Critical view on the stakeholder implementation process

Concerning the stakeholder workshop, a main point of criticism was the definition of the ideal development for the region. In this respect, experts see differences between Austria and Hungary. In their opinion the current situation of the related services varies from one country to the other. While, for example, traffic infrastructure in the Landform ‘Marshland’ in Austria is relatively well developed, Hungary shows evidence of clear deficits. Another point of criticism was the partially unclear definition of terms, which caused problems in valuation, for example, speaking of agriculture. It has to be clarified if one means intensive or extensive agriculture because extensive agriculture should increase whereas intensive agriculture should decrease. Also the key points of the umbrella function of the label “Biosphere Reserve” should become more evident.

Referring to the presented evaluation system, the question has been raised if it is possible to take current or planned projects like the rewetting of the Hanság into account and to draw comparisons. According to Dr. Thomas Wrbka (PP05) it is possible to display the functions potentially, which allows to compare how interventions in the landscape affect the landscape services.

To sum up it can be said that this evaluation has been a first step of stakeholders' knowledge implementation into our structural framework for the BR „Neusiedler See" and also the first interaction concerning the issue of its ecosystem service provision between project partners and stakeholders. Therefore points of criticism mentioned above and experiences from the workshop should be integrated in further analyses.

4.5.2.2 General recommendations for structural framework of planning measures

Handling the variegated duties and responsibilities of BR like nature protection, regional development, monitoring, education or communication adequate planning concepts based on regional conditions are needed. The present study approves that the concept of landscape functions and services is an appropriate instrument for the identification, measuring and communication of the ecological and socio-cultural values within regions and different Landforms. Especially within protected areas, analysis on ecosystem services provide scientific basis to display umbrella functions and the conservation effectiveness of different sites.

The stakeholder implementation process integrates the bottom-up approach into our structural framework for planning measures and may adapt analysis to local conditions. This is especially important for BR that is based in a large extent on active participation of residents and locally adapted concepts for development.

5 Assessing the biodiversity of ecological networks with airborne laser scanning

Action 5.5.1

ASSESSING THE BIODIVERSITY OF ECOLOGICAL NETWORKS WITH AIRBORNE LASER SCANNING IN THE INVESTIATION AREA NEUSIEDLER SEE/FERTŐ

Authors:

Werner Mücke, Markus Hollaus, Norbert Pfeifer

PP04 – Dept. of Geodesy and Geoinformation, Vienna University of Technology

Michael Kuttner, Thomas Wrbka

PP05 – Dept. of Conservation Biology, Landscape- and Vegetation Ecology, University of Vienna, Austria

5.1 Introduction

In analyses of WP5 biodiversity of habitats is not measured directly, rather substitute indicators, so-called proxies, are assessed and interpreted. In the course of interpretation a number of factors and complex interactions have to be considered. Fieldwork and biological expert knowledge will always be necessary for successful assessment of landscape element (LE) quality, but airborne laser scanning (ALS) can support this process in three ways: (1) identification of diversity hot spots of habitats or areas of significant change, (2) provision of objective and area wide quantification of relevant features, therefore reducing the possibility of inter- and intra-observer errors and (3) in a comparison and evaluation process, highlighting problematic areas for revision.

Recent research papers have shown the need and potential for the integration of the third dimension into landscape structure indices (Hoechstetter, 2009; Jenness, 2004). ALS is a line-of-sight direct 3D measurement technique and is able to penetrate through little gaps in the foliage. It can therefore provide 3D information not only on the horizontal, but also on the vertical distribution of the vegetation. With this study we suggest to make use of the 3D information and penetration capability of ALS for the derivation of novel landscape metrics. The presented approaches exploit the collected information about the vegetation layer structure in order to describe not only if two landscape patches are connected, but also how this connection is composed in terms of vertical structure of the plants building the patches. It therefore integrates knowledge of different vegetation layers into shape metrics.

5.2 Description of the study area and data

5.2.1 Study area

Within the TransEcoNet trans boundary project region Central South, a number of local study sites located in the federal country of Burgenland, the Hungarian Hanśag and Sopron regions were defined. For the ALS data acquisition four of these sites located in the so-called Seewinkel*,* meaning the area east of the Neusiedler See on the border to Hungary, were selected (see Figure 136).

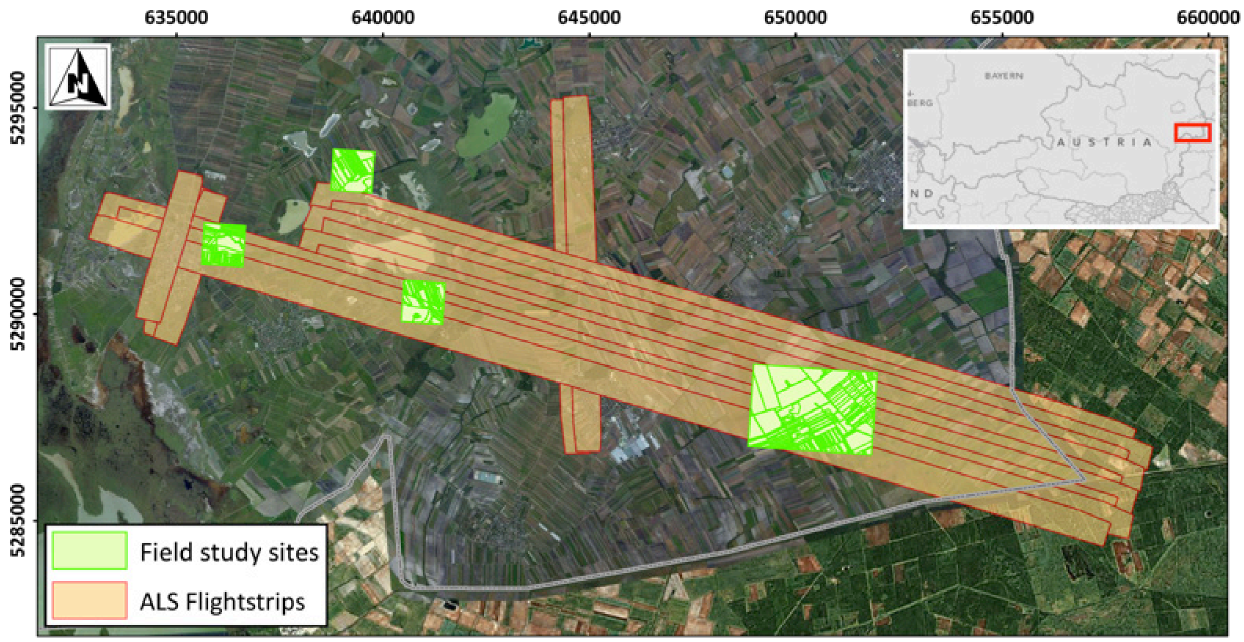


Figure 136: Overview of ALS campaign and local study sites in Austrian-Hungarian border region Seewinkel / Hanśag

5.2.2 Field data

Field data were collected in all of the determined study areas. Based on digital aerial photographs and semi-automatic image processing tools a basic delineation of LEs was created, which was subsequently refined and improved manually by visual validation. Maps comprising this delineation were produced and taken to the field, where experts in biology and landscape ecology assessed a number of attributes for each of the LEs. These attributes, describing resource potential, disturbance, endangerment, management and structure of the LE, were stored in a database.
Detailed information on the field data and a list of attributes is given in Hermann et al. (submitted). On the basis of this database of collected attributes the evaluation of the landscape elements regarding their biodiversity, functionality and ecosystem services was carried out (Hermann et al., submitted; Kuttner et al., in press).

5.2.3 ALS data

5.2.3.1 Full-waveform ALS

Full-waveform (FWF) ALS systems are capable of detecting and storing the whole emitted and backscattered signal for echo extraction in post-processing. During this process, the echoes are detected and the ranges of the scanner to the target, as well as additional variables are derived. In addition to the amplitude, the width of the backscattered signal (i.e. echo width) is determined. The usage of these additional observables opens up new prospects for DTM (digital terrain model) generation from ALS data, although very rarely used so far (Lin & Mills, 2009; Mandlburger et al., 2007; Mücke et al., 2010a). Wagner et al. (2006) stated that the echo width is dependent on the vertical distribution of small surface elements within the footprint area of the laser beam. The canopy, under storey or near ground vegetation is assumed to have larger variations in vertical directions and consequently larger echo widths than the terrain. Therefore, the echo width can be interpreted as a measure of surface roughness.

5.2.3.2 Data acquisition and quality check

Two ALS data acquisition campaigns were carried out in the above described study area. The novel RIEGL LMS-Q680i laser scanner (Riegl, 2012) was employed mounted on a fixed wing aircraft. The scans took place in February under leaf-off and in July under leaf-on conditions providing an optimal data basis for studies of vegetation phenology. A mean flying altitude of approximately 500 m, together with a 50% strip overlap resulted in point densities of 14,1 and 13,7 points per m^2 for the leaf-on and leaf-off flight.
A quality check was carried out for the data sets from both acquisition times using OPALS software packages (Mandlburger et al., 2009; Opals 2012). For this purpose, strip wise digital surface models (DSM) were computed and the height differences of the neighbouring (i.e. overlapping) strips were calculated. In this way the relative geometric accuracy, i.e. the planar and vertical discrepancy, of the strips could be assessed. It resulted in σ_{MAD} = 1,7 cm (σ_{MAD} = median of absolute deviation to median * 1.4826, a robust estimator for the standard deviation) for the February and σ_{MAD} = 3,1 cm for the July data, documenting the high quality and relative accuracy of the ALS data.

5.2.4 Basic digital height models

Based on the first and single returns a landscape dependent digital surface model (DSM) with a grid width of 0.5 m was calculated as described in Hollaus et al. (2010). The concept is based on the derivation and fusion of two different types of surface models dependent on the surface roughness.
For the creation of the digital terrain model (DTM), a process that is also referred to as filtering, only the last returns were selected. The FWF information is used as additional criterion for the identification of terrain echoes, a most critical step in DTM generation. The echo width was incorporated in a pre-filtering step of the ALS point cloud to identify ground echoes, neglecting last

echoes with large echo widths because they were likely to represent vegetation (Csaplovics & Schmidt, 2011; Hollaus et al., 2011; Mücke et al., 2010a). Based on this a-priori selection of points a DTM with a resolution of 0.5 m was calculated by hierarchical robust filtering (Kraus and Pfeifer, 1998).

For further computations, a model comprising the actual vegetation and object heights was needed. For this purpose a normalised DSM (nDSM) was derived as the difference of DSM and DTM.

Apart from that, two height models, one based on the highest and one based on the lowest point in a grid cell excluding terrain points were computed. The difference model of the two, in the following referred to as DSM_{diff}, is expected to depict the vertical extents of the branches, needles and leaves. It is further used for the derivation of vegetation layer structure. Both differential height models have a spatial resolution of 0.5 m.

5.3 Methods

5.3.1 Derivation of a building and a vegetation mask

Proximity of artificial buildings like roads and settlements has a significant negative influence on landscape element structural functionality (Kuttner et al., in press). Thus, maps showing where they are located and giving information on their extents (i.e. the building footprint) should be included in the process of landscape evaluation. Furthermore, to improve the performance of the proposed methods over large areas, all of the following calculations are limited to vegetated areas only. This is achieved by the application of a building and vegetation mask, which are derived in a multi-step approach by morphological image processing based on the nDSM and a measure of local transparency, the so-called echo ratio (ER) (Höfle et al., 2009). Both approaches are similar, differing primarily in the setting of parameter thresholds. They result in binary maps representing the classified building- and vegetation-areas. For further processing, the connected regions of building and vegetation pixels are vectorized as shown in Figure 137.

5.3.2 Segmentation of vegetated areas

The aim of the segmentation step is to extract homogenous features like shrubs, single tree crowns or sub-tree crowns for larger distributed single tree crowns (e.g. large deciduous trees). The derived segments are subsequently used as a reference unit for the calculation of structure parameters using the original 3D point cloud. Based on the nDSM an edge-based segmentation procedure is applied.

This segmentation approach has been described and tested in densely forested areas (Höfle et al., 2008; Hollaus et al., 2009) and in densely built-up urban areas (Höfle & Hollaus, 2010; Höfle et al., 2012). The main idea of the segmentation is to delineate convex objects (i.e. tree crowns) in the nDSM by finding concave edges between the convex objects.

5.3.3 Derivation of 3D landscape metrics

5.3.3.1 Surface-to-volume ratio

The main concept is the relation of a patch's surface, defined as the area of its enveloping canopy, to the volume enclosed by it. So if a vegetation object is shaped like a sphere, meaning it is very compact, it will show a very small surface compared to its enclosed volume. On the contrary, if a vegetation object is more branched, its surface will get larger compared to the volume it encloses. The surface is computed as the sum of all visible lateral faces, the top and bottom face of a cell column in the raster domain. The workflow is implemented in GRASS GIS (2012). The computation of the volume is achieved by multiplication of the respective value of the DSM_{diff} and the cell size. Finally, the ratio of the surface and the volume are computed for each raster cell and assigned to the vegetation segments (Mücke et al., 2010b).

5.3.3.2 Vegetation layer structure

The distribution of the laser echoes in the vegetation allows us to draw conclusions on its structural complexity. We calculate the so-called penetration index as a measure of penetrability and geometric structure. The 3D point cloud is reduced to the vegetated areas by intersection with the vegetation mask and it is divided into a terrain and a vegetation point cloud using relative heights computed for each return with respect to the DTM. Subsequently, the points are assigned to height levels (L1-L3), which were derived as percentage of the maximum occurring point height within a grid cell of 0.5 m. Each of the afore derived vegetation segments is assigned the according percentage values and mean values for each segment are derived. Finally, a decision tree based strategy is used to classify the segments, the results of which represent the penetration index map.

5.3.4 Delineation of landscape elements

Manual delineation of landscape elements based on aerial photography is afflicted with a degree of uncertainty and is disadvantageous especially in overgrown areas. It is therefore one of the aims of TransEcoNet to find ways for ALS to compensate these drawbacks and support the conventional methodologies in landscape structure assessment. One way is comparing the results of the semi-automatic biotope delineation used for ground truth assessment with biotope boundaries derived from ALS measures. This can be done on the basis of geometric, as well as radiometric features. It was found that especially the echo width is suited for this purpose, as surface roughness is a sufficient indicator to discriminate between a large number of biotope types.

Based on the echo widths, a surface roughness raster map is created with a spatial resolution of 0.5 m containing the mean echo width per grid cell. To create a biotope delineation based on this high resolution echo width map a stepwise image processing approach was developed. It is intended to smooth the raster map while still preserving the significant edges of distinct areas of differing roughness.

5.4 Results

5.4.1 Building and vegetation mask

The applied method for building outline derivation is aimed at full completeness, rather than full correctness. For the purpose of this study, it is more important where buildings are located and how large they are, compared to deriving their exact outlines. Nevertheless, we found good correspondence through visual comparison of the automatically delineated building mask with aerial photographs (see Figure 137).

Reducing the area of actual computation for the 3D landscape metrics to only the vegetated parts increased performance of the applied methods significantly and therefore efficient analysis of the reduced original point cloud was possible. As the vegetation mask was derived from raster layers of 0.5 m, it is very accurate, as can be seen in Figure 137b.

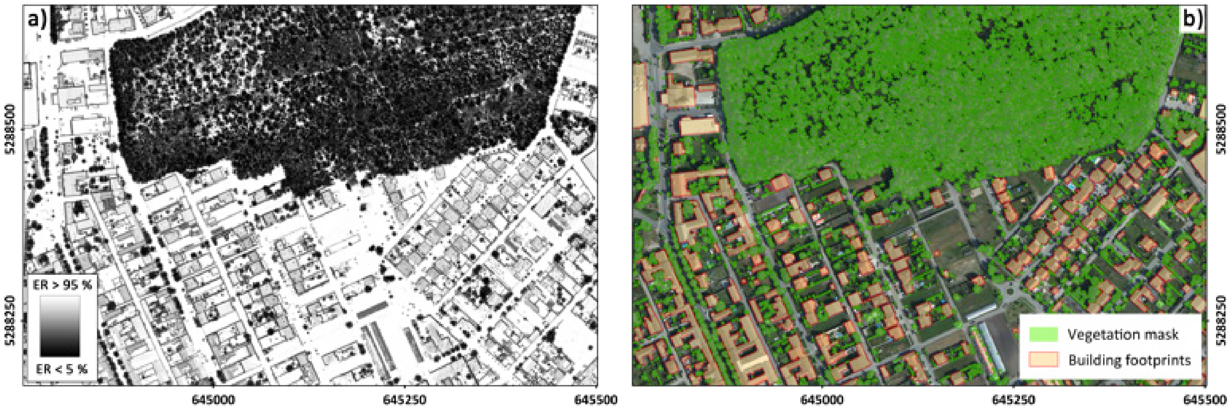


Figure 137: (a) Echo ratio in percent. White means impenetrable, black means highly penetrable. Spatial resolution is 0.5 m. (b) final vectorized building (red) and vegetation masks (green).

5.4.2 Segmentation of vegetated areas

The utilized segmentation method successfully delineated crowns of coniferous trees and, as to be expected, of single (meaning standing alone) vegetation objects of any species. The delineation of single trees or tree crowns of densely grown deciduous trees is generally more difficult. As the applied segmentation algorithm detects convex objects separated by concave areas, it works very well for single trees with clearly distinct crowns, as can be seen in Figure 138. But especially older or larger deciduous trees often develop large crowns with multiple maxima, resulting in multiple convex areas and therefore being represented by more than one segment. A further limitation occurs in very dense young deciduous forest, characterised by a smooth canopy surface. Because of the less distinct crown shapes, the resulting segments often include multiple trees.

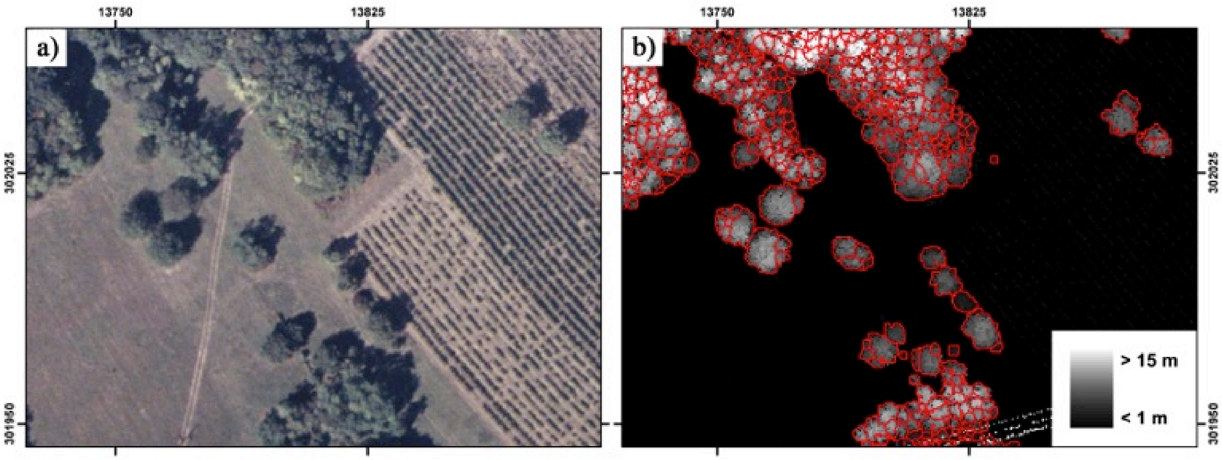


Figure 138: (a) True colour orthophoto, (b) nDSM overlaid with the result of the vegetation segmentation (Mücke et al., 2010b).

5.4.3 Surface-to-volume ratio

The vegetation surface and volume ratio can be seen as a proxy for the compactness of a particular landscape element. Changing compactness along a geometric element implies a change in structure and consequently permeability. This permeability is of significance for certain species, e.g. highly adapted birds, whose requirements do not allow structural changes within their habitats. In Figure 139a the computed vegetation surface to volume ratio is shown. A high voltage power line runs right through the study area crossing several vegetation corridors. It is clearly visible in the ratio image that the character of the vegetation structure is changing significantly below the power line.

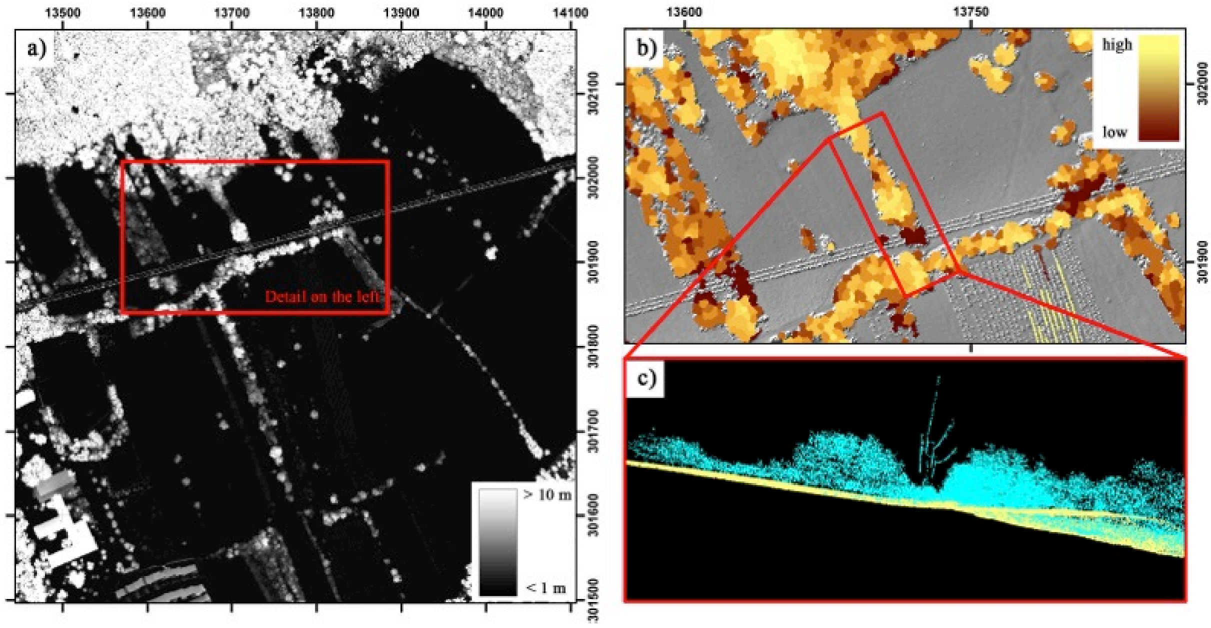


Figure 139: (a) colour coded nDSM, (b) surface-to-volume ratio, (c) profile of point cloud showing the differing character of vegetation in the sample area (Mücke et al., 2010b).

For evaluation of the results, visual examination of the 3D point cloud had to be used, because of the lack of an adequate ground truth measurement method for the proposed surface-to-volume ratio. A profile view is given in Figure 139c and it can be seen that the changing of the corridor vegetation character, as indicated by the ratio, is supported by the 3D point cloud. This dissecting power line element is particularly disturbing habitat or corridor connectivity and thus decreasing structural landscape functionality in terms of species migration, which could subsequently lead to inbreed and extinction of local species populations.

5.4.4 Vegetation layer structure

The resulting penetration index map for the study area can be seen in Figure 140. For evaluation purposes, three profiles of the 3D point cloud, which are meant to display the structural diversity of a particular area, were created. In the chosen study area four dominant types of vegetation structure could be identified: L1 + L3 > 80% (red), L2 + L3 > 80% (light green), L3 > 80% (dark green) and equally distributed structure (yellow). Below the profiles the corresponding raster lines from the penetration index map are given. They demonstrate that the classification result corresponds very well with the actual structure of the forest.

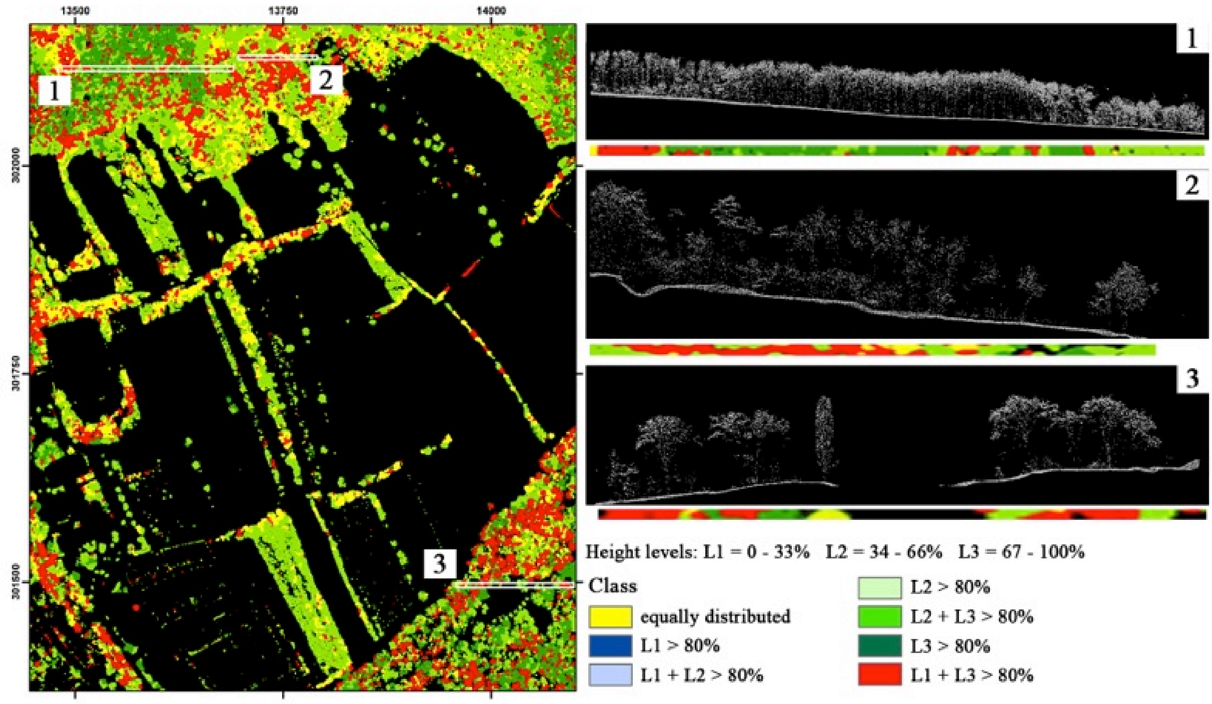


Figure 140: Left: penetration index map. Right: profile views of the ALS point cloud. The location of the profiles can be found in the left image. Below the profiles the corresponding line from the penetration index map are given.

5.4.5 Comparison of biotope delineation based on aerial photography and ALS

The biotope delineation achieved with conventional methods through semi-automatic image segmentation and classification in general shows good agreement with the ALS-based one derived for this study (see Figure 141 and Figure 142). The borders of larger, more homogenous landscape elements and biotopes correspond quite well. Differences can be found in the degree of detail of the delineated borders, which is mainly attributed to the higher resolution of the ALS-based map (see Figure 142b).

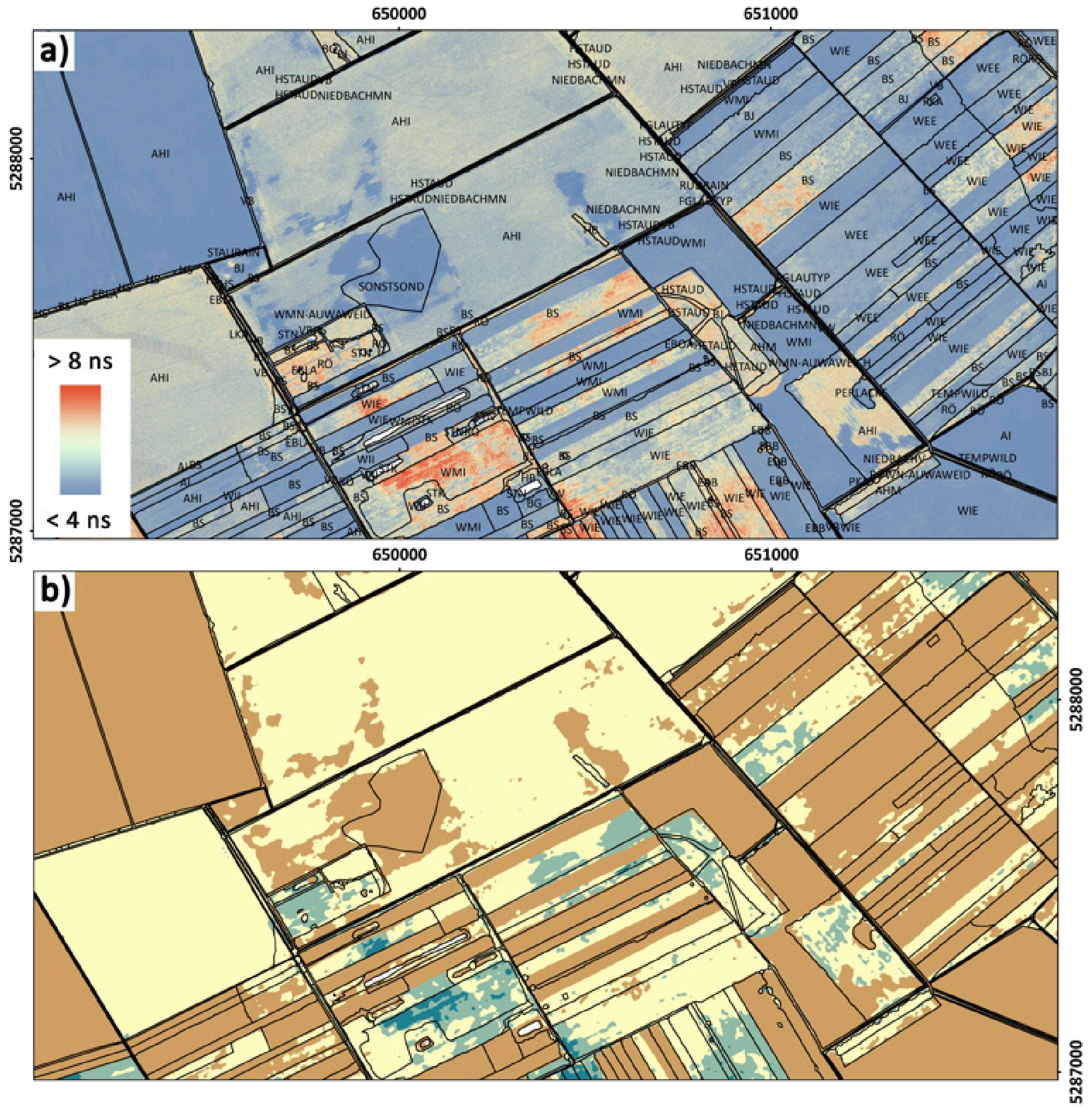


Figure 141: (a) Echo width / surface roughness map overlaid with orthophoto-based biotope delineation and biotope type label from field survey. (b) Echo width / surface roughness map after image processing and classification.

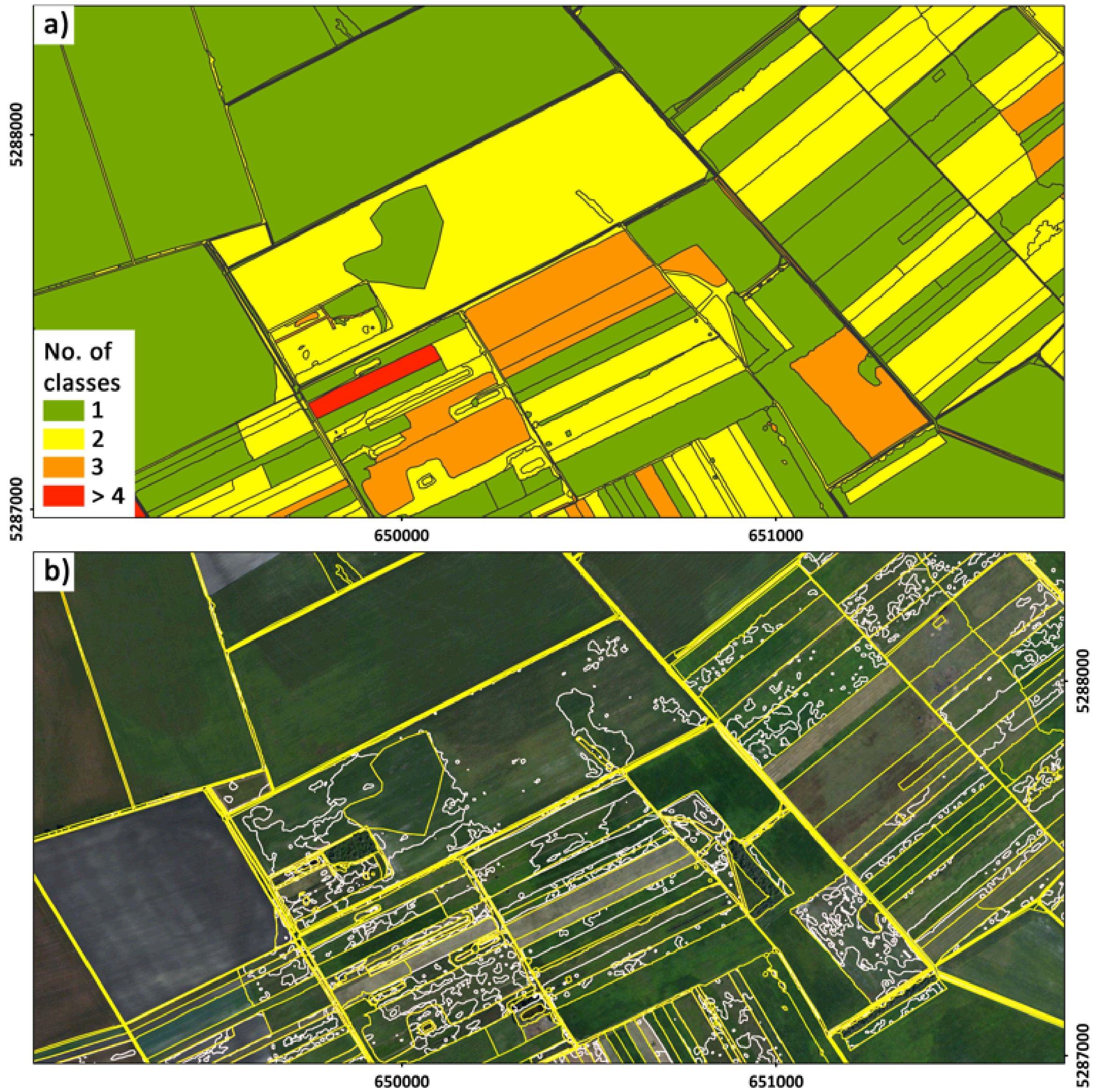


Figure 142: (a) Identified biotopes with higher (green) or lower correspondence (yellow – orange – red) judged by the number of different classes within every biotope. (d) Result of automatic delineation of inner-biotope boundaries (white lines) based on echo width / surface roughness map.

5.5 Conclusion

The presented study shows the potential of ALS applications in landscape ecology. The advantages of ALS provide 3D information on the vegetation, which is of great significance and not derivable with conventional methods based on orthophoto analysis and manual field surveys alone. ALS is capable of delivering additional information for the assessment of landscape elements, which can further be used in the evaluation process and for the derivation of landscape functionality indices.

5.6 Acknowledgements

The authors would like to thank the company RIEGL Laser Measurement Systems GmbH for kindly providing two days of flight and airborne laser scanning data acquisition for the TransEcoNet project.

6 References

Bakkera, M.M., Veldkamp, A., 2008. Modelling land change: the issue of use and cover in wide-scale applications. Journal of Land Use Science 3, 203–213.

Barsch, H., Saupe, G., u.a., 1994. Bewertung und Gestaltung der naturnahen Landschaft in Schutzgebieten, Erholungs- und Freizeitgebieten, Teil 1 bis 3. Potsdam. Potsdamer Geographische Forschungen, 8.

Bastian, O., 1997. Gedanken zur Bewertung von Landschaftsfunktionen – unter besonderer Berücksichtigung der Habitatfunktion. NNA-Berichte 10, 106–125. Schneverdingen (Alfred Toepfer Akademie für Naturschutz (NNA)).

Bastian, O., Schreiber, K.-F., 1999. Analyse und ökologische Bewertung der Landschaft. Heidelberg, Berlin (Spektrum), 2nd edn.

Benz, U.C., Hofmann, P., Willhauck, G., 2004. Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information. ISPRS Journal of Photogrammetry and Remote Sensing 58, 239-258.

Blaschke, T., 2010. Object based image analysis for remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing 65, 2-16.

Bohn, U., Neuhäusl, R., with contributions by Gollub, G., Hettwer, C., Neuhäuslová, Z., Raus, Th., Schlüter, H., Weber, H., 2000/2003. Map of the Natural Vegetation of Europe. Scale 1 : 2 500 000. Münster, Landwirtschaftsverlag.

Boyd, J., Banzhaf, S., 2007. What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63, 616–626.

Bundesamt für Bauwesen und Raumordnung, 2005. Raumordnungsbericht 2005, Bonn, S. 209/20.

Burkhard, B., Kroll, F., Müller, F., Windhorst, W., 2009: Landscapes' Capacities to Provide Ecosystem Services - a Concept for Land-Cover Based Assessments. Landscape Online 15, 1-22.

Burnett, C., Blaschke, T., 2003. A multi-scale segmentation/object relationship modelling methodology for landscape analysis. Ecological Modelling 168, 233-249.

Chan, K.M. A., Shaw, M.R., Cameron, D.R., Underwood, E.C., Daily, G.C., 2006. Conservation Planning for Ecosystem Services. DOI: 10.1371/journal.pbio.0040379.

Csaplovics, E., Schmidt, J., 2011. International symposium on advanced meth-ods of monitoring reed habitats in Europe. Fernerkundung und Angewandte Geoinformatik, Bd. 9, Rhombos-Verlag.

Daily, G.C. (Ed.), 1997. Nature's Services: Societal Dependence on Natural Ecosystems, Washington DC (Island Press).

Definiens AG, 2009a. Definiens eCognition Developer 8 Reference Book. - Definiens AG, Munich. S. 276.

Definiens AG, 2009b. Definiens eCognition Developer 8 User Guide. - Definiens AG, Munich. S. 236.

Deutscher Rat für Landespflege (Ed.), 2010. Biosphärenreservate sind mehr als Schutzgebiete – Wege in eine nachhaltige Zukunft, Meckenheim.

EEA - European Environmental Agency, 2006. Corine Land Cover (CLC) 2006. http://dataservice.eea.europa.eu

Egoh, B., Rouget, M., Reyers, B., Knight, A.T., Cowling, R.M., Jaarsveld, A.S., van Welz, A., 2007. Integrating ecosystem services into conservation assessments: A review. Ecological Economics 63, 714 – 721.

Engels, B., 2008. Räumliche Ansprüche des Sektors „Freizeit und Tourismus“ an Natur und Landschaft. In: Institut für Technikfolgenabschätzung und Systemanalyse (ITAS) (Hsg.) Technikfolgenabschätzung – Theorie und Praxis, Nr. 2, 17. Jahrgang - September 2008, S. 52-59. URL: http://www.itas.fzk.de/tatup/082/enge08a.htm, 1.11.2009.

Fisher, B., Turner, R.K., 2008. Ecosystem services: Classification for valuation. Biological Conservation 141, 1167–1169.

del Giorgio, P.A., Cole, J.J., Cimbleris, A., 1997. Respiration rates in bacteria exceed phytoplankton production in unproductive aquatic systems. Nature 385, 148–151.

Goldman, R.L., Thompson, B.H., Daily, G.C., 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. Ecological Economics 64, 333 – 343.

Grabaum, R., Meyer, B.C., Friedrich, K.E., Wolf, T., Meyer, T. ,Gehring, J., 2005. Interaktives Nutzerhandbuch für das Verfahren MULBO – Textdokumente – Bewertungshandbuch – Sozio-ökonomische Bewertungsverfahren (OLANIS Expertensysteme GmbH 2005).
URL: http://www.mulbo.de/download/bewert_soziooeko.pdf, 8.8.2009.

GRASS GIS, 2012. GRASS GIS - the world leading free software GIS, Available online at http://grass.fbk.eu/. Accessed on 2012/05/24.

Greif, F., Pfusterschmid, S., Wagner, K., 2002. Beiträge zur Landwirtschaftlichen Raumplanung, Schriftenreihe der Bundesanstalt für Agrarwirtschaft Nr. 93, Wien. URL: https://www.dafne.at/prod/dafne_plus_common/attachment_download/b427fd19cfa378c49c5b4f9e3b6961bb/Interreg%20IIC_Struktur_Bodennutzung.pdf, 18.11.2009.

de Groot, R.S., 1992. Functions of Nature: Evaluation of nature in environmental planning, management and decision making, Groningen (Wolters-Noordhoff BV).

de Groot, R.S., Wilson, M. A, Boumans, R.M.J. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics, 41: 393-408

de Groot, R.S., 2006. Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. Landscape and Urban Planning, 75: 175-186

de Groot, R.S., Alkemade, R., Braat, L., Hein, L., Willemen, L., 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7, 260–272.

Haase, G., Mannsfeld, K. (Hrsg.), 2002. Naturraumeinheiten, Landschaftsfunktionen und Leitbilder am Beispiel von Sachsen. Forsch. Z. dt. Landeskde, Bd.250, Flensburg.

Haines-Young, R., Potschin, M., 2008. England’s Terrestrial Ecosystem Services and the Rationale for an Ecosystem Approach. Full Technical Report, Defra Project Code NR0107”, pp. 1–89, London (Department for Environment, Food and Rural Affairs (DEFRA)). Online version (accessed 28 February 2011): http://www.ecosystemservices.org.uk/reports.htm.

Haines-Young, R., Potschin, M., 2010. The links between biodiversity, ecosystem services and human well-being. In: Raffaelli, D. & C. Frid (eds.): Ecosystem Ecology: a new synthesis. BES Ecological Reviews Series, CUP, Cambridge.

Harfst, W., 1980. Zur Gültigkeit von Erholungsbewertungsmethoden. Kritische Analyse derzeitiger Verfahrensansätze als Instrumente der Landschaftsplanung, Hannover.

Havstad, K.M., Peters, D.P.C., Skaggs, R., Brown, J., Bestelmeyer, B., Fredrickson, E., Herrick, J., Wright, J., 2007. Ecological services to and from rangelands of the United States. Ecological Economics 64, 261-268.

Hein, L., van Koppen, K., de Groot, R.S., van Ierland, E.C., 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics 57, 209- 228.

Hermann, A., Schleifer, S., Wrbka, T., 2011. The Concept of Ecosystem Services Regarding Landscape Research: A Review. Living Rev. Landscape Res. 5.

Hermann, A., Kuttner, M., Hainz-Renetzeder, C., Konkoly-Gyoró, É., Tirászi, Á., Brandenburg, C., Allex, B., Ziener, K., Wrbka, T., submitted. Assessment framework for landscape services in European cultural landscapes – an Austrian Hungarian case study. Ecological Indicators x.

Hoechstetter, S., 2009. Enhanced methods for analysing landscape structure: Landscape metrics for characterising three-dimensional patterns and ecological gradients. Rhombos-Verlag.

Höfle, B., Hollaus, M., Lehner, H., Pfeifer, N., Wagner, W., 2008. Area-based parameterization of forest structure using full-waveform airborne laser scanning data. Presented at the SilviLaser 2009, in Edinburgh (UK), 17-19.09.2008.

Höfle, B., Mücke, W., Dutter, M., Rutzinger, M., Dorninger, P., 2009. Detec-tion of building regions using airborne lidar a new combination of raster and point cloud based GIS methods. In: Geospatial Crossroads @ GI_Form '09 - Proceedings of the Geoinformatics Forum Salzburg. 2009, pp. 66 - 75.

Höfle, B., Hollaus, M., 2010. Urban vegetation detection using high density full-waveform airborne lidar data-combination of object-based image and point cloud analysis. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences 38(7B), pp. 281-286.

Höfle, B., Hollaus, M., Hagenauer, J., 2012. Urban vegetation detection using radiometrically calibrated small-footprint full-waveform airborne lidar data. ISPRS Journal of Photogrammetry and Remote Sensing 67(0), pp. 134-147.

Hollaus, M., Mücke, W., Höfle, B., Dorigo, W., Pfeifer, N., Wagner, W., Bauerhansl, C., Regner, B., 2009. Tree species classification based on full-waveform airborne laser scanning data. Presented at the 9th International Silvilaser Conference, 14-16 October 2009, Texas A&M University (USA). In: Proceedings of SilviLaser 2009. 2009, pp. 54-62.

Hollaus, M., Mandlburger, G., Pfeifer, N., Mücke, W., 2010. Land cover de-pendent derivation of digital surface models from airborne laser scanning data. In: Bretar, F., Pierrot-Deseilligny, M., Vosselman, G. (Eds): Laser scanning 2009. IAPRS, Vol. XXXVIII, Part 3/W8 – Paris, France, 1-2 September 2009.

Hollaus, M., Aubrecht, C., Höfle, B., Steinnocher, K., Wagner, W., 2011. Roughness mapping on various vertical scales based on full-waveform airborne laser scanning data. Remote Sensing 3(3), pp. 503-523.

INSPIRE Thematic Working Group *Coordinate reference systems and Geographical grid systems*, 2009. D2.8.I.2 INSPIRE Specification on Geographical Grid Systems – Guidelines. http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_Specification_GGS_v3.0.pdf

Jenness, J. S., 2004. Calculating landscape surface area from digital elevation models. Wildlife Society Bulletin 32(3), pp. 829-839.

Jungmeier, M., Zollner, D., 2005. Biosphere Reserves in Austria - Grundlagenerhebung und Stand der Forschung. Study by order of the Austrian MAB committee of the Austrian Academy of Sciences. DOI: 10.1553/biosphere_reserves.

Kiemstedt, H., Bechmann, A., Heitmsann, G., Hoerschelmann, O., Hultsch, E., Muhs, C., Meyer, E., 1975. Landschaftsbewertung für Erholung im Sauerland. Teil I: Textband, Dortmund (Schriftenreihe Landes- und Stadtentwicklungsforschung des Landes Nordrhein-Westfalen. Band1.008/I).

Konkoly-Gyuró, É., Tirászi, A., Wrbka, T., Prinz, M., Renetzeder, C., 2010. Der Charakter grenzüberschreitender Landschaften (The character of transboundary regions). University of Western Hungary, ISBN 978-963-9883-53-6, Sopron. [in German and Hungarian]

Kraus, K., Pfeifer, N., 1998. Determination of terrain models in wooded areas with airborne laser scanner data. ISPRS Journal of Photogrammetry & Remote Sensing 53(4), pp. 193-203.

Kronen Zeitung, 2011. Biosphärenpark „Neusiedler See“ – UNESCO fordert Konzept. Sorge um Schutzgebiet wächst -Land muss endlich handeln!. In: Kronen Zeitung, Dec. 13th 2011, p. 21.

Krutzler, D., 2012. UNESCO-LABEL. Dem Neusiedler See droht die Abwertung. In: Der Standard, Jan. 18th 2012; Source: http://derstandard.at/1326503106962/Unesco-Label-Dem-Neusiedler-See-droht-die-Abwertung, February 2012.

Kuttner, M., Hainz-Renetzeder, C., Hermann, A., Wrbka, T., in press. Borders without barriers – Structural functionality and green infrastructure in the Austrian-Hungarian transboundary region of Lake Neusiedl. Ecological Indicators x.

Landeshauptstadt Dresden, Umweltamt (Hrsg.), 2007. Umweltatlas Dresden - 2.10 Bewertung der Erholungseignung – Karte und Erläuterungen. URL: http://www.dresden.de/de/08/03/01/04/c_0330.php, 2.11.2009.

Layke, C., 2009. Measuring Nature’s Benefits: A Preliminary Roadmap for Improving Ecosystem

Levin, S.A., 1992. The Problem of Pattern and Scale in Ecology. Ecology 73, 1943–1967.

Limburg, K.E., O’Neill, R.V., Costanza, R., Farber, S., 2002. Complex systems and valuation. Ecological Economics 41, 409–420.

Lin, Y. C., Mills, J. P., 2009. Integration of full-waveform information into the airborne laser scanning filtering process. In: Bretar, F., Pierrot-Deseilligny, M., Vosselman, G. (Eds): Laser scanning 2009. IAPRS, Vol. XXXVIII, Part 3/W8 – Paris, France, September 1-2, 2009.

Mandlburger, G., Briese, C., Pfeifer, N., 2007. Progress in lidar sensor technol-ogy-chance and challenge for DTM generation and data administration. In: Fritsch, D., (Ed.), 2007. Proceedings of the 51th Photogrammetric Week. Her-bert Wichmann Verlag, Stuttgart, pp. 159-169.

Marks, R., Müller, M., Leser, H., Klink, H.-J., 1992: Anleitung zur Bewertung des Leistungsvermögens des Landschaftshaushaltes. Forsch. Z. dt. Landeskde, Bd. 229. Zentralausschuß für deutsche Landeskunde, Trier.

MEA Millennium Ecosystem Assessment, 2003. Ecosystems and Human Well-being: A Framework for Assessment. Island Press, Washington (DC).

MEA Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well Being. Island Press.

Mönnecke, M., Wasem, K., 2005. Anleitung zur Berücksichtigung der Naherholung in der kommunalen Planung, Rapperswil. URL: http://www.arp-daten.bl.ch/arpdaten/publikationen/anleitung-naherholung_2006.pdf, 5.11.2009.

Mücke, W., Briese, C., Hollaus, M., 2010a. Terrain echo probability assignment based on full-waveform airborne laser scanning observables. International Ar-chives of the Photogrammetry, Remote Sensing and Spatial Information Sci-ences 38, pp. 157-162.

Mücke, W., Hollaus, M., Prinz, M., 2010b. Derivation of 3D landscape metrics from airborne laser scanning data. Presented at the 10th International Confer-ence on LiDAR Applications for Assessing Forest Ecosystems (Silvilaser 2010), in Freiburg (D), 14– 17 September 2010. In: Silvilaser 2010. 2010, 11.

Neusiedler See Tourismus GmbH (ed.), 2008a. Rad, Natur und Weltkultur (Radwegekarte).

Neusiedler See Tourismus GmbH (ed.), 2008b. Touren für Aufsteiger (Reitwegekarte).

Niklfeld, H., 1970/89. Natürliche Vegetation. In: Breu, J. (ed.). Atlas der Donauländer, p. 171 .

OPALS, 2012. Opals - orientation and processing of airborne laser scanning data. Available online at http://www.ipf.tuwien.ac.at/opals/html/index.html. Accessed on 24.05.2012.

Perez-Soba, M., Petit, S., Jones, L., Betrand, N., Briquel, V., Omodei-Zorini, L., Contini, C., Helming, K., Farrington, J.H., Mosselo, M.T., Wascher, D., Kienast, F., de Groot, R.S., 2008. Land use functions – a multifunctionality approach to assess the impact of land use change on land use sustainability. In Helming, K., P´erez-Soba, M., Tabbush, P., eds., Sustainability Impact Assessment of Land Use Changes, pp. 375–404, Berlin; New York (Springer).

Poole, G.C., 2002. Fluvial landscape ecology: addressing uniqueness within the river discontinuum. Freshwater Biology 47, 641-660.

Pötke, P.-M., 1979. Der Freizeitwert einer Landschaft. Quantitative Methode zur Bewertung einer Landschaft für Freizeit und Erholung, Trier (Materialien für Fremdenverkehrsgeographie, Heft 2).

RIEGL, 2012. Riegl - lms q680i. Available online at http://www.riegl.com/nc/products/airborne-scanning/produktdetail/product/scanner/23/. Accessed on 25.04.2012.

Ruppert, K.L., 1971. Zur Beurteilung der Erholungsfunktion siedlungsnaher Wälder. Mitteilungen der Hessischen Landesforstverwaltung Bd. 8, 142.

Seppelt, R., Dormann, C. F., Eppnik, F. V., Lautenbach, S., Schmidt, S., 2011. A quantitative review of ecosystem service studies: approaches, shortcomings and the road ahead. Journal of Applied Ecology 48, 630-636.

Swanwick, C., 2002. Landscape Character Assessment - Guidance for England and Scotland; The Countryside Agency and Scottish Natural Heritage.

TEEB (ed.), 2010. TEEB - The Economics of Ecosystems and Biodiversity for Local and Regional PolicyMakers.
http://www.teebweb.org/ForLocalandRegionalPolicy/localandRegionalPolicyMakersChapterDrafts/tabid/29433/Default.aspx.

Termorshuizen, J.W., Opdam, P., 2009. Landscape services as a bridge between landscape ecology and sustainable development. Landscape Ecology 24, 1037–1052.

Umlandverband Frankfurt (UVF) (Hrsg.), 2000. Landschaftsplan des Umlandverbandes Frankfurt, Band II: Bestandsaufnahmen und sektorale Bewertungen, Erläuterungen für das Gebiet des Umlandverbandes, Frankfurt. URL: http://www.planungsverband.de/media/custom/1169_653_1.PDF?1144980611, 16.10.2010.

UNESCO (Hrsg.), 1996. Biosphärenreservate: Sevilla-Strategie und die Internationalen Leitlinien für das Weltnetz, Bundesamt für Naturschutz, Bonn.

UNESCO – MAB Secretariat, 2010. Biosphere Reserves World Network. URL: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_mab_BRList2010_EN.pdf, 20.6.2012.

Verburg, P.H., van de Steeg, J., Veldkamp, A., and Willemen, L., 2009. From land cover change to land function dynamics: A major challenge to improve land characterization. Journal of Environmental Management 90, 1327–1335.

Wagner, W., Ullrich, A., Ducic, V., Melzer, T., Studnicka, N., 2006. Gaussian decomposition and calibration of a novel small-footprint full-waveform digitis-ing airborne laser scanner. ISPRS Journal of Photogrammetry & Remote Sens-ing 60(2), pp. 100-112.

Wallace, K.J., 2007. Classification of ecosystem services: problems and solutions. Biological Conservation 139, 235–246.

Walz, U., Berger, A., 2004. Analyse der Auswirkungen des Landschaftswandels auf die Erholungseignung. In: Strobl, J, Blaschke, T und Greisebner, G. (Hrsg.): Angewandte Geoinformatik 2004, Beiträge zum 16. AGIT-Symposium Salzburg 2004, S. 760-759, Heidelberg. URL: http://www2.ioer.de/recherche/pdf/2004_walz_berger_agit.pdf, 1.11.2009.

Willemen, L., Hein, L., van Mensvoort, M.E.F., Verburg, P.H., 2010. Space for people, plants, and livestock? Quantifying interactions among multiple landscape functions in a Dutch rural region. Ecological Indicators 10, 62–73.

Wrbka, T., Hainz-Renetzeder, C., Kuttner, M., Hermann, A., Brandenburg, C., Ziener, K., Allex, B., Liebl, U., Czachs, C., Konoly-Gyuró, É., Tirász, Á., Balázs, P., Bacsárdi, V., 2012. Biodiversity and Ecosystem Services as scientific foundation for the sustainable implementation of the Redesigned Biosphere Reserve “Neusiedler See”. Report OEAW, Wien.

Wu, J., Loucks, O.L., 1995. From Balance of Nature to Hierarchical Patch Dynamics: A Paradigm Shift in Ecology. The Quarterly Review of Biology 70, 439-466.

Zweckverband Großraum Braunschweig (ed.), 2008a. Regionales Raumordnungsprogramm für den Großraum Braunschweig 2008. Beschreibende Darstellung, Braunschweig. URL: http://www.zgb.de/barrierefrei/misc/downloads/RROP2008_Beschreibende Darstellung.pdf, 2.11.2009.

Zweckverband Großraum Braunschweig (ed.), 2008b. Regionales Raumordnungsprogramm für den Großraum Braunschweig 2008 – Begründung, Braunschweig. URL: http://www.zgb.de/barrierefrei/misc/downloads/RROP2008_Begr%FCndung.pdf, 2.11.2009.

Homepages:

Market-based instruments for ecosystem services: http://www.ecosystemservices.de/, 20.6.2012

World Network (WNBR) I United Nations Educational, Scientific and Cultural Organization: http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/world-network-wnbr/, 20.6.2012.