Green-blue veining and landscape services as a potential alternative to the robust corridor strategy

A THESIS STUDY IN COLLABORATION WITH
WAGENINGEN UNIVERSITY AND PROVINCE OF GELDERLAND

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Abstract

In 2011 the Dutch government announced major budget cuts on its programme to create robust corridors between nature reserves, called the National Ecological Network (NEN). Due to this, there is a need for an alternative to the robust corridor strategy; one that fits better in the current political and economic climate in the country. An opportunity could be found in a network of small-scale semi-natural elements between agricultural fields, known as green-blue veining. In this research the potential for green-blue veining and landscape services as an alternative to the robust corridor strategy are investigated.

This thesis outlines some of the necessary configuration requirements of a multifunctional green-blue veining structure. The ecoprofile approach, is in this thesis used as a tool to investigate these necessary configuration requirements for multiple species. The ecoprofile approach is based on three dimensions; the ecosystem type, the ecosystem area requirements, and the configuration of the ecosystem; making it a comprehensive approach in finding necessary spatial conditions for a multifunctional green-blue veining network.

With the requirements of two selected ecoprofiles, a checklist has been developed containing habitat requirements and other spatial norms for the two ecoprofiles. This checklist functions as the basis for an ArcGIS model, which generates an overview of the concentration of landscape elements in the entire case study area and presents it in a raster map made up by a 1x1 kilometer grid. The outcome of this analysis, is a map for every ecoprofile, giving an interpretation of the pattern of landscape elements in terms of providing connectivity in the current situation as well as providing an indication of the suitability of the current landscape as a green-blue veining corridor. In locations with a cluster of high concentration raster squares, of >10% concentration of landscape elements, it is assumed that the current situation is appropriate for the dispersal of the species in the ecoprofile. In this way, areas which require adaptation measurements can be selected.

In a focus case study area, a more detailed analysis of the concentration of landscape elements and landscape services is conducted. A rating, based on the dependency of landscape services on the landscape elements, indicates which landscape services are most dependent on landscape elements. Four criteria are the basis for a proposed green-blue veining network: following moderate and strong levels of seepage; connecting high concentration areas along the corridor route; connecting key habitat areas of both ecoprofiles; and the possibility of a stepping stone after 7,5km of corridor. With these criteria a planning concept of a green-blue veining network has been proposed, encompassing a core zone and a buffer zone. The core zone has a more natural shape, containing minor forms of extensive agricultural, whereas the focus in the buffer zone is limited to only the linear landscape elements along (intensive) agricultural fields. By implementing linear landscape elements, multiple landscape services can be added and improved in the area. The 7% regulation in the reformed Common Agricultural Policy 2014-2020 opens great chances for the development of green-blue veining.

The proposed integration of land uses requires a collaborative planning approach. By focusing on the various benefits in landscape services coming from the linear landscape elements; spatial planners can take a strategic position in collaborative stakeholder meetings, which can help to generate support for a large and multifunctional green-blue veining network as an alternative to the robust corridor strategy.

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Foreword

While doing an internship and graduation assignment in Malaysia for my Bachelor degree, I was confronted with the importance of ecological connectivity. It was very shocking to see the effects of fragmentation by developments, new infrastructure and switches in land use in and around National Parks. These experiences during my study at Van Hall Larenstein Velp have persuaded me to carry on in the subject of defragmentation measurements. After my bachelor graduation I decided to start a Master study with a specialization in spatial planning in order to gain further knowledge in this topic. During my Master study I focus on gaining both theoretical knowledge and practical experience in the ecological connectivity topic, this by combining my thesis work with contemporary connectivity topics in the Netherlands.

This report is the outcome of a minor thesis project (24 ects) and forms a part of my MSc Landscape Architecture and Planning programme at Wageningen University. The thesis has been conducted in collaboration with the Province of Gelderland and the University of Wageningen (WUR). This project generates a methodology for the implementation of landscape services in green infrastructure; therefore it also contributes as a source of information for the GIFT-T! programme (Green Infrastructure For Tomorrow - Together!). This interreg project develops methods for sustainable development of landscapes by means of green infrastructure and landscape services. INTERREG IVB NWE is a financial instrument of the European Union's Cohesion Policy (http://nweurope.eu/).

In this research the potentials of green-blue veining as a means to create habitat connectivity are investigated. An important aspect in this research is the possibility of implementing multifunctional landscape services in green-blue veining. The in 2010 announced major budget cuts on the NEN-programme request a renewed and fresh look on the NEN-programme with alternative forms of habitat connectivity in the landscape.

The aim of this report is to provide the Province of Gelderland with an alternative approach for the creation of ecological corridors. The research focusses on a pilot area, this is the potential international corridor between the Veluwe and Germany. In this area many projects are executed to improve the landscape and environment, but so far connectivity between the reserves requires additional attention. In order to help species survive, corridors have to be established. This research investigates the potentials of an alternative form of connectivity between nature reserves, one which is not based upon the robust corridor strategy but which constitutes out of finer landscape elements, also familiar as green-blue veining.

Don’t hesitate to contact the author with questions or remarks about this report.

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Table of Contents

List of figures

List of tables

Introduction

The Netherlands is a country with a high population density. Due to a variety of conditions such as pollution, drought, excavation activities, road developments, urban growth and agricultural intensification the quality and quantity of ecosystems deteriorated significantly. These conditions caused a rapid change of the landscape, which altered into a patchy and human dominated shape. This research focusses on the physical alteration of the landscape. Many nature areas on land are now disconnected from surrounding nature areas due to a matrix of other forms of land use than nature. Human use of the landscape consequently led to large-scale fragmentation of habitats, causing a loss of biodiversity (Grashof-Bokdam et al. 2008). Species populations tend to fluctuate due to a variety of causes in relation to weather conditions, requiring the possibility for species to recover from those events in order to sustain (Opdam et al. 2005). Together with the above mentioned fluctuation comes another worry, namely climate change. The effects coming from fluctuations in temperature; rainfall; drought; frequency of extremes; and the introduction of invasive species, are difficult to predict accurately yet it is known that without a cohesive network some species will find difficulties in the migration towards suitable habitat (Vonk et al. 2010). Large scale ecological networks are necessary to maintain viable populations. Proper landscape connectivity will give species a better chance of survival in the long term. Moreover, the impact of climate change may be decreased if landscapes are well connected (Van der Sluis et al. 2004). In order to create ecological connectivity between nature reserves, the National Ecological Network (NEN) was introduced in the 90's. The aim of this programme was to create cohesive networks of nature. Halfway the NEN-programme, in 2000, an evaluation of the implementation of the programme showed that the expected spatial cohesion would still be insufficient, because the protected areas were too small and insufficiently connected (Opdam et al. 2008). The NEN-programme was therefore extended with the robust corridor strategy. Last year the Dutch government announced a major budget cut in this NEN-programme, which has its effects on the development of a cohesive network in the Netherlands. Decentralization is also a part of the change in the programme, meaning that all twelve provinces can individually decide on how and in which extent they fulfill the NEN-programme, either with or without the robust corridors being a part of the programme. Which form this adapted NEN-programme is going to get, is so far still uncertain. However, it is likely that the 60% budget cut is going to force the provinces towards withdrawal of the robust corridor programme due to the financial constraints. With this massive budget loss in mind, there is a great need for an alternative to the robust corridor strategy; one that fits better in the current political and economic situation of the Netherlands. One approach which could fit better in this situation in the Netherlands, is based upon green-blue veining. This approach builds on small-scale semi-natural (fine) elements like field margins, road verges, ditch banks, hedgerows and small woodlots that surround agricultural fields and is a part of the matrix landscape that surrounds nature reserves (Grashof-Bokdam et al. 2008). Grashof-Bokdam et al. 2008 proposed that a synergy of mutual benefits generates from a combination of nature reserves and green-blue veining, this by influx of colonizing offspring from the nature reserves to green-blue veining, while green-blue veining supports nature reserves with temporary habitat and increasing matrix permeability by facilitating dispersal or foraging. The finer element features of green-blue veining also provide other landscape services in addition to habitat extension, for example pest control; recreation opportunities; water filtering and water retention opportunities. Green-blue veining is therefore in this research understood as a multifunctional concept for the adaptation of the landscape in order to enable dispersal of species. It is a concept that could possible join the various landscape services into one cohesive structure. Because of this multifunctional character of green-blue veining, it is likely that it fits better in both the current economic and current political situation of the Netherlands.

The objective of the research is to investigate the potentials for the green-blue veining concept as an alternative to the robust corridor strategy (NEN-programme); this will be done by investigating the configuration requirements of green-blue veining as a corridor in the landscape and by exploring the benefits coming from multifunctional landscape services within green-blue veining. The research will make use of a case study, which is the ecological network from the Veluwe towards the border near Winterswijk.

The general research question of this research is;

"What configuration is required for the implementation of green-blue veining as a corridor in the landscape and what benefits in the form of multifunctional landscape services result from the development of green-blue veining?"

This fairly comprehensive research question has been split up into the following sub-questions;

- What are the characteristic landscape elements within green-blue veining?
- Which locations in the case study area require a development of green-blue veining in order to create a corridor in the landscape for the ecoprofiles?[1]
- Is the current structure of green-blue veining appropriate for the ecoprofiles and if not what landscape elements are necessary to implement?
- What landscape services could potentially be provided by green-blue veining?
- What approach for stakeholder communication should be taken, seen the supply and demand for landscape services?

Reading guide

In the first chapter of this report scientific literature is analyzed and policy documents of the Province of Gelderland are investigated in order to obtain information about the research topic and to establish a theoretical framework. In the second chapter a theoretical basis for the research methodology is provided. This second chapter starts with an explanation about the ecoprofile concept and an explanation about green-blue veining. Then, a list of ten selected potential ecoprofiles is provided and from this selection, two suitable ecoprofiles are chosen for the continuation of the research. This chapter also provides an overview of the present ongoing projects in the case study area.

The third chapter of this report starts with the identification of landscape elements in the case study area. The requirements of the landscape elements are related to the two chosen ecoprofiles from chapter two. This will result in an overview of landscape elements in the case study

[1] Further clarification on the definition of an ecoprofile in Ch. 2.1

area, which will be presented in a rating map, which shows an interpretation of the pattern of landscape elements in terms of providing connectivity in the current situation to the selected ecoprofiles. This will give an indication about the suitability of the present landscape to function as a green-blue veining corridor. The third chapter ends with the selection of a focus case study area for the continuation of the research.

In the fourth chapter there will be zoomed-in on the focus case study area. The current situation in the focus case study area will be tested with the requirements of the ecoprofiles, this in order to find the missing landscape elements in the area. This is done to gain a more detailed understanding about the requirements of the landscape to fulfill the function of a corridor for the ecoprofiles. Chapter four also contains the link with the landscape services. The focus case study area will be tested upon the availability of landscape services and its relation with the landscape elements. This will give an indication about the dependency of landscape services on landscape elements. The fourth chapter will give insight in what is currently present in the focus case study area and what is missing in order to function as a green-blue veining corridor.

In chapter five, the landscape adaptation measurements for the two ecoprofiles will be presented. The overview of required landscape elements from chapter four will be used to design a landscape which suits the requirements of the ecoprofile and provides multiple landscape services from the above described dependency rating. Landscape elements which are associated with a landscape service are used for the adaptation of the landscape. Chapter five will give an idea about the opportunities of green-blue veining in the focus case study area and functions as a strategy for landscape adaptation of the selected ecoprofiles. In this chapter, a link will be made with the 'Common Agricultural Policy 2014', which will be used for the proposed solutions for the ecoprofiles.

Chapter six links the proposed adaptation measurements with the supply and the demand for landscape services. In this chapter a recommendation about a strategic approach for stakeholder communication is given.

Chapter seven is the conclusion of the thesis. Some additional recommendations on the configuration of green-blue veining as landscape adaptation for dispersal of species, will as well be given in this chapter.

Study area

This research is conducted by means of a case study area. The study area lies in the (north)east of the Province of Gelderland. The case study area encompasses the landscape between the Veluwe, the ecological transition zone of the Veluwe called Soerense poort (national park Veluwezoom towards the river IJssel), the stream corridor of the Baakse Beek and the landscape around Winterswijk (see fig.1). The land use in this area of the Netherlands is dominated by intensive agriculture, predominantly dairy production, and is intertwined with different nature reserves and estates.

The eastern part of this area is known for its cultural-historic character of small-scale agriculture mixed with nature areas (Valbuena 2010). Small streams entwine in forests, peat lands and agricultural fields form a great variation of landscape types around the town Winterswijk and the border area with Germany. Old farmstead landscapes with small meadows, hedgerows and field margins are mixed with forests and streams.

The middle part of the case study area is known for the stream area of the Baakse beek and its surrounding riparian forests. The surrounding landscape consists largely out of grassland.

The western area of the case study area, the so called "Gateways", form the link between the forests of the national park Veluwezoom and the river landscape of the Ijssel. The area constitutes out of a semi-agricultural landscape where estates are interwoven with small forests and agricultural activities. This area is important as both cultural heritage, agriculture land and contains special types of natural areas due to the high quality of seepage water from underground aquifers. The different Gateways, also form an important linkage between the Veluwe and on the other side of the river IJssel; the Achterhoek (Provincie Gelderland 2009).

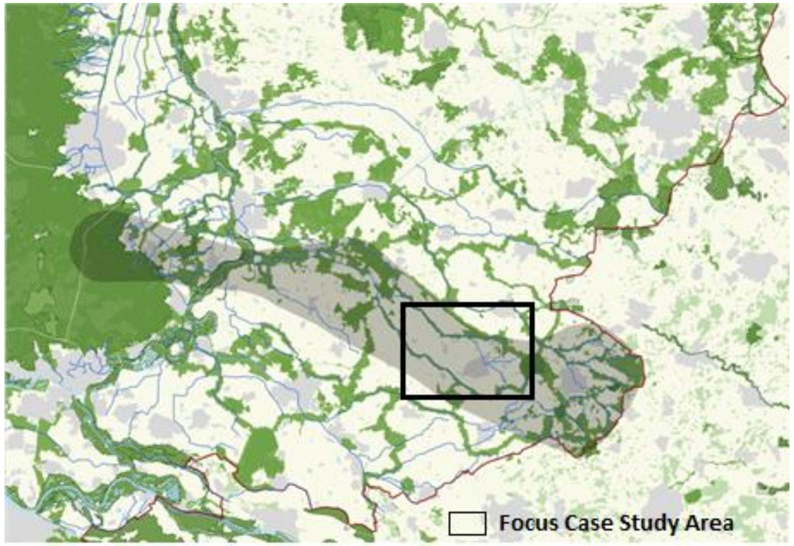

Figure 1. The light grey zone is the case study area. The dark square is the focus case study area of chapter 4, 5 and 6
(source: Province of Gelderland)

1. Theoretical context: Land-use change and biodiversity conversation

This chapter outlines some of the key definitions and background theory about ecological connectivity; constructing a framework of literature for this research. The aim of this chapter is to deliver sufficient information to support the choices and conclusions in the next chapters and to clarify reasoning behind the chosen methodology of the different phases in the research. This chapter has been created through a selection of main themes within that of the research topic.

1.1 Ecological context: fragmentation and dispersal

One of the first theories about the abundances of species was from MacArthur & Wilson (1967), suggesting that species numbers on islands is set by an equilibrium between immigration rates and extinction rates. Species immigrate into an island as a result of dispersal of colonists from other islands; more remote islands thus means lower immigration rates. Their work builds on the first principles of population ecology and genetics to explain how distance and area combine to regulate the balance between immigration and extinction in island populations (MacArthur & Wilson 1967). Later this theory was studied by conducting several experiments around colonization. Their suggestions was soon by other ecologists applied to natural habitats on land. Whittaker noted: "In contrast to most island species, ideals from island biogeography have successfully colonized the continents, in application to the problem of fragmentation and loss of habitats" (Lomolina et al. 2004). One of the first suggestions on defragmentation, connectivity and habitat linkages came around 1975, primarily focusing on island recolonisation as well as firstly recommending corridors for the increase in dispersal rates (Diamond 1975). This leaded to the development of metapopulation theory (Donald & Evans 2006); defined as spatially structured sets of populations, vulnerable to extinction, connected by dispersing individuals and framed by changes in habitat suitability (Wilcox et al. 2006). In other words the metapopulation is an interaction between extinctions and recolonisation of species from and to habitat patches (or islands), depending on the dispersal suitability of the landscape. In metapopulations individual populations may go extinct, but they can be recolonized from other populations; if the survival of surrounding populations are also threatened and movement between these populations is impossible, serious genetic problems may develop for maintaining the species (Barnes 1998).

Species in agricultural landscapes often occur in so called source-sink situations. Small patches of marginal habitat, known as sinks, are supported by larger patches of high quality habitat; the source (Foppen et al. 2000). Barnes (1998) shows that the impossibility of species movement could lead to extinction of a population, depending on whether they exhibit a source or sink patch of a

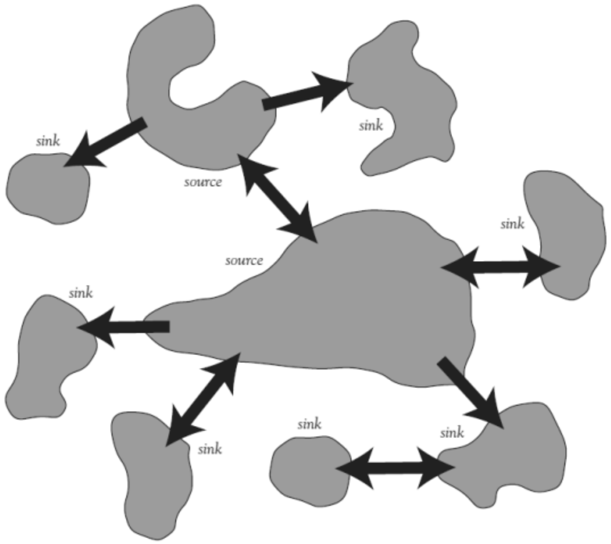

Figure 2. Contribution of source-sink situations to the maintenance of species
(Source: Barnes 1998)

metapopulation (see fig. 2). On the other hand a sink can in some occasions contribute to the stability of sources and encourage larger metapopulation size and larger source population size (Foppen et al. 2000). The study conducted by Foppen et al. (2000) recommends planners to note the importance of small (seemingly unimportant) landscape elements, because of their contribution to the viability of larger patches. Sinks could in some cases function as a buffer for the source. This indicates that an alteration of the landscape structure may interrupt the equilibrium of a metapopulation (Moilanen & Hanski 1998). The dispersal flow of species depends on the configuration of the landscape, which has different effects for different species (Opdam 1991). Completely isolated populations will go extinct if reproduction is lower than mortality plus emigration (Opdam 2002). Dispersal prevents extinction, but is dependent on matrix permeability.

Many species are vulnerable to fragmentation of their habitat. In this research a habitat is seen as the resources and conditions present in an area that produce occupancy by a given species (Hall et al. 1997), which indicates the existence of a relation between species and the features of an area. Habitat fragmentation can then be defined as a set of mechanisms leading to the discontinuity in the spatial distribution of resources and conditions present in an area at a given scale that affects occupancy, reproduction and survival in a particular species (Franklin et al. 2002). Fragmentation is caused by barriers such as highways and roads, urban areas, inaccessible agricultural land, or by a decrease of landscape elements (Jongman 2002). Fragmentation has so far been described as negative for the survival of biodiversity. However, for some non-forest species fragmentation could lead to positive effects when their ecological requirements are fulfilled, due to for example increased foraging and roosting sites for birds (Ethier & Fahrig 2011), while for species restricted to the original forest the habitat is dissected into patches, leading to negative effects and even creating barriers for some (Opdam 1991). This research focusses on species finding negative effects from fragmentation. For most species roads, large monotone agricultural areas and urban areas become obstacles which are impossible to cross. Ultimately this process of isolation and population extinction due to the fragmentation, can lead to reduction of biodiversity (Rosenberg et al. 1997).

Another important factor that can have profound effects on populations is climate change due to temperature rise, rainfall changes, drought and increased number of weather extremes. The rate of which climate change together with the change in land cover is occurring; is threatening the persistence of many species (Davis & Shaw 2001). A study by Opdam & Wascher (2003) explains the risk to biodiversity coming from climate change and habitat fragmentation, recommending three features: stabilization of key areas for regional recovery; heterogeneity in the landscape for less vulnerable populations; and increased permeability of the landscape.

1.2 Connectivity

A study by Odum & Barrett (2004), clarifies the difference in ecological levels and hierarchy: every level consists out of groups of lower-level units (populations are composed of groups of organisms, for example). For this thesis study it is important to note that the community and the nonliving environment together functions as an ecological system, explaining the term ecosystem (Odum & Barrett 2004). A landscape can therefore be defined as a heterogeneous area composed out of a mosaic of interacting ecosystems. A landscape is thus not defined by size, but by interaction by of ecological processes.

As Opdam & Wascher (2003) suggested; landscape connectivity is important to stop the process of population decline and to sustain interaction between species. This can be reached through the implementation of corridors for connectivity in the matrix between otherwise isolated patches. A corridor is a linear landscape element that provides for movement between habitat patches (Rosenberg et al. 1997) and creates connectivity in the landscape between habitats of a given species. There are diverse definitions about landscape connectivity; they vary from landscape structural based definitions such as "degree to which the landscape facilitates or impedes movement among resource patches" (Taylor et al 1993) to more biological built definitions as "functional relationship among habitat patches, owing to the spatial contagion of habitat and the movement responses of organisms to landscape structure"(With et al. 1997). Both factors; structure and species, require attention and therefore should be included in any research about connectivity. With et al. 1997 notes that the key to understanding impact of landscape patterns on populations is to take an organism-centered viewpoint. Many studies on the influence of landscape structure on species suggest that either heterogeneity, or connectivity, or area of semi-natural elements has a positive influence on species richness and abundance (Billeter et al. 2008). Corridors facilitate biological processes such as dispersal, migration and regular movement of animals and as such, corridors strengthen the spatial cohesion of the network of habitat patches, which is crucial to the survival of many species (Van der Sluis et al. 2004). Stepping stones enhance the connectivity in the landscape for fragmented populations (Baum et al. 2004). Barnes (1998) shows that colonization is from a source island to a target island, this via sink islands (or stepping stones). Corridors are shaped as a strip of habitat; stepping stones however, are not contiguous areas of habitat, but instead shaped as a habitat patch (or island). Even minute islands (stepping stones) can enhance the dispersal of species significantly (MacArthur & Wilson 1967). A habitat network is in this context seen as a collection of semi natural patches of habitat, embedded in a matrix of nonhabitat, in which the habitat conditions for a particular species are realized (Opdam 2002). The efficiency of corridors and stepping stones is higher when implemented in a low-resistance matrix compared to a high-resistance matrix (Baum et al. 2004). It is important that corridors are made for the movement of a particular species or a group of species; they should be tailor-made (Van der Sluis et al. 2004), meaning that the individual demands of species are taken into account during the development of a corridor. Movement between patches can only be ascertained by analyzing landscapes from the perspective of species and making sure that the landscape elements that allow each species to move, exists in the required spatial scale and pattern (Kettunen 2007). In a multifunctional planning context single-species approaches are inappropriate (Opdam et al. 2008). Landscapes are planned for biodiversity instead of a single species, it is therefore necessary to use a tool that integrates a variety of requirements of species (Opdam et al. 2003) (more in Ch. 2.1).

1.3 Land consolidation and effects for the Netherlands

Landscapes can be defined from the perspective of biodiversity and from a human perspective in terms of land-use types. In most literature these two viewpoints on landscape are kept separate. In biological terms landscapes are often related to interaction between spatial patterns and ecological processes, this while most of us think about landscapes in terms of land-use types (agriculture, urban, wetland etc.) (Turner et al. 2001;). There are many possible definitions about a landscape; in this research a human-biological merged perspective on landscape is used; this can be defined as; area of human altered land containing a distribution of landscape elements and remains of habitat patches which affects the occurrence of species and the facilitation of landscape services to humans. This perspective on landscape is formed through the scope of the research, focusing on the Dutch countryside which is strongly human-influenced.

During the twentieth century the Netherlands significantly intensified in land-use practices which led to a massive loss of semi-natural habitats and fine structured agricultural landscapes. The appearance of the country rapidly changed as the demand increased for more efficient and faster forms of working methods on agricultural land in the country. The most important shift in the history of land alterations is the agrarian depression in the beginning of the twentieth century which led to modernization of small farmers, later to price and production regulation and after 1954 to large scale land consolidation (Bergh 2004). During that time the influence on the appearance of the land was connected to alteration of farmland for increased crop productivity, this through land consolidation of fragmented agricultural land. The process of land consolidation was concerned with both enlargement of farm parcels, the improvement of accessibility of land, water control in the form of canalizing streams and improving drains and also enlargement of farmland holdings. Removal of natural areas encompassed land consolidation, leaving only small remnants of natural landscape behind. These small remnants of natural land are also known as patches. Patches can be defined as relatively homogenous areas that differ from surrounding land (Levin 2009). A variety of these patches (or multiple elements) creates heterogeneity within the landscape (Gutzwiller 2002). The nonhabitat environment between patches is called the matrix (Ricketts 2001) and the whole spatial configuration of habitats within a landscape formed by patches arranged within a matrix is called a landscape mosaic (Kettunen 2007). The matrix between remnants of forest is alien to almost all members of the forest, however some greatly benefit from the increase in the total amount of edge (Haila 2002).

Landscapes continuously change through time due to new practices associated with economics, ecology, culture and politics. At first the wish for economic and agriculture improvements enforced land consolidation in the Netherlands, however nowadays this is connected to the demand for non-agricultural space and improving the general spatial quality by integrated implementation for nature, creation, landscape, cultural history and water (Brink 2004). As a result of the intensification of agricultural production, as well as the construction of infrastructure and increased urban environment; there is a distortion in the relation between the natural landscape elements and agricultural activities leading to a removal of the equilibrium between nature, landscape and man (Chung 1994). Harms et al. (1987) stated this as; "..we are faced with the special situation of a small and crowded country with an extremely productive agriculture and an environment that is stressed by it".

During the land consolidation many natural elements in the landscape were removed for improved farmland efficiency; in recent times it became clear that many of these smaller landscape elements such as field margins (Vickery et al. 2001; Berendse et al. 2004; Marshall & Moonen 2002); hedgerows (Barr et al. 1995); riparian zones (Jongman et al. 2002); tree lines; forest edges; remnant habitat patches, ditch verges and road verges (Tsipe et al. 2008; Marshall & Moonen 2002) have an important function for biodiversity. The developments described above has had serious effects on the natural environment in the Netherlands, causing diversity of species of plants and animals to drop as their ecosystems deteriorated critically and the landscape increasingly fragmented. Studies have showed that landscape elements are important for many species of plants, invertebrates, amphibians, reptiles, mammals and birds and as linear elements in the landscape they also function as corridors for the movement of flora and fauna (Berggren et al. 2001; Marshall & Moonen 2002; Geert et al. 2010; Tewksburry et al. 2002). Negative effects on biodiversity continued in the second half of the twentieth century and landscape elements continued to disappear for further intensification of land use.

In 1990 the loss of natural area started to reverse, because of the introduction of nature reserves, agri-environmental schemes and organic farming (Veen et al. 2008). It was in this period of time that the importance of ecological connectivity amongst habitat remains started to rise in the Netherlands and a programme was introduced for the implementation of ecological networks, called the National Ecological Network (NEN).

1.4 NEN programme

During the period of the decline of nature areas in the Netherlands, researchers, governments and politicians started to consider the conservation and enhancement of nature in the late 70s. In the early 80s the provinces developed reports about agricultural land with high potential for the conservation and development of nature reserves. Around 1985 these reports contributed to the concept of an ecological network of nature reserves throughout the entire country. The reckless decline of nature in the Netherlands encouraged politicians to start a new nature programme in the 90s. The National Ecological Network (NEN-programme) was by them introduced in the 1990s as a part of the national Nature Policy Plan, which was presented in order to create a network of nature reserves throughout the entire country. It was considered in those days as a measurement to make existing nature more cohesive as an answer to habitat loss and fragmentation; this by enlarging existing nature areas, developing new nature areas, restoring environmental quality and establishing coherence by ecological corridors between nature reserves (Hootsmans and Kampf 2004). The objective of the NEN-programme can therefore be understood of two components; increasing carrying capacity of nature areas (increasing the area and improving the quality of habitat) and increasing the coherence of the nature areas (permeability of countryside) (Hootsmans and Kampf 2004). The aim of the NEN-programme is to contain a coherent network of high quality nature reserves by 2018, this of about 728.500 hectares on land and about 6.3 million hectares in water (Werkgroep IBO-natuur 2009). The network contains core areas, ecological development areas, connection zones and buffer zones (Bredenoord et al. 2011). The core areas are the larger areas of international importance, ecological development areas are areas with perspectives of becoming natural areas of international importance, the connection zones are aimed at conserving or realizing migration opportunities for species between the core areas, the buffer zones provide the necessary conditions in nature reserves. In 2000, a policy document "Nature for people, people for nature" included a number of points to improve and expand the programme; one of the most important arguments is the expansion of the National Ecological Programme with robust corridors between the large core areas. These robust corridor links form the main arteries within the National Ecological Network and constitutes out of 27.000 hectares. Administrative agreements were reached between central government and provinces at the end of 2003 concerning these robust corridors. In 2005 the NEN-programme also reached an official status in the "Nota Ruimte". Enactment of the new Dutch Rural Area Development Act (Wet Inrichting Landelijk Gebied; WILG) in 2007 allowed a more flexible approach and gave the Provinces a central/leading role within projects as well as one central budget (ILG) for the realization of these goals.

A European network known as Natura2000 will be developed and is based on the Birds and Habitats Directives, aiming to stop the loss of biodiversity in Europe. Almost all Natura2000 areas in the Netherlands overlap with the National Ecological Network. The National Ecological Network should eventually link up with the nature reserves in other European countries to form the European Green Infrastructure, which will contribute to the EU 2020 biodiversity policy. Austerity measures by the Dutch cabinet in 2011 brought a big change into the National Ecological Network, halting the development of robust corridors and reducing the available budget of up to two-third. This development requires a review of the spatial plans and the appointed budgets for the NEN-programme, which will take place throughout 2012.

2. Theoretical basis for the research approach

2.1 Planning from a species perspective

Most papers recommend the use of a species-oriented approach in relation to landscape connectivity. These papers suggest numerous approaches for the aim in a corridor project. Several approaches are built on single species such as indicator, flagship, endangered species, keystone or umbrella species (Opdam et al. 2008; Simberloff 1998) in order to fulfill demands of individual species in a corridor. Simberloff 1998 notes that the indicator species approach is the most appreciated, because indicator species presence and fluctuations are believed to reflect those of other species and because they are believed to reflect changes in the environment. Umbrella species are species with such high habitat requirements that saving it will automatically save many other species. Flagship species are species that have become a symbol and leading species for a program. Keystone species are species with a disproportionately large impact on the ecosystem. These single-species approaches have received numerous critique on its practical implementation (conflicting management programmes due to different target species), costs and inefficiency (Lindenmayer et al. 2002; Simberloff 1998; Moilanen 2005). Later, alternative approaches were developed which focused on multiple species or even on ecosystems. Several alternative approaches and tools to landscape connectivity exist (Huggett 2007). In the end, landscape connectivity related questions such as "what sort of pattern is required in a landscape", cannot be answered lacking a reference to the species requirements (Lambeck 2003). It is thus important to use species requirements within the scope of the research. Some papers however suggest to expand this perspective in landscape planning with larger-scale approaches such as ecosystems based approaches (Franklin 1993). In this research an expanded perspective is used, containing a multi-species approach called "ecoprofiles".

Opdam et al. (2008) also recommend the use of a multi-species approach; in their study they suggest to use the ecological profile (ecoprofile) matrix instead of the single-species approaches. The ecoprofile approach is based upon a matrix with spatial features of the corridor as axes (Nassauer & Opdam 2008). This approach meets the requirements of flexibility in negotiations and is more incorporated in an ecosystem-based approach (Opdam et al. 2008), making it suitable for a multifunctional planning context. The ecoprofile concept was introduced during a study by Vos et al. (2001) which concluded that the approach forms a useful tool for the predictions about the spatial conditions of the landscape. The ecoprofile concept was also used by Alterra to assist the Dutch government with a manual comprising operationalized guidelines for the robust corridor strategy (Alterra 2001). Ecoprofiles represent a number of comparable species groups, priority habitats and key ecological processes (McHugh & Thompson 2011). It groups species in clusters according to three dimensions: the ecosystem type, the ecosystem area requirements, and the configuration of the ecosystem (Opdam et al. 2008). An ecoprofile thus gives an overview of target species requirements of the habitat and of the corridor requirements, as well as providing information about the size of patches for the movement of the ecoprofile species between key habitat areas. A key habitat area is a relatively large population of species in a network. An ecoprofile can be defined as a set of species demanding similar dimensions (ecosystem type, requirements, dispersal capacity) of an ecosystem network in order to persist at a regional scale (Opdam et al. 2008).

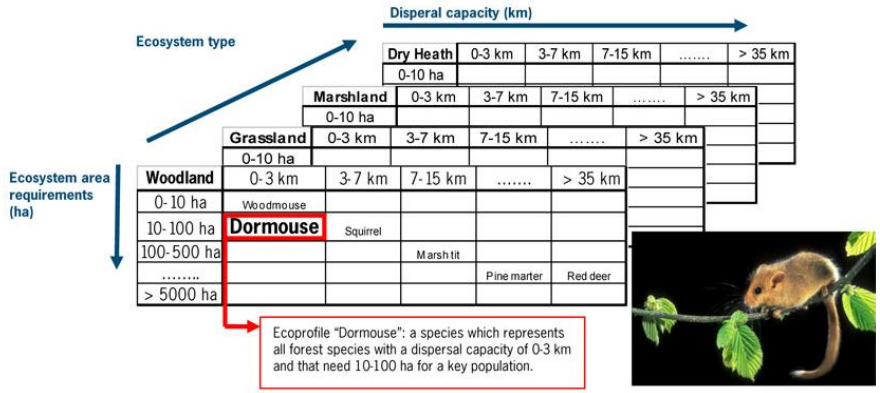

Figure 3. Ecoprofile matrix, giving spatial norms for an ecosystemtype; the area requirements and the dispersal distance of ecoprofiles.
Source: Alterra (www.ontwerpenmetnatuur.wur.nl/UK)

With this information about the ecoprofile, corridors can be developed that suit the requirements of broad spectrum of species. In addition to providing information about habitat and corridor requirements; the ecoprofile also indicates which barriers, such as roads or canals with steep edges, form an obstacle that is impossible to cross for the ecoprofiles species group. The ecoprofile matrix (fig. 3) is in this research used to identify spatial conditions of the case study area; selecting the key habitat areas and to indicate which areas still require adaptation of the landscape in order to facilitate the dispersal of the selected ecoprofile species. More detailed information about the ecoprofiles, such as habitat requirements and corridor requirements have been derived from the Robust Corridor handbook made by Alterra (Alterra 2001).

2.2 Green-blue veining

The increase of agricultural and urban areas in the twentieth century caused fragmentation of habitats in the Netherlands and consequently a loss of biodiversity. The remaining biodiversity is mostly found in semi-natural areas (Grashof-Bokdom & Langevelde 2004) and the small patches of natural area in and around agricultural landscapes. These semi-natural areas contain mostly linear landscape element features such as field margins, hedgerows, tree rows and other small-scale elements that form the border of agricultural areas and forms a part of the matrix landscape (Grashof-Bokdom & Langevelde 2004; Grashof-Bokdam et al. 2008). This network of small-scale semi-natural elements between agricultural fields is known as green-blue veining. Green-blue veining can increase the matrix permeability by enabling dispersal and foraging, which contributes to connectivity of the landscape and provides temporary habitat for species (Grashof-Bokdam et al. 2008). Nature reserves and semi-agricultural landscapes are known to provide multiple benefits to humans, this from the services that an ecosystem offers. Ecosystem services are the components of nature, directly enjoyed, consumed, or used to yield human well-being. Termorshuizen & Opdam 2009 propose the term landscape services as a more appropriate concept to ecosystem services, because of the relationships between spatial pattern of landscape elements and landscape processes and because of being a more appropriate concept to unify scientist and local actors. In view of the above the term “landscape services” is used in relation to services from the natural environment instead of ecosystem services. The term “multifunctionality” describes the various benefits from land, in terms of providing environmental, social and economic functions (Wiggering et al. 2003). Green-blue veining can provide several benefits in semi-natural environments including various fields such as biodiversity, agriculture, recreation, tourism, water and to the quality of life in an area (Henkens & Raffe 2002). Green-blue veining can thus contribute to a multifunctional landscape. De Groot 2006 notes that in order to fit landscape conservation with the changing demands of society on land use and natural resources, it is essential that the ecological, socio-cultural and economic values of the landscape be fully taken into account in planning and decision-making for sustainable conditions. Yet these values are often not taken into account and landscapes are often altered into simple, single-function land use types (de Groot 2006). The spatial pattern of land uses and land use modifications can determine the functionality of landscapes; a proper understanding of the interrelations of land uses and functions is thus indicative for sustainability and opens opportunities for win-win situations of apparently conflicting land use demands (Wiggering et al. 2003). The addition of fine landscape elements such as natural woody hedgerows, tree lines and riparian buffers contribute to landscape heterogeneity, improving the quality of the landscape matrix and conserving biodiversity by providing ecological networks (Lovell & Johnston 2008). The addition of landscape elements also contributes to a multifunctional landscape by providing landscape services.

2.3 Ongoing projects in the case study area

The province of Gelderland is currently active at a number of project sites in the case study area. These ongoing projects have been merged together into one overview map: fig. 4. The ongoing projects areas include:

- Winterswijk:
  Around Winterswijk are principally four important conservation areas; Korenburgerveen, Bekendelle, Wooldse Veen and Willink Weust. Around these areas and between these areas measurements are implemented to improve, protect and reconnect these internationally important nature reserves (SAB 2010).

- Baakse Beek-Veengoot:
  Water board Rijn&IJssel and the Province of Gelderland work together in a multifunctional program with a broad variety of stakeholders. The program aims on the sustainable development of the area Baakse Beek-Veengoot. The collaborative character of this project plays a central role in the improvement of the area. Some central tasks in this project include measurements against drought, realization of ecological connectivity (part of corridor Veluwe-Germany), strengthening of agricultural structure, water catchment improvement, cultural heritage, recreation and improvement of environmental experience (Drok 2010).

- IJsselsprong:
  The programme IJsselsprong stands for better protection again floods, improvement of infrastructure, nature development, ecological connectivity between Veluwe, Achterhoek and Germany and urban development around Brummen and Zutphen. The area focusses on the municipalities of Brummen, Voorst and Zutphen (Projectbureau IJsselsprong 2009).

- Ecological Gateways:
  In and around the Veluwe several projects are going on in order to preserve the continuity of the area and to reconnect the Veluwe to the surrounding landscape for migration and foraging of fauna. On the southeastern part these projects include the Havikerpoort, Soerense Poort and the Beekbergse poort.

- Drought projects:
  In the area different hydrological measurements are being implemented against drought, such as groundwater level rise and the development of hydrological buffers around nature reserves.

- Natura2000:
  Natura2000 is an ecological network composed of sites designated under the Birds Directive and the Habitats Directive. In these areas, the habitats and species are protected and different measurements are undertaken for the enhancement of the areas.

The project areas above, are partially overlaying and form almost a chain of areas where environmental measurements are being taken (fig.4).

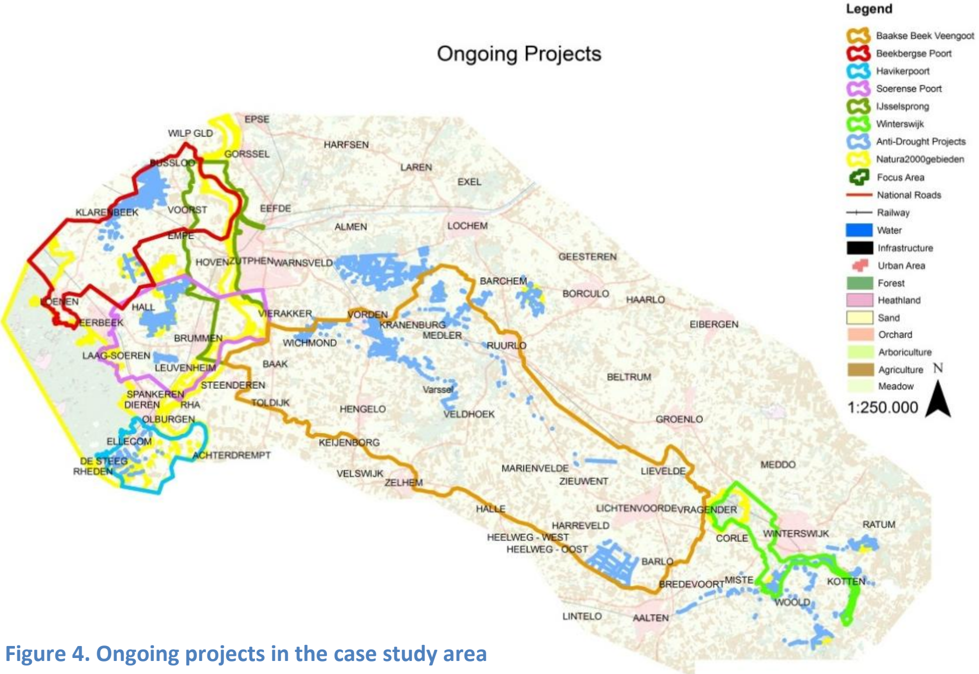

Figure 4. Ongoing projects in the case study area

2.4 Selecting ecoprofiles

In this research the ecoprofile approach is used to determine the current spatial conditions and to develop a landscape adaptation plan.

The selection of the ecoprofiles is based on a number of criteria;

- Ecoprofiles must focus on wet/moist ecosystems which can be found around streams of the case study area, including (wet) grassland ecosystems and hedge-/treerow ecosystems;
- The target species of the ecoprofile should exist in the case study area;
- The ecoprofiles must comprise out of both a large dispersal distance and a small dispersal distance;
- The ecoprofiles must comprise out of both smaller ecosystem area requirements and larger ecosystem area requirements;

With the criteria ten potential suitable ecoprofiles have been selected and ordered according to dispersal capacity and area requirements (Table 1).

From these ten ecoprofiles, two ecoprofiles have been designated as focus profiles for the continuation of the research. This has been done in collaboration with the Province of Gelderland. The two selected ecoprofiles include the profile Great Crested Newt and the profile Badger. These two have been selected for the reason that they comprise the outer edges of the ecoprofile matrix, indicating that they have most contradictory dispersal capacities and ecosystem area requirements (Table 1). Also, the two ecoprofiles comprise two different ecosystem types which can both be found in the landscape around the streams in the case study area; these include the wet grassland ecosystem with

		Dispersal Capacity (m)			
		disp (0-500)	disp (500-2500)	disp (2500-5000)	disp (>5000)
Ecosystem area requirements (ha)	0-10	Great Crested Newt	Harvest Mouse, Water Shrew		
	10-100		Sooty Copper, European Tree Frog, Purple Emperor	Mazarine Blue	
	100-500				Grass Snake
	500-5000				Badger
	>5000				Common Kingfisher

Table 1. Matrix of ten ecoprofiles of different ecosystem types, ordered according to dispersal capacity and ecosystem area requirements[2]

small ponds for the Great Crested Newt and for the Badger these include forest edges, tree- and hedgerow ecosystems. These two ecosystem types can both be found around streams in the case study area, the first comprising the moister grounds and the latter on the dryer grounds. Another aspect which has been taken in consideration during the selection of the two profiles, is the amount of available data (literature and GIS) about the ecoprofiles; the profiles Great Crested Newt and Badger are both profiles which have been applied in robust corridor studies and therefore hold the necessary data on habitat requirements, minimum patch size, corridor requirements and corridor size.

[2] The ecoprofile Common Kingfisher has not been selected because of the limited amount of available data on the corridor requirements and its strong association to water bodies (streams) in the case study area

2.5 Ecoprofile Great Crested Newt

The ecoprofile Great Crested Newt should be perceived as an ecoprofile for different amphibian species of which the Great Crested Newt contains the highest habitat requirements. Other amphibians and also other, on ponds depended, species such as frogs, butterfly and dragonfly species can be seen as a sub target species within the profile of the Great Crested Newt. Some species which do not necessarily require ponds in their habitat, also benefit from the fine maze of landscape elements which is required for the ecoprofile Great Crested Newt.

The Great Crested Newt disperses over land to forage for food and to move between ponds. Their max dispersal distance is around 500 meters (Alterra 2001), but in some exemptions they can reach a 1000meters (Langton et al. 2001) depending on the quality of the land which has to be crossed. New ponds on a distance of maximum 700 meters will be occupied by a population after roughly three years time (Spikmans et al. 2007). For the ecoprofile Great Crested Newt, the size of the stepping stone is not relevant as they require a linear shaped structure of land which provides suitable land for dispersal as well as temporary habitat after every 500meters. In this study a dispersal distance of 500m is used, even though some literature sources suggest distances of up to 1000meters (Langton et al. 2001).

A key habitat for the Great Crested Newt contains a cluster of at least 5 ponds in an area of suitable land for dispersal (>10% landscape elements). A corridor for the Great Crested Newt is at least 70m wide and contains a cohesive linear structure of landscape elements with a gap distance of max 10m.

	Minimum Corridor width	*Max length of gap within corridor*	*Area of key habitat*	*Max dispersal distance*	*Size of stepping stone*
Great Crested Newt	*70m*	*10m*	*5 ponds*	*500m*	*0 ha*

Table 2. Ecoprofile requirements of Great Crested Newt (Alterra 2001)

The Great Crested Newt is the largest of the four Newt species which can be found in the Netherlands, they are about 15 (males) to 18 (females) centimeters in length. They can be recognized by their dark grey-brown backs and flanks, and darker coloured spots on their bodies. The underside of the Great Crested Newt is yellow or orange-coloured and is covered by black markings. The males have a jagged crest in the breeding season, which is lacking on the females (Langton et al. 2001). In the Netherlands the Newt can be found on sandy soils in the eastern and southern part of the country (roughly east of the line Vlissingen-Assen) (Schut et al. 2008). Oldham et al. (2000) showed that Great Crested Newts are depended upon habitats with a certain range of characteristics and the quality and quantity of them determines presence and size of the Newt population. Characteristics that determine presence include the water temperature (large amount of sun exposure), medium sized ponds up to 250m^2, moderate nutrient levels, rich and varied vegetation, no or very little fish present in the pond, refuge habitat for shelter during drought or freezing and dispersal opportunities such as hedgerows and ditches (Gustafson et al. 2009; Oldham et al. 2000; Langton et al. 2001). Ponds in a late succession stage and with a high drought frequency have the highest extinction risks. Temporary ponds which dry out every so often, however can support populations, partly because periodic drying out reduces the abundance of predators (Langton et al. 2001).

2.6 Ecoprofile Badger

The ecoprofile of the Badger exists out of different target species which have similar or less habitat requirements. These species include the Stone Marten and the Roe Deer. These species have advantage from landscape adaptation measurements according to the ecoprofile Badger.

The Badger requires a wide corridor with a fine maze of landscape elements. The corridor should be generally about 500m wide, but can in some locations be smaller (up to 100meters). A finer structured agricultural landscape is not a major barrier as long as landscape elements between field edges are available.

A gap of 1000m of agricultural land is not a problem for the Badger, however can become a barrier for other sub-species under this ecoprofile such as the Stone Marten.

A gap distance of 100m is therefore recommended. After 7,5km of corridor, a stepping stone of at least 200ha with sufficient hiding places should provide temporary habitat for the Badger (Alterra 2001; Bolck & Fris 2003).

Urban areas and infrastructure form a major obstacle for the Badger and require adaptation measurements (such as Badger tunnels). A gap of landscape elements is not a major difficulty, however roads do cause many traffic casualties (Zee et al. 1992).

	Minimum Corridor width	*Max length of gap within corridor*	*Area of key habitat*	*Max dispersal distance*	*Size of stepping stone*
Badger	*100m*	*100m*	*3000 ha*	*30km*	*200*

Table 3. Ecoprofile requirements of Badger (Alterra 2001)

The Badger is easily recognizable with a black and white striped head and greyish body of up to a meter in length. They have a variety of habitats from woodland to semi-agricultural land, but prefer well drained (sandy) soil for burrowing (Lee 2003). Here, they construct complex dens with a large number of tunnels which are passed on from generation to generation. They are highly adaptable in their diet and eat a wide range of animals and plants including worms, insects, small mammals, cereals and fruits. An ideal Badger area thus includes soils which are well drained and easy to dig, adequate food supply throughout the year, enough cover around the setts and little disturbance.

In the Netherlands the Badger faced a steady decline between the 1950's and 1980's, together with the decline of suitable habitat. More than 50% of the setts that were reported to be occupied in 1959 were found to be empty in 1980 (Lankester et al. 1991). From 1990's on an increase in the distribution of the species can be seen in the Netherlands, which has mainly to do with the introduction of badger-friendly measurements such as tunnels, fences and artificial setts (Apeldoorn et al. 2005; Dekker & Bekker 2010).

3. Classification of case study area

3.1 Observation checklist

With the in chapter 2.5 and 2.6 described habitat requirements, a checklist has been produced which can be used to analyze the case study area. The checklist includes the type and size of the necessary landscape elements for the ecoprofiles and includes information about the corridor requirements such as width, length, dispersal distance, stepping stone size and area of key habitats.

Checklist for Ecoprofile Great Crested Newt					
Landscape elements necessary for habitat and dispersal	The species under the ecoprofile Great Crested Newts are depended on habitats with a range of characteristics including: Tree/hedgerows and linear vegetation/verges, ditches, drains with embankment, streams with embankment, forests and ponds with land vegetation				
	Width Assumptions for buffering(m)				
Tree rows	10m (2x5m)				
Hedgerows/verges	6m				
Ditches with embankment	6m				
Drains with embankment	6m				
Streams with embankment	30m				
Forest	All types				
Ponds	500m dispersal distance around pond				
	Corridor width	Max length of gap within corridor	Area of key habitat	Max dispersal distance	Size of stepping stone
	70m	10m	5 ponds	500m	0 ha

Table 4. Checklist for ecoprofile Great Crested Newt

Checklist for Ecoprofile Badger					
Landscape elements necessary for habitat and dispersal	The species under the ecoprofile Badger are depended upon habitats which vary from woodland to semi-agricultural land with sufficient landscape elements. These areas include a certain range of characteristics; Tree rows, Hedges including other linear vegetation/verges and Forests				
	Width Assumptions for buffering (m)				
Tree rows	10m (2x5m)				
Hedgerows/verges	6m				
Forest	All types				
	Corridor width	Max length of gap within corridor	Area of key habitat	Max dispersal distance	Size of stepping stone
	100m	100m	3000 ha	30km	200 ha

Table 5. Checklist for ecoprofile Badger

These two checklists form the basis for the classification of the case study area.

3.2 Definition of landscape elements

For species dependent upon forest habitat, fragmentation as in the focus case study area results in the formation of smaller habitat patches surrounded by gaps of inhospitable countryside. The provision of corridors can facilitate species with pathways between these patches of habitat (see ch. 1.2). The existence of linear landscape elements in the form of hedges, tree rows, embankments etc. can provide the movement between these areas (see ch. 2.2). Due to the time limitation and insufficiency in (GIS) data, the concentration calculations in ch 3.3 of this research do not include the quality aspect of landscape elements, nevertheless it is important to note that quality of landscape elements is decisive in providing dispersal opportunities of species (more information in Appendix I). For this study the different utilized landscape elements with buffer assumptions are defined as followed;

- Tree row:
  A number of trees which are planted into a linear shape as a form of barrier between fields/properties or as contour along pathways, containing a variety of shrub undergrowth in a zone of approximately 10meters wide.
- Hedgerow:
  A number of woody plants and shrubs that have been linked to form a border or a barrier between properties. A zone of approximately 6 meters wide contains a variety of shrubs that forms up the area of the hedge
- Ditches with embankment:
  An area in and around agricultural fields that functions as drainage after rainfall and does not contain crops or cattle. This includes a zone of approximately 6meters wide containing out of the ditch itself and the vegetation on the embankment around it.
- Drains with embankment:
  A wider drain around agricultural fields that controls the water levels in the surrounding area. A zone of approximately 6 meters wide consist of the water body and the vegetation on embankment.
- Streams with embankment:
  A wider, often meandering body of water with a current having a broad zone of riparian vegetation along both sides, together forming a zone of approximately 30meters wide.
- Forest:
  An area with a high density of trees, which is not shaped as a narrow line. In this study all types of forests have been used.
- Pond:
  A body of standing water where light penetrates to the bottom, allowing a wide variety of water plants to grow inside the pond and around its embankment.

3.3 GIS calculations

The developed checklists in ch. 3.1 are very suitable for working in an ArcGIS environment, however it is also possible to do a similar calculation manually. In a manual form, the checklist would function as a basis for field observations. Total areas of landscape elements could then be calculated by doing a combination of field work with studying satellite or aerial imagery (the width of landscape elements can be observed in the field, however length of linear landscape elements would require a system of aerial surveys). Using this method in a manual form is likely to produce more accurate estimations, yet it is a very labor intensive approach and can therefore only be used in smaller study areas.

A drawback of using GIS data for area calculations is that the available data is limited and often only available in the form of lines, this also happened during the calculations with the two selected ecoprofiles. Due to this shortage in detail of the GIS data, some assumption had to be made in order to calculate total areas of landscape elements. The landscape elements which are required for the two selected ecoprofiles are generally available for GIS, yet they only appear as lines and not as polygons. In order to calculate areas these lines must be buffered prior to area calculations. These buffer assumptions have been added to the checklists of both ecoprofiles. The assumptions for the different landscape elements used during this study are rough estimations of widths of landscape elements. The correctness of these estimations are exposed to discussion; here it is important to note that using smaller or larger assumptions does not result in significant changes in the end result of the GIS calculations; this would lead to an average decline or raise in landscape element areas, which would then lead to a relative change in the entire case study area.

Using the two checklists with ArcGIS, requires undertaking a set of steps prior to generating the classification map. An overview of steps taken to develop the classification maps can be found on the right side of this page.

On the next page the outcome of the GIS calculations can be found. Besides calculating the percentage of landscape elements in the case study area, the different ongoing projects and key habitat areas have been added to the layout.

Collect	Collect GIS data (Top10)
Select	Select necessary data from Top10 files (tree lines, hedgerow lines , streams etc)
Clip	Clip selected data with boundary of project area
Buffer	Buffer selected lines with Ecoprofile requirements and assumptions about landscape elements (result: Appendix IV)
Intersect	The buffered line is intersected with the Kilometer Grid (1x1km) data which functions as a raster
Join fields	The different landscape element layers (tree lines, forest, hedgrows etc) are joined together into the table of the Kilometer Grid
Dissolve	The different landscape element data is dissolved together into one polygon in order to eliminate any overlap
Add Field to table	A field is added to the table which is used to calculate the total area of the dissolved landscape element (consisting out of forest, streams, drains, ditches, hedgerows and tree rows)
Add Field to table	Another field is added to the table which is used to calculate the percentage of landscape elements for every raster square, this by dividing the area of landscape elements with the area of a raster square mutiplied by honderd
Add graduated colors according to classes	The symbology is appointed to the added percentage field, using clasify tool in order to create different classes (in this case 5 classes 0-3-10-20-50-100) (result: Appendix II & III)

Table 6. ArcGIS steps in order to generate a classification map for the ecoprofiles.

Concentration of landscape elements for ecoprofile "Great Crested Newt"

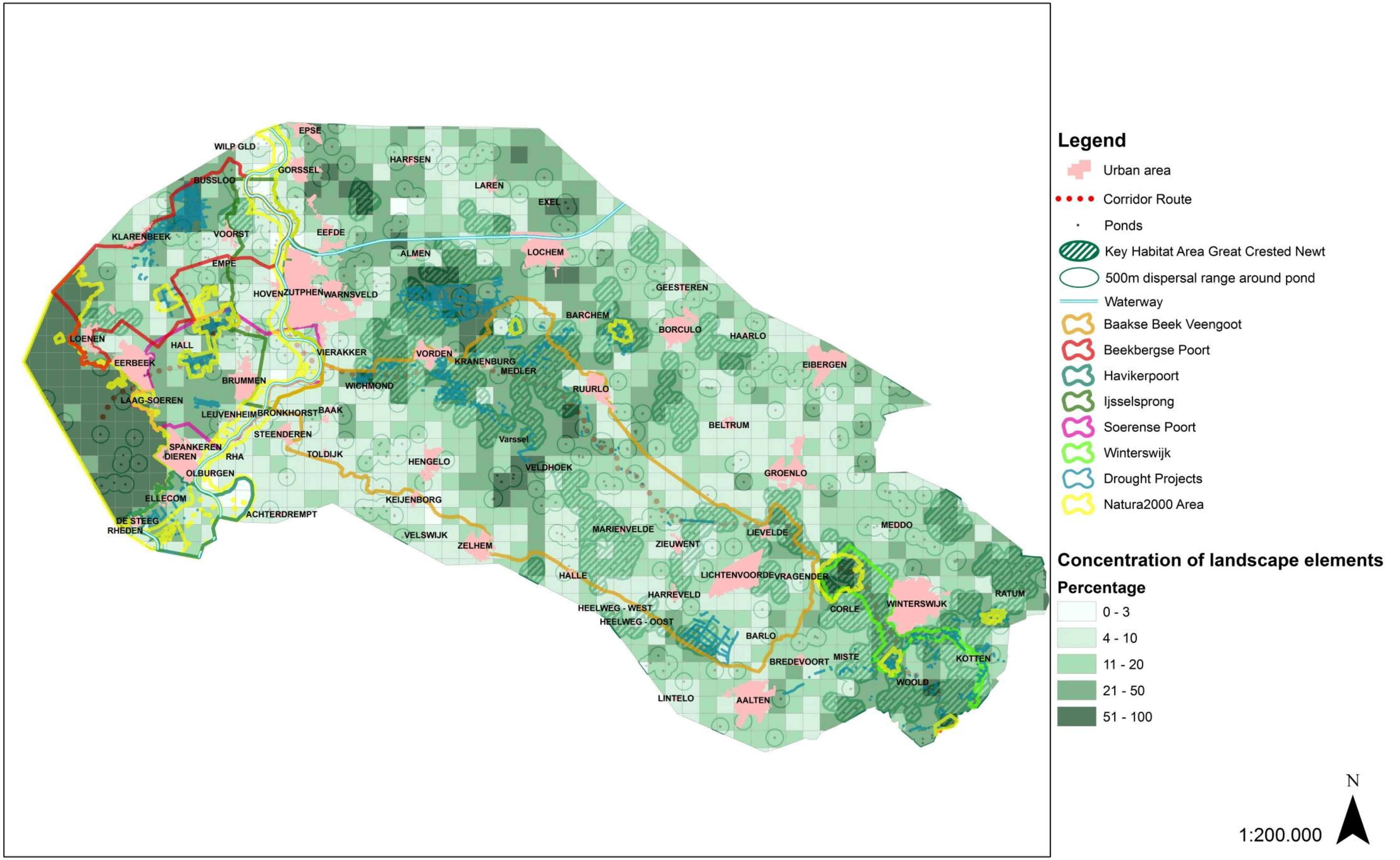

Figure 5. Concentration of landscape elements for ecoprofile Great Crested Newt (Appendix II for different frames)

Concentration of landscape elements for ecoprofile "Badger"

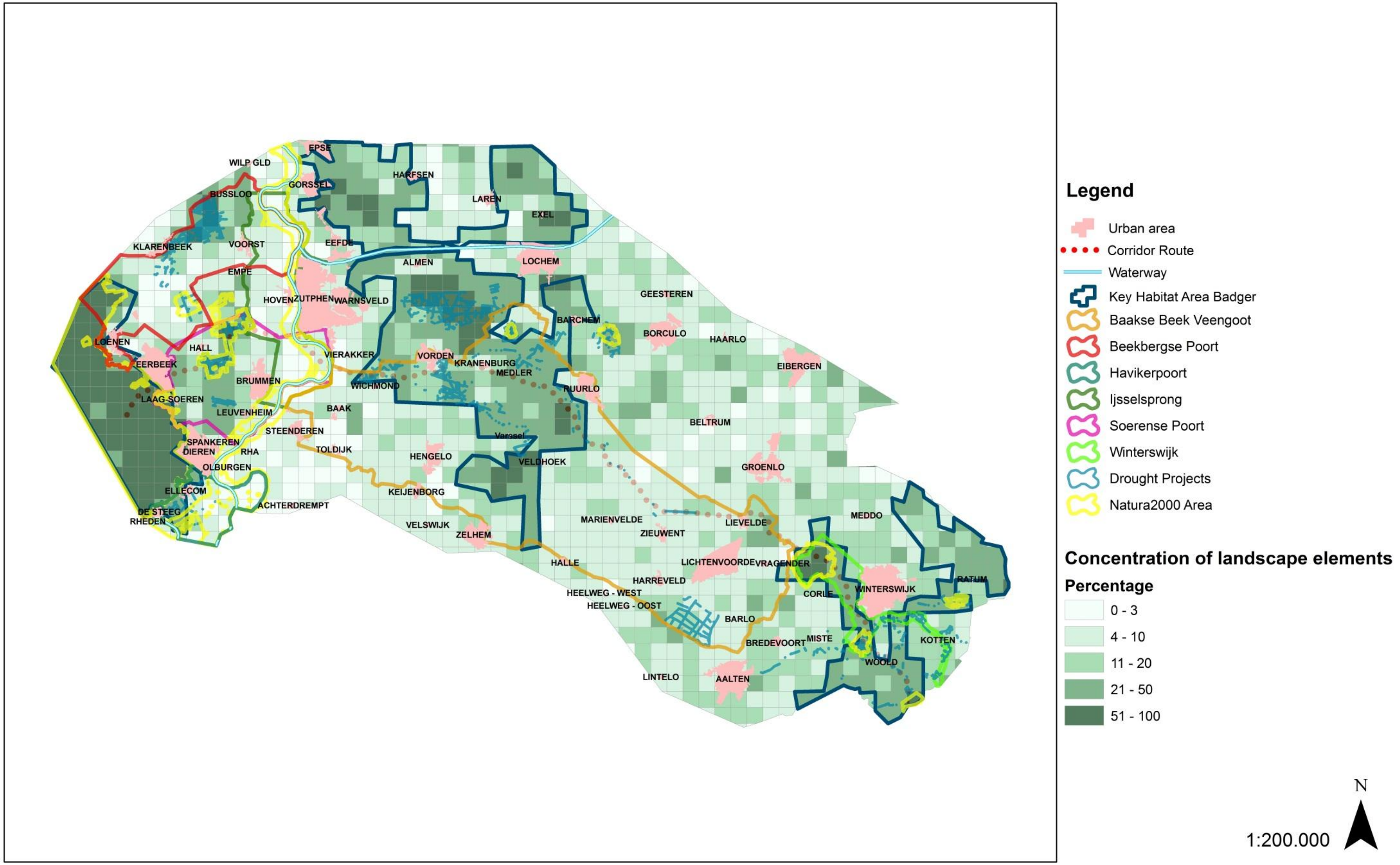

Figure 6. Concentration of landscape elements for ecoprofile Badger (Appendix III for different frames)

3.4 Interpretation of maps

The two maps (figure 5 en 6) give an overview of the concentration of landscape elements in the case study area. Besides providing a concentration overview, the maps can also be seen as an interpretation of the pattern of landscape elements in terms of providing connectivity in the current situation to the two selected ecoprofiles. The two maps as well show the potential key habitat areas for the ecoprofiles of the Badger and the Great Crested Newt. The key habitat of the ecoprofile Great Crested Newt comprises out of at least 5 ponds in cluster, encompassing out of at least 10% landscape elements (a cluster consists out of overlapping 500m buffers). The key habitat of the ecoprofile Badger is 3000ha with adequate concentrations of landscape elements (>10%), which is a cluster of 30(>10%) raster squares on the map.

The maps (figure 5 en 6) give an indication about the suitability of the landscape as a green-blue veining corridor. In locations with a network (in this context a network is seen as a linear cluster of high concentration raster squares) of >10% concentration of landscape elements it is assumed that the current situation is appropriate for dispersal between key habitat of the ecoprofiles. In raster squares with a concentration of <10% it is assumed that the quality and quantity of landscape elements is inappropriate for dispersal between key habitats.

For the ecoprofile Great Crested Newt an additional requirement for dispersal is a pond after every 500m, providing temporary habitat for the species under this ecoprofile. Ponds can be seen on the map as small dots surrounded with a 500m buffer (dispersal distance). For the ecoprofile Great Crested Newt the landscape can thus be suitable for dispersal (>10%), though when a pond is lacking after 500m, the distance between habitats becomes an obstacle for dispersal.

The locations of current ongoing project areas and the corridor route between the Veluwe and Germany can also be seen on the two maps. It can be seen that between the Veluwe and Germany different project areas overlap each other, except for the project areas Baakse Beek-Veengoot and Winterswijk. The corridor route has been derived from NEN-programme data of the Province of Gelderland. Although the NEN-programme suggests different alternatives for the route, it generally follows the in the two maps used direction (indicated with red dots). From the two maps can be understood that the corridor route generally passes areas with high concentrations of landscape elements. For the ecoprofile Great Crested Newt most areas on this route contain above 10% landscape elements, however the number of ponds on this route is unsuitable for dispersal and requires adaptation measurements. What is also significant; is the fact that a large potential key habitat for the Great Crested Newt around the village of Marienvelde is not included to the corridor route and therefore under risk of seclusion. For the ecoprofile Badger a large area between Ruurlo and Lievelde with unsuitable concentrations of landscape elements has to be crossed. Although the dispersal distance of the ecoprofile Badger allows the distance between these key habitats to be crossed (dispersal distance 30km), the Badger requires a fine maze structure of landscape elements with a concentration of at least 10% per km^2 in order to be suitable for dispersal.

3.5 Choosing a focus case study area

The two concentration of landscape elements maps (fig 5 and 6) function as the base for the selection of the focus case study area. Choosing a focus case study area will be done with a set of criteria.

The criteria for selection are:

- Focus area should be an area between two key habitats
- Focus area should contain a high concentration of landscape elements >10% without forming a cohesive network (intersected by area with a lower concentration <10%)
- Focus area should be positioned between current ongoing projects
- Focus area should be on or close to the corridor route

These criteria above have been generated in collaboration with the Province and have been discussed during an expert meeting. Using these criteria, a focus case study area has been appointed (together, during the expert meeting). An area between Marienvelde – Beltrum – Meddo – Barlo has been designated as focus area (fig. 7). The area lies between key habitats of both ecoprofiles, it is an area with a high concentration of landscape elements however dissected by lower concentrations, the area lies between the projects of Baakse Beek-Veengoot and Winterswijk as well as on the border of the Natura2000 area Korenburgerveen and the area is crossed by the (stream) corridor route.

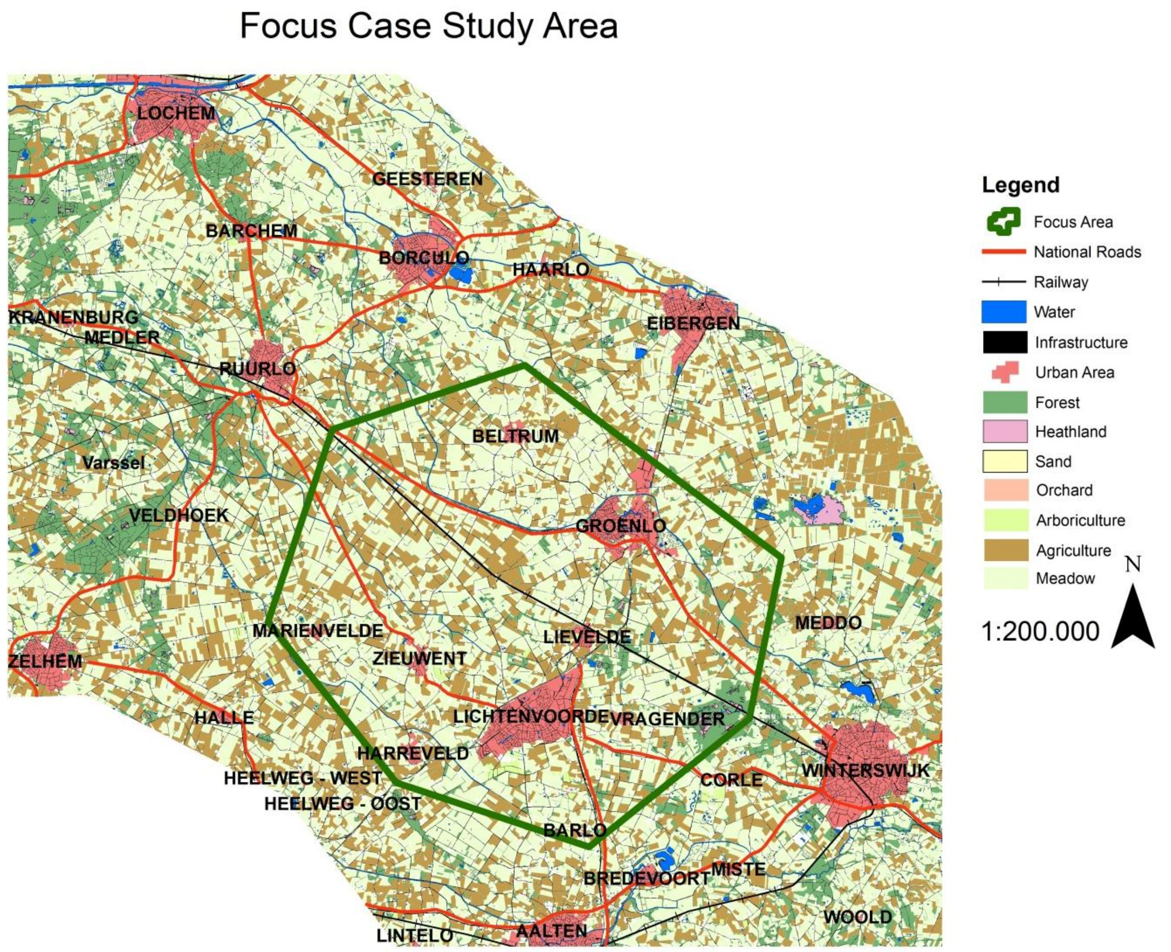

Figure 7. The location of the focus case study area

4. Landscape elements and landscape services in the focus case study area

This chapter starts with a description of the functionality of the focus case study area for the two ecoprofiles. Next, an analysis of the landscape services in the focus case study area will be displayed in a table overview. The link between the landscape services and the landscape elements will then be described, resulting in a ranking about the dependency of landscape services on landscape elements which are currently present in the focus case study area. This chapter forms the basis of the adaptation measurements for the two ecoprofiles, which will be further clarified in chapter 5.

4.1 Functionality for ecoprofiles and missing landscape elements

The focus case study area can be characterized by a blend of agricultural areas, streams and peatland marshes (Korenburgerveen) in the east, resulting into strong regional differences. This area gets close to English 'bocage' landscape, which refers to the semi-agricultural land of forests, hedgerows, pasture land and small towns.

At first sight the density of landscape elements in this area seems rather high (fig. 8), yet the area is not adequately cohesive, making it hard or even a barrier for the two ecoprofiles to cross. For the ecoprofile Great Crested Newt the area along the corridor route appears to be relatively consistent in landscape elements, though some gaps with concentrations of landscape elements below 10% can be seen (west of Korenburgerveen, north of the town Lievelde and north of Marienvelde). The ecoprofile Great Crested Newt requires a linear network of ponds in order to be able to disperse between habitats. The amount of ponds in the area is high and key habitats can be found, yet these clusters of ponds are not interconnected and distances between ponds exceed the maximum dispersal distance of 500meters (see fig 8 and appendix VI). Due to this fact, dispersal between key habitats becomes impossible for the ecoprofile Great Crested Newt. Besides the lack of a network of ponds; the spaces between different patches of landscape elements exceed the max gap distance of the ecoprofile (10m) blocking the dispersal capacity of this ecoprofile. For this ecoprofile the missing links which require adaptations measurements, are concentrated around the network of ponds and the links between the current present elements (establishing connectivity between different stretches of hedgerows, tree lines, drains etc.).

For the ecoprofile Badger the eastern part of the focus case study area contains high concentrations of landscape elements, which are mainly centered in and around Korenburgerveen and northeast of the town Lievelde (see fig 8). The nature reserve Korenburgerveen is a part of the key habitat of this ecoprofile. The stretch between Lievelde and the key habitat of the ecoprofile Badger around Ruurlo forms a large expanse of unsuitable land for this ecoprofile (containing <10% elements). The amount of landscape elements which the ecoprofile Badger requires for dispersal is in this stretch still too low, demanding adaptation before being suitable for dispersal between the two key habitats. Besides the unsuitable density of landscape elements, the currently present landscape elements also exceed the max gap distance (100m) (Appendix VII). Adaptation of the landscape for this ecoprofile is mainly concentrated on creating suitable concentrations of landscape elements for dispersal and reducing the gap distance to 100m.

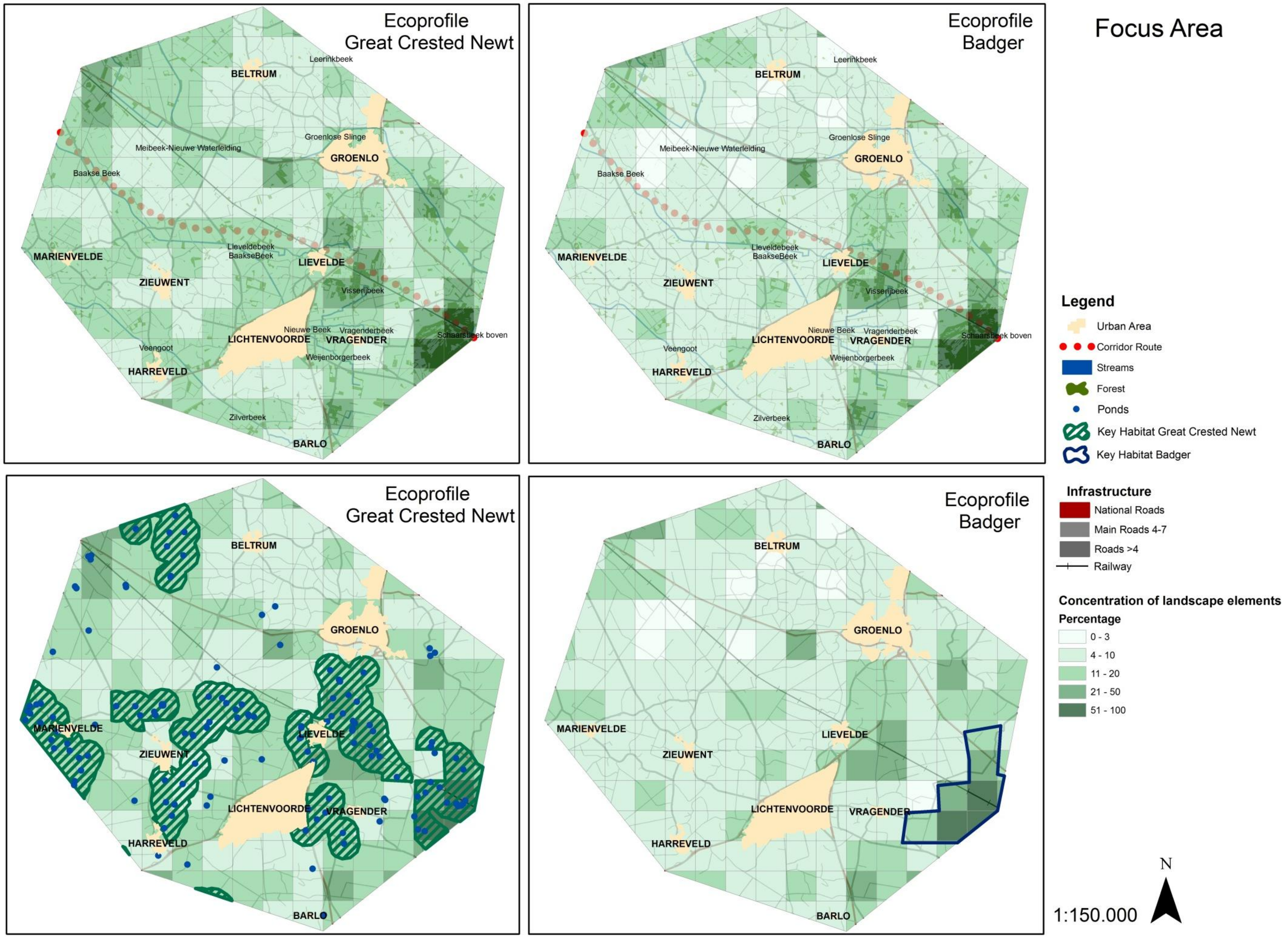

Figure 8. Concentration of landscape elements in the focus case study area

4.2 Landscape services in the focus case study area

Ecosystem services are the goods or services provided by the ecosystem to society, and provide the basis for the (financial) valuation of the ecosystem (Hein et al. 2006). The value of ecosystems has received a lot of attention in scientific literature. This interest in benefits coming from the ecosystems has been growing ever since the 1960s and varies greatly for different stakeholders and at different scales (Hein et al. 2006). Ecosystems can for example filter water, mitigate floods, provide recreation, improve nearby food production and so on. Because of the relation between landscape elements and landscape processes, the term landscape services is used instead of ecosystem services (see ch 2.2)

Due to increasing farm size and land consolidation (see ch. 1.3) field sizes increased significantly at cost of linear elements such as field edges and small tree islands in fields. These landscape elements were seen as an obstacle to the production and therefore removed. The removal of this fine maze of natural elements resulted in an overall loss in the ability of the landscape to provide services to agriculture such as the retention of water, nutrient provision and pollination.

Most of these functions had been replaced by technical measures such as water drainage systems, fertilizers, pesticides and herbicides. Besides services to agriculture, the removal of the fine maze landscape has it effects on society as a whole and the overall biodiversity of the landscape. For the long-standing sustainability of the landscape to deliver services to agriculture and society and to provide dispersal opportunities to species, these benefits from the fine maze of landscape elements should be further analyzed and used in future spatial planning practices.

There are different frameworks available to analyze benefits coming from ecosystems and landscapes in general. Frequently these different frameworks use three domains to analyze landscape services, namely:

- Ecological
- Socio-cultural
- Economical

(Groot et al. 2010; SELS research program)

This research concentrates on the services aspect delivered by ecosystems and the landscape in totality and uses the three domains by Groot et al. 2010. Valuation in financial terms is beyond the scope of this research. The three domains are used to analyze the focus case study area on the presence of landscape services and the relation with the present landscape elements. Table 7 provides the overview of landscape services and the relation with landscape elements in the focus case study area.

A rating is added to this relation between landscape service and the landscape elements, this rating is based upon the dependency of the service on present landscape elements. The idea behind this rating will be further described in chapter 4.3.

Landscape service in focus case study area	Description of service	Link with landscape elements	Dependency of service on landscape elements (low-medium-high)
Economical:			
• **Intensive food production**	Intensive food production; high inputs of capital, labor, technologies as pesticides, herbicides and fertilizers.	Generally (intensive) food production is controlled by artificial inputs such as fertilizers, pesticides and herbicides. Using these inputs, production can persist even with limited numbers of landscape elements around fields.	Low
• **Extensive food production / Organic farming**	Food production without artificial inputs such as fertilizers, pesticides and herbicides; using natural capacity for farming	When artificial inputs for crop production are removed; food production becomes dependent on surrounding landscape elements for their regulating services. Elements such as natural field margins, hedgerows, tree rows and small patches/remains of forests can provide these services.	High
• **Drinking water provision**	Filtering and storage of drinking water by natural elements	Landscape elements such as ditches, drains and ponds surrounding the agricultural fields function as an additional filter for polluted water (for example due to emissions of nitrate and phosphorus from intensive livestock farming) prior to infiltration in aquifers.	Medium
• **Air quality improvement**	Filtering of dust particles in the air / purification of Ammonia in air	Landscape elements such as hedgerows, tree rows, solitary trees and small remains of forests, function as a filter of fine dust particles and overall air improvement of local areas.	High
• **Protection against weather extremes**	Stabilization of weather extremes / buffer function	Elements as tree rows, small patches of forest, hedgerows, drains, ditches and streams function as a buffer during weather extremes (floods, droughts, wind force etc.) because of their ability to absorb stresses and as a refugee for species.	High
• **Water filtering**	Water purification and waste treatment	Vegetation along natural embankments in ponds, drains and streams has the ability to filter water (for example reed beds).	Medium
• **Erosion mitigation**	Protection against erosion from runoff water and the stability of embankments	Absorbance of runoff water and percolation to aquifers by root systems of linear elements such as tree rows, hedgerows and small patches of forest.	High
• **Pollination and seed dispersal**	Dispersal of seeds and pollination of plants	Crop pollination by bees and other animals forms an essential service in the landscape. Increasing floral and nesting resources improves pollination services in the landscape, this can be reached by realizing flowering field edges, hedgerows, tree rows and field margins. Seeds dispersal is done by wind, vertebrates (ingested or stick to skin), ants, water or by plants itself. Presence of landscape elements such as drains, ditches, hedgerows, tree rows and patches of forest increase the dispersal capacity of seeds.	High

• **Pest regulation**	Natural predation of "pest" species / natural regulation of populations	A diversified landscape with flowering field edges, tree lines, hedgerows, small patches of forest, field margins, ditches, drains and streams (including natural embankment) enhances natural pest control, due to its higher content of natural enemies.	High
Socio-cultural:			
• **Tranquility / Appreciation with surroundings**	Green environment as a function of tranquility and rest for local inhabitants (intrinsic value)	A landscape with a high abundance of natural elements is found to buffer negative impacts of job stress and improves the general well-being of humans.	High
• **Recreation**	Outdoor activities for leisure / tourism	The recreational attractiveness of an area is characterized by the density of the visual structure of the landscape, which constitutes out of land-use type, relief, forest and water borders.	High
• **Culture**	Cultural history and monuments	Some landscape elements have a high cultural and historical value. These elements include the old tree lanes (along roads) in the case study area.	Medium
• **Identity of region (for local inhabitants and tourism)**	The fine maze of landscape elements has a strong association with the identity of the region (National Landscape)	The fine mixture of landscape elements maintains the visual character. Increasing the amount of landscape elements can enhance the identity of the region.	High
• **Education**	Educational and scientific value of the area	The fine maze of landscape elements and large nature reserves as a source for local education (school excursions etc.)	Low
Ecological:			
• **Habitat for species**	Refugee, foraging and dispersal opportunities and breeding ground for different species	The fine maze structure of different landscape elements are important for the species persistence. On a landscape scale the smaller landscape elements function as a corridor through semi-agricultural land	High
• **Genepool**	Large number of species in surrounding reserves as a genetic resource	The protection of genepools depends on opportunities for species dispersal, which can be reached with linear landscape elements along fields.	High
• **Filter and buffer function**	An area around the Korenburgerveen functions as a buffer for the wetland system	Landscape elements such as tree rows and hedgerows provide noise mitigation for the nature reserves and form a buffer against other external influences (such as pollution).	Medium

Table 7. Overview of landscape services and relation to landscape elements in the focus case study area[3]

[3] *Scientific literature for the relation between landscape services and elements: Winkler K. 2005; Oosterbaan et al. 2006; Verboom & Huitema 1997; Forman & Baudry 1984; Geertsema et al. 2002; Ricketts et al. 2008; Bianchi et al. 2006; Steffan-Dewenter & Westphal 2008; Velarde et al. 2007; Langers & Vreke 2008; Buro Stroband 1996*

4.3 Dependency rating

Table 7 gives an overview and description of landscape services. Each landscape service depends on the overall structure and the functioning of the network of landscape elements in the direct surrounding landscape. Both the quantity and quality of the landscape elements in the landscape are decisive to the functioning of landscape services. Some landscape services however are not dependent on small-scale fine landscape element, but on larger areas of natural environment (such as Korenburgerveen).

The link between a landscape service and the surrounding landscape elements can be described by a level of "dependency", in this study indicated by low, medium or high. The appointed level of dependency indicates to which amount the landscape service can continue without the presence of the landscape elements in the direct surroundings.

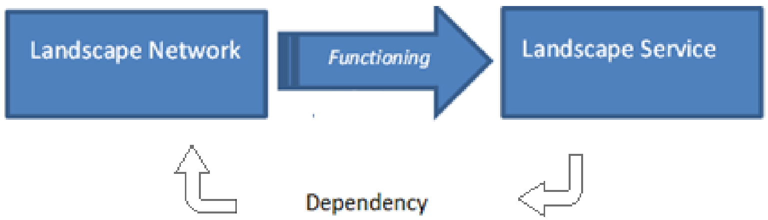

Figure 9. Relation between landscape service and the network of landscape elements

A high score indicates that the landscape service is very dependent on the landscape elements and cannot continue without its presence. A medium score indicates that the quality and/or quantity of the landscape service will diminish considerably, yet the landscape service will continue in some form. A low score indicates that the landscape service is not dependent on landscape elements and thus continues even when little or no landscape elements are available in the surrounding landscape.

By implementing a dependency rating to this relation with landscape elements, it becomes more obvious which services can be used to create a multifunctional landscape with the use of linear landscape elements.

Services with a high rating are very dependent on landscape elements and can thus best be used in the adaptation measurements for the ecoprofiles, partly because stakeholders will support these measurements due to the associated landscape services and partly because the use of the high rating services creates a multifunctional landscape zone where ecological functions are combined with economic and socio-cultural functions. In some cases, these landscape services are automatically added or improved in the landscape when a network of landscape elements has been realized (for example with air quality improvement or as a buffer against weather extremes). However, some landscape services (such as recreation) need some additional measurements such as hiking routes and or cycling paths in order to be effective.

5. Landscape adaptation measurements

5.1 Linking key habitat areas

In order to safeguard a balance between extinctions and recolonisation in metapopulations and to generate interaction between populations of species, it is important to provide a for dispersal suitable landscape. A suitable landscape offers those opportunities necessary for the recolonisation of individual populations after environmental disturbances, helping to safeguard entire populations and sustaining genetic diversity to metapopulations. A network of green-blue veining can provide the necessary circumstances for the dispersal of species, yet a sufficient concentration of landscape elements is required. The current concentration in the focus case study area is not sufficient to allow the dispersal of the species under two selected ecoprofiles (see Ch 3.1). For the ecoprofile Great Crested Newt some areas require additional landscape elements in order to reach the sufficient concentration (>10%), however the main concern is the distance between different ponds which currently exceeds the dispersal range of 500m. The main areas which require adaptation have been selected with blue lines in fig. 10. For the ecoprofile Badger the main priority is to provide the necessary concentration of landscape elements (>10%) for dispersal. These areas have been selected with green lines in fig 10.

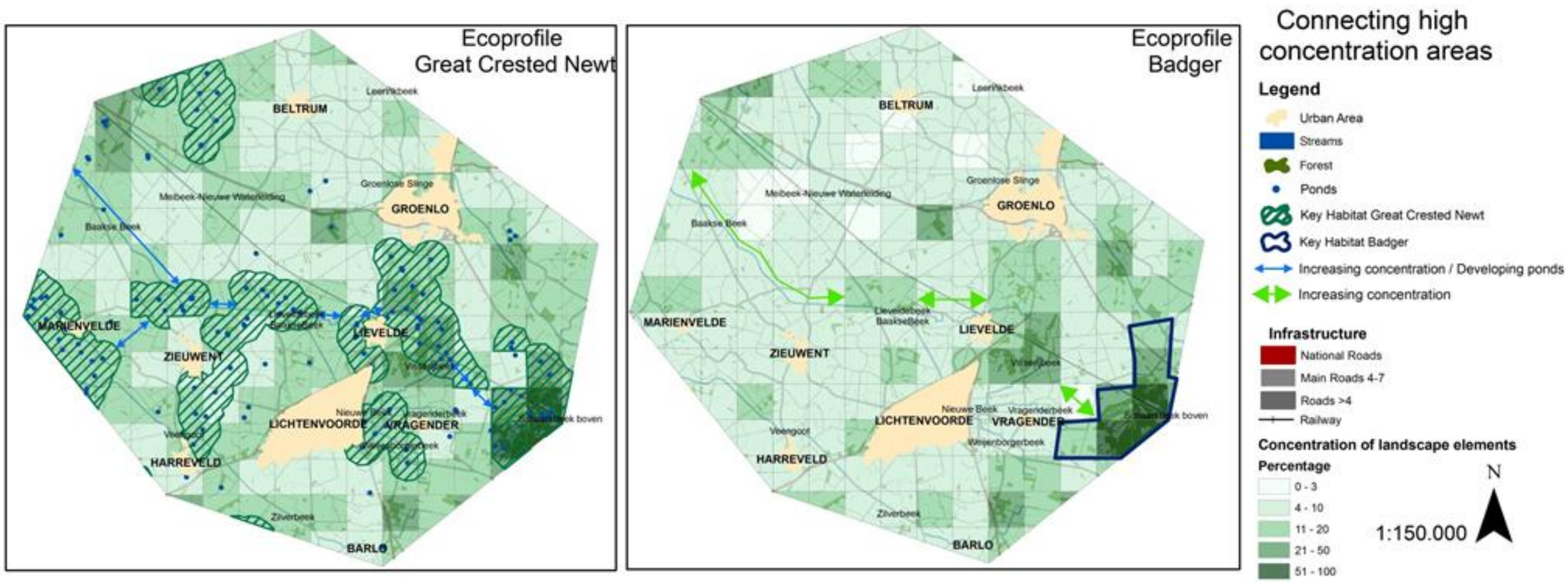

Figure 10. Connecting high concentration areas

The focus case study area can be divided into two sections: West of settlement Lievelde and East of settlement Lievelde. the area west of the settlement Lievelde is a low-laying and rather flat landscape, whereas the area east of the settlement Lievelde contains a moderately hilly terrain and is slightly higher located compared to the western section of the focus case study area (see Appendix V). Besides this, the area west of the settlement Lievelde contains an overall lower ground water table and a higher amount of seepage as compared to the eastern section of the focus case study area (see Appendix V). Locations of groundwater seepage are more suitable for the development of ponds as it contributes to richer environmental circumstances. Besides this, seepage also contributes to more water in the ponds, even during periods when the in infiltration areas located ponds dry up.

In view of the above, the following criteria have been set up for the development of a Green-Blue veining network (fig.11):

- Following areas of moderate and strong levels of seepage (see Appendix V)
- Connecting the high concentration areas along the corridor route (see fig 10)
- Connecting key habitat areas of both ecoprofiles (see fig 10 and/or fig 5/6)
- The possibility of a stepping stone after 7,5km of corridor (see ch2.6)

In addition to these criteria, the observations which were made during a field visit also contribute to the proposed concept of a green-blue veining network. During this field trip, different project areas along the stream Baakse Beek were visited and different forest patches around the settlement Lievelde have been explored. These smaller project areas along the stream Baakse Beek and the different patches of forest have a great potential of becoming a sort of a foundation of the green-blue veining network. The conditions in the observed areas in combination with the in this research identified necessary adaptation measurements contribute to the proposed separation of the green-blue veining network in a “Core” and a “Buffer” zone.

Seen the fact that the realization of the necessary habitat conditions for the species of the ecoprofiles requires several landscape adaptation measurements (such as a pond after every 500m), a designated core zone could be ideal to implement these fundamental adaptation measurements. A wide buffer zone around the proposed green-blue veining core, will enhance the dispersal of species. Green-blue veining is expected to provide an alternative to the robust corridor strategy; to achieve the same level of functionality a much wider corridor zone is therefore recommended. This is partly because individual species are more influenced by external factors and have less guidance through the landscape in the proposed green-blue veining network, compared to a situation with a robust corridor.

With the combination of the earlier proposed set of criteria and the different field observations, an area in fig. 11 is therefore proposed as a green-blue veining network. In this map, both core and buffer zone can be seen.

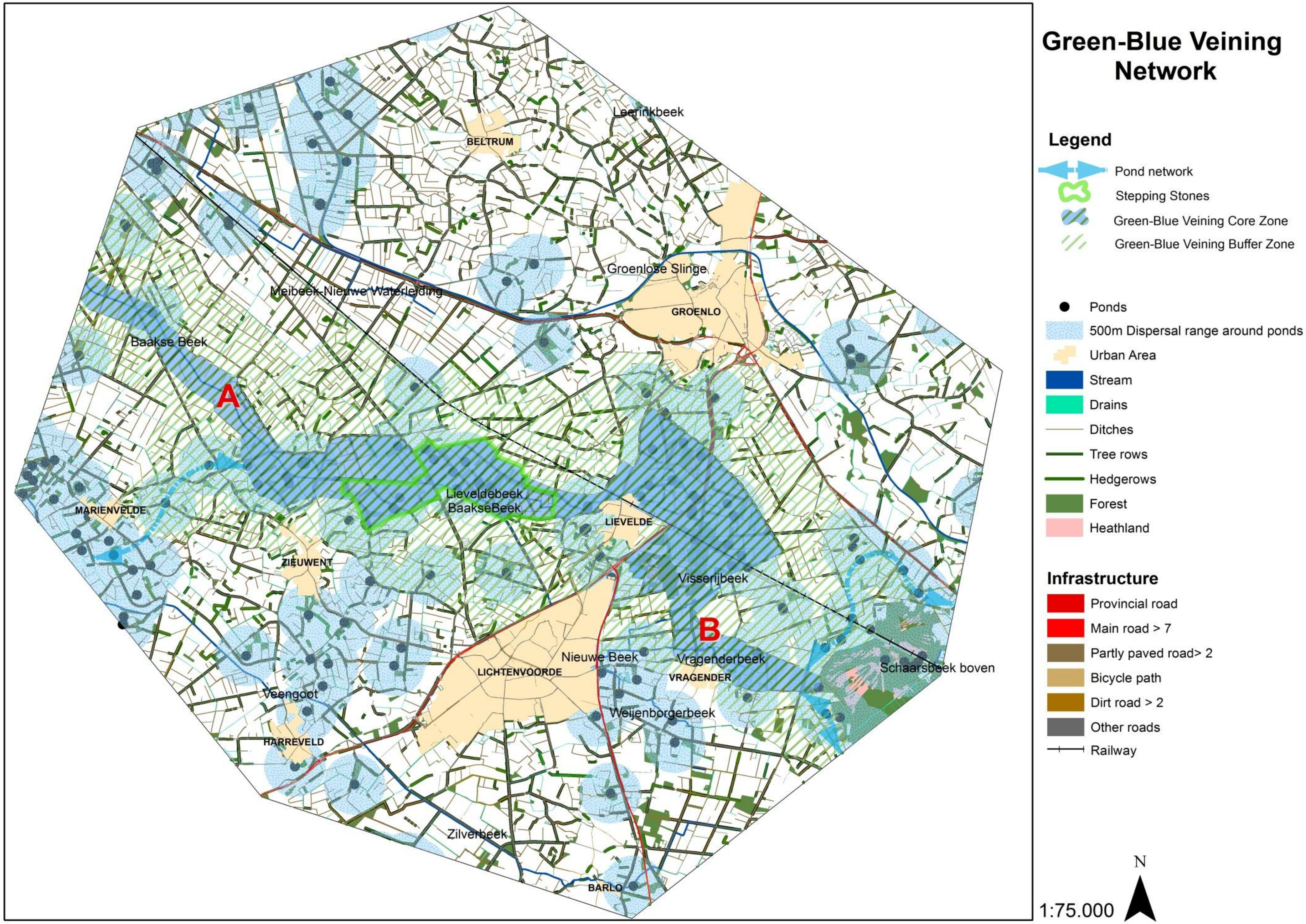

Figure 11. Proposed Green-Blue Veining Network – The letters A en B are the locations of which the two sketches (fig. 14 en 15) give an impression of a possible future situation

5.2 Interpretation of the proposed green-blue veining network

In fig. 11 a - for the species in the two selected ecoprofiles - proposed planning concept of a green-blue veining network can be seen. In this concept, four key areas are marked: the green-blue veining core zone, the green-blue veining buffer zone, the stepping stone and the pond network. In this part a further clarification of these areas will be provided.

Green-blue veining core zone:
The green-blue veining core zone can be characterized by a mix of natural environment and extensive forms of agriculture. The natural environment will be build up by the current present remains of forest and natural grassland areas in combination with previously implemented projects along the stream Baakse Beek. In addition to this, the core zone will be further adapted to provide the necessary conditions which are required for the dispersal of the species in the two ecoprofiles (for example a pond every 500m). Because the different forest patches are added to the green-blue veining core zone, some areas are wider (for example northeast of Lievelde) than others (for example along the stream Baakse Beek). Though the primary form of land-use in the core zone can be designated as natural environment, agriculture is not forbidden in this area but instead concentrates on extensive methods of production so that the natural environment in the core zone will be less affected.

Green-blue veining buffer zone:
The green-blue veining buffer zone will remain its current form of land-use. Instead, the focus in this zone will be on the field edges. The green-blue veining buffer zone can therefore be characterized as a primarily (intensive) agricultural zone, with a strong emphasis on the development of linear landscape elements along the fields. These field edges should be adapted to allow the dispersal of species through the matrix (realizing >10% concentration of landscape elements per km^2), this is necessary because the green-blue veining core zone still contains (extensive) agricultural areas causing more disturbance and providing a smaller amount of guidance through the landscape. To allow the dispersal of species, a wider buffer zone as a substitute to the designated core zone is necessary.

Stepping stone:
A requirement of the species under the ecoprofile Badger is a stepping stone after 7,5km: one that provides temporary habitat with sufficient shelter. The nature reserve Koolmansdijk (fig. 12) can be upgraded to provide this function. The area does need additional habitat for the species in the ecoprofile Badger, this to reach the area requirement of at least 200ha and the required amount of shelter (see ch. 2.6).

Figure 12. Koolmansdijk
(source: IVN)

Pond network:
Around the nature reserve Korenburgerveen a pond network should be developed to (re)connect with the ponds around the settlement Winterswijk and to connect with key habitat areas of the ecoprofile Great Crested Newt. Besides this one, another pond network should be established to connect the ponds in the core zone with the key habitat area of the ecoprofile Great Crested Newt southwest of Marienvelde.

5.3 Developing green-blue veining network with landscape services

In chapter 4.2 the landscape services in the focus case study area have been analysed and a rating has been applied. The landscape services with a high rating, indicating a high level of dependency on landscape elements, will be used for the development of a green-blue veining network.

The landscape services with a high rating are:

- Extensive food production
- Air quality improvement
- Protection against weather extremes
- Erosion mitigation
- Pollination and seed dispersal
- Pest regulation
- Tranquility / Appreciation with surroundings
- Recreation
- Identity of the region
- Habitat for species
- Genepool

These landscape services have the strongest association with linear landscape elements and are therefore added (and/or improved) in the area when a cohesive network of linear landscape elements can be realized.

5.4 Impression of the future situation

For the two, in fig.11, indicated locations a simple sketch has been produced to provide an impression of a potential future situation with a cohesive green-blue veining network. In both sketches the proposed green-blue veining core zone and a green-blue veining buffer zone can be seen. The core zone has a predominantly natural shape, mixed with extensive agriculture, this while the buffer zone is dominated by a more intensive form of agriculture. In the buffer zone the focus lies on the establishment of linear elements along the fields without changing the current type of land use in the surrounding agricultural area. These linear elements function as a form of veins in the matrix of hostile environment for the species under both the ecoprofiles. The development of cohesive linear landscape elements along agricultural fields also generates additional landscape services such as air quality improvement, a buffer against weather extremes, erosion mitigation, pollination and seed dispersal as well as providing pest regulation. Green-blue veining is therefore very beneficial to the surrounding agricultural landscape.

Adaptation measurements for location A in fig.11 are mainly centered in a zone along the embankment of the stream “Baakse Beek”. Ponds will have to be realized in order to meet the requirements for the species of the ecoprofile Great Crested Newt. This can be done on both sides of the stream, however the southern embankment is most beneficial seen the amount of key habitat areas around the settlements Zieuwent and Marienvielde.

On the sketch of fig. 14 a network of ponds can be seen on the southern embankment of the stream. Extensive agriculture can be allowed along the embankment, though large scale access of livestock to these ponds should not be permitted. Presence of livestock in low numbers can help keep ponds ‘open’, however over stocking causes the disappearance of plant, invertebrate and amphibian species (Langton et al. 2001).

A natural embankment with smooth edges should enhance the growth of a variety of aquatic plant species in ponds (fig. 13). The land around the ponds should provide the species of the ecoprofile Great Crested Newt with sufficient feeding and shelter opportunities. Rough grasslands with a variety of vegetation provide feeding and sheltering opportunities. Linear landscape elements aloung the stream guides the species of both ecoprofiles during dispersal between key habitats. On the northern side of the stream, the focus can be on recreational facilities; this by a combination of hiking routes and cycling routes. Retention sites for water can be combined with hiking routes on raised wooden floors (see fig. 14).

Figure 14. Sketch of location A in fig. 11

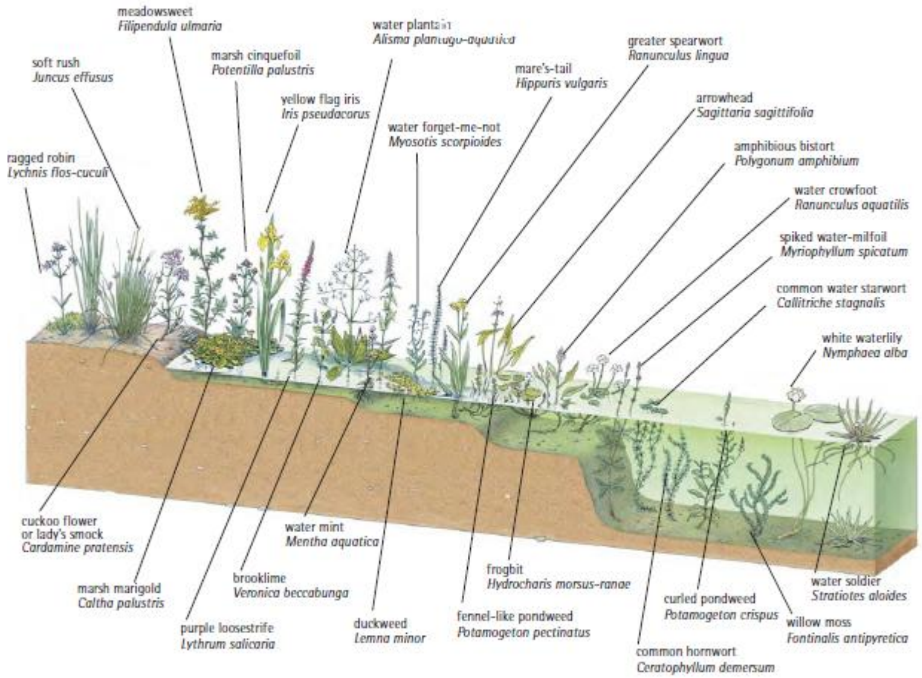

Figure 13. Typical aquatic plant species at great crested newt ponds
(source: Langton et al. 2001)

The realization of a dense and cohesive network of lanscape elements on both sides of the stream will greatly enhance several landscape services, such as food production; protection against weather extremes, erosion mitigation of the stream, enhance pollination and seed dispersal of surrounding agricultural land, improve pest regulation as well as give a boost to the regions identity, recreation and appreciation to the natural environment. Besides these services, the realization of dense and cohesive linear landscape elements as hedgerows and treerows, will allow the dispersal of species of both ecoprofiles along the stream.

The surrounding agricultural land will remain its current land use form. In this (buffer) area the focus will be on the realization of a fine maze of linear landscape elements along the field edges. A combination of hedgerows, tree rows, ditches/drains with embankment should be realized in this zone in order to meet the requirements of both ecoprofiles for the dispersal through semi-agricultural land (more in ch 5.3).

Adaptation measurements for location B in fig. 11 are mainly centered on the creation of a pond network between the nature reserve Korenburgerveen and the forest patches on the western side of the national road N18. By following the areas of seepage, a core zone can be realized between these forests (see fig. 15). An area around the stream 'Vragenderbeek' is most suitable for the development of new ponds, seen the amount of seepage along this stream (see Appendix V). The core zone has to cross the railway and the national road N18 before reaching the forest patches north of the settlement Lievelde. The realisation of small fauna tunnels for the species under the two ecoprofiles underneath these barriers can easily help to pass the barriers. A pond network around the Korenburgerveen will create the necessary connectivity with key habitat areas around Winterswijk (see fig. 5 and 6) and can function as an additional buffer for the Natura2000 reserve; Korenburgerveen.

The realization of a dense and cohesive network of lanscape elements in and along the core zone will greatly enhance several landscape services, as food production; protection against weather extremes, erosion mitigation of the streams, enhance pollination and seed dispersal of surrounding agricultural land, improve pest regulation and increase the identity of the area. The realization of recreational routes along the core zone can function as a link between the popular Korenburgerveen and the forests north of Lievelde and beyond, giving a great boost to the regions attraction level and appreciation to the environment. Besides the services above, the realization of dense and cohesive linear landscape elements as hedgerows and treerows, will increase the dispersal of species of both ecoprofiles between the area of the Baakse Beek and the Korenburgerveen (and beyond towards Winterswijk/Germany).

In the surrounding green-blue veining buffer the focus will be on the establishment of landscape elements along the agricultural fields.

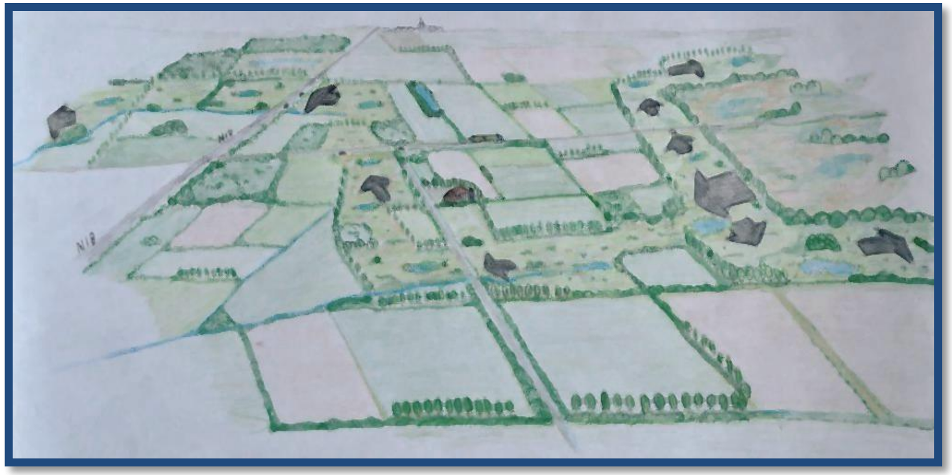

Figure 15. Sketch of location B in fig. 11

5.5 Multifunctional landscape: using the Common Agricultural Policy 2014-2020

The area around the green-blue veining core zone, designated as buffer zone in fig. 11, will remain its current form of (intensive) land use under the current environmental policy. In this green-blue veining buffer zone, the focus will be on the realization of a fine maze of landscape elements along field edges and between different properties. Opportunities for the realization of this fine maze structure of landscape elements along agricultural fields could be found in the new Common Agricultural Policy 2014-2020.

The Common Agricultural Policy (CAP) is a system of the European Union comprising out of agricultural subsidies and programmes for price agreements (European Commission 2008). It aims on an European agriculture that is competitive on world markets, with strict standards on environment, food safety and animal welfare, this within a framework of a sustainable and dynamic rural economy (European Commission 2008).

In 2014 the new Common Agricultural Policy (CAP) will come into force. The new CAP contains a reform in the policy for the period 2014 to 2020, this to build up a more sustainable, smarter and more inclusive growth for rural Europe (European Commission 2010)

The challenges of the CAP are structured in two complementary pillars, with annual direct payments and market measures making up the first (market support), and multi-annual rural development measures for the second pillar (selective payments) (European Commission 2010). The reviewed CAP contains a greener and more equitably distributed first pillar and a second pillar focusing more on competitiveness and innovation, climate change and the environment (European Commission 2010), besides this support is more targeted to active farmers and to the services they provide to society.

One of the important adjustments in the CAP is on the income support of farmers. This adjustment in the course of the CAP is going to bring substantial changes in the subsidy income for farmers in the case study area. The European Commission proposed this change as a form of greening of the EU farm income support for the enhancement of the environmental performance of the CAP (European Commission 2010). As a part of this greening of the farmers income support, in the future 30% of the market support (pillar1) will only be made available, when farmers include sustainable practices. One of these practices is the obligatory setting aside of 7% of land for ecological purposes in order to get the payment. This development could lead to significant change in farming practices in the region. The 7% regulation could become a great enhancement for the establishment of a green-blue veining structure in the designated green-blue veining buffer zone in fig. 11. By focusing on the establishment of a cohesive linear landscape elements along agricultural fields, a win-win situation could be reached in which farmers receive their additional 30% income support and biodiversity obtains a permeable matrix.

As Zeijts et al. 2011 state: “Greening the CAP could improve the effectiveness for biodiversity by stimulating farmers to design ecological set-aside areas in such a way that a regional ‘green infrastructure’ would be created, facilitating the spread of source populations in farmed areas“.

6. Supply and demand for green-blue veining

The ecological corridors which have so far been proposed under the NEN-programme have a predominantly natural character. Even though some are combined with recreational zones, most of the other forms of land use are kept out of the robust corridor strategy. In chapter 5 a much more cultural landscape has been proposed as an ecological corridor. The designation as ecological corridor is here strongly linked to the conservation and enhancement of a cultural landscape where nature values are merged together with agriculture and recreational aspects.

The proposed integration of land uses requires a strong (bottom-up) collaborative planning approach, in which the interests of the various stakeholders are merged and in which a great diversity of stakeholders are involved in the process of landscape adaptation. Working together in a meaningful way is subjected to a number of changing and unpredictable factors, such as the willingness to cooperate and participate; the diversity of stakeholders (if only some stakeholder groups participate, it might result in an unbalanced picture) and the skills and experience of the stakeholders. Such an approach is therefore an thorough and long process. Besides these, the participation of various stakeholders is also under influence of the proposed scale of the project site. A meeting for stakeholders which is limited to a small "local site", might receive less or different stakeholders compared to a wider approach as "landscape".

A landscape with a well-functioning green-blue veining network delivers multiple landscape services to society as a whole (fig 16). The proposed landscape adaptation measurements for a green-blue veining network in ch.5 contains significant opportunities in the shared interests and values of the different stakeholders involved. Although the demand for landscape services from green-blue veining is coming from the entire society - depending on the different interests of an individual - the supply of landscape services has to come from landowners in the area; such as farmers, different levels of government (state, provincial, municipality, water boards), nature organizations and private parties. Supply of a well-functioning landscape network is on the other hand triggered by the amount and type of demand coming from society. Demand for landscape services can activate landowners to work on a green-blue veining network.

The above described two-way supply-demand process requires a bottom-up approach and a participatory methodology in planning.

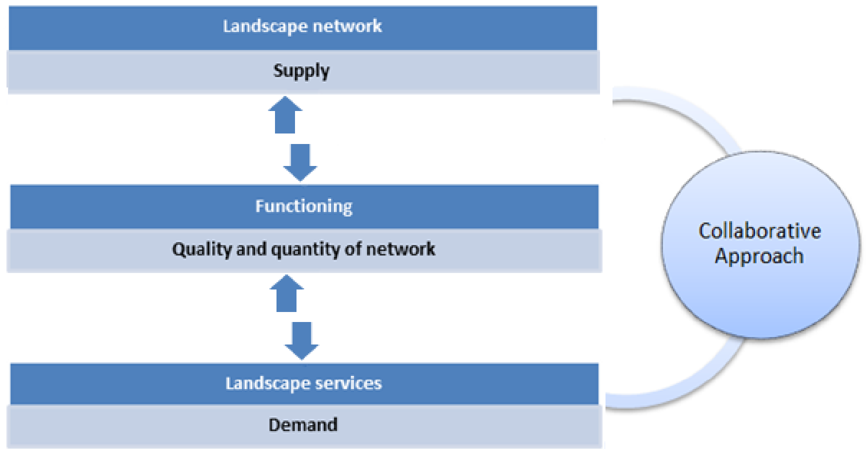

Figure 16. Supply-Demand relation in a green-blue veining network

By focusing on the benefits from landscape services; spatial planners can take a strategic position in collaborative stakeholder meetings, which can help to generate support and might even help to generate supply of green-blue veining (fig. 16).

A collaborative approach can therefore help to design an effective green-blue veining network that reflects the interests of the different stakeholders and helps to build a common understanding on the topic of green-blue veining. Financial support can be created at the demand site (such as drinking water companies, owners of recreation/camping sites etc.), however this requires a long process which takes multiple years to grow. To start with, some of the measurements in green-blue veining would have to be generated by the supply site: this through government run financial mechanisms, such as direct investments in nature reserves (in the green-blue veining core) and support through subsidy schemes (in the green-blue veining buffer) (see ch. 5.3).

By promoting green-blue veining as a multifunctional strategy that enhances different interests of various stakeholders and by already implementing some of the measurements in the green-blue veining core zone, a higher level of demand for a green-blue veining network can be created. With a high level of demand other stakeholders in the area could eventually become interested in investment and/or lobbying for a green-blue veining network and potentially even take over some of the landscape adaptation measurements in the area.

7. Conclusion

Throughout this thesis study a number of questions have been investigated to get an idea about the potential of the green-blue veining strategy as an alternative to the robust corridor. This chapter contains the key findings of this thesis study and proposes a set of recommendations for the Province of Gelderland and proposes some potential future research topics. This chapter also reviews whether the research question of this thesis study has been answered and reflects on the applied methodology.

7.1 Critical reflection on the applied methodology

The development of a methodology to analyze a large case study area has been one of the main themes in this research. From the beginning on the ecoprofile approach has been used. This approach has proved to be a useful tool in a spatial planning question, yet it limits the scope of the research to the selected ecoprofiles only. In this research the ecoprofile Badger and ecoprofile Great Crested Newt, were used to answer the research questions. Though a lot of information about the corridor requirements of the two selected ecoprofiles were available, some additional assumptions about the spatial requirements of landscape elements had to be made to be able to analyze the case study area.

In this research total areas of landscape elements in the current situation have been calculated with ArcGIS. Because of a limit in the available ArcGIS data (landscape elements mainly available as line data instead of polygons), assumptions were made in order to calculate total areas. For this reason the outcomes of the ArcGIS analysis should not simply be taken for granted. The concentration maps which have been produced with the ArcGIS calculations give an interpretation of the pattern of landscape elements in the case study area, seen the fact that the landscape elements in these maps are generally based on width assumptions the concentration of these landscape elements could be different in reality. Running a similar ArcGIS model with different widths would give a relative decrease/increase of concentrations depending on applied (buffer) widths of landscape elements, yet the general pattern of landscape elements would remain the same.

The in this research applied ArcGIS steps appeared to be useful for the analysis of a large case study area. Though the applied model in this research has been kept rather simple because of the limited available time, a more detailed analysis could easily be applied by using a finer grid size, using more accurate widths or by using larger variety of landscape elements when necessary. For this reason the applied ArcGIS tool could potentially also be convenient for future analysis of landscape elements on a larger scale when this model is further extended to create a more detailed outcome.

Key habitat areas of the species in the two selected ecoprofiles, have also been built on general assumptions. For the ecoprofile Badger an assumption of a cluster of at least 30 raster squares with > 10% concentration of landscape elements is seen as a key habitat area. For the ecoprofile Great Crested Newt, 5 ponds in a cluster with at least 10% landscape elements and within reach of the max dispersal distance, are seen as a key habitat area. The quality aspect of these habitat requirements has not been analyzed (for example the quality of different ponds). Whether or not these assumed key habitat areas actually contain the populations of species in order to be seen as a key habitat area is therefore uncertain.

Because the subsequent steps in this research are founded on the outcomes of the concentration maps (including the locations of key habitat areas), the proposed locations for landscape adaptation are also established on the assumptions of this research. Thorough research is therefore recommended to clarify the locations of key habitats and to further determine the locations which require adaptation measurements.

Seen the fact that this research focused on two selected ecoprofiles, it is also important to note that the recommended spatial measurements are similarly limited to the requirements of the species under these two ecoprofiles. Whether or not a similar planning concept as provided in fig 11 could be applicable for other ecoprofiles, therefore remains uncertain and would have to be investigated in future research.

In general this research has had a strong emphasis on the spatial and ecological dimensions of green-blue veining. The question on how to organize such a green-blue veining network in a collaborative bottom-up manner, has received limited attention and should therefore be further deliberated in future research.

With the landscape services coming from a green-blue veining network, demand for the green-blue veining strategy could potentially be created. In this research a rather simple rating method has been applied to analyze the relation between landscape services and landscape elements. In order to get a more detailed understanding about the relation between landscape services and landscape elements, a more thorough analysis would have to be applied.

Furthermore, it remains unspecified what quantity and quality of landscape elements is required to deliver well-functioning landscape services to landowners and to society in general. In general, the design aspect of landscape elements has been beyond the scope of this research. It therefore remains uncertain whether the design requirements of landscape elements to allow species dispersal are similar as to the design requirements of landscape services. It might be possible that a wider zone between agricultural fields is necessary in order to achieve the desired level of landscape services, whereas a smaller linear network of landscape elements might already provide dispersal opportunities to some species.

7.2 Response to research questions

The current economic and political climate of the Netherlands makes it very difficult to realize a comprehensive and expensive strategy such as the robust corridors. This research focused on the potential of green-blue veining as an alternative to the robust corridor strategy. In order to find out whether or not green-blue veining could be used as an alternative, the following research question was established;

"What configuration is required for the implementation of green-blue veining as a corridor in the landscape and what benefits in the form of multifunctional landscape services result from the development of green-blue veining?"

In order to explain this comprehensive research question a set of sub-questions have been answered.

The first sub-question is: “What are the characteristic landscape elements within green-blue veining?”. To answer this question a thorough desk study has been applied, including various scientific papers about green-blue veining and papers about the underlying required knowledge on species dispersal and fragmentation solutions. Green-blue veining can be seen as a network of small-scale semi-natural elements between agricultural fields such as field margins, hedgerows, tree rows and other small linear elements; helping to increase matrix permeability. In order to find the characteristic green-blue veining elements for landscape connectivity a reference to species requirements cannot lack. The ecoprofile approach was therefore in this thesis used as a tool to examine the configuration requirements of green-blue veining. An ecoprofile provides a combined overview of multiple target species requirements for the habitat and the corridor requirements. This tool has been applied in the development of two observation checklists for the selected ecoprofiles; Ecoprofile Great Crested Newt and Ecoprofile Badger.

The second sub-question is: “Which locations in the case study area require a development of green-blue veining in order to create a corridor in the landscape for the ecoprofiles?”. To answer this question, the above mentioned observation checklists were used as the foundation in an ArcGIS model, which generated an overview of the concentration of landscape elements in the entire case study area and presented it in two raster maps made up by a 1x1 kilometer grid. These maps gave an overview of the concentration of landscape elements in the case study area and gave an interpretation of the pattern of landscape elements in terms of providing connectivity in the current situation to the two selected ecoprofiles. In this way, appropriate and inappropriate areas for dispersal of the species under the two ecoprofiles were made visible. A concentration of at least 10% of linear landscape elements per square kilometer is required for the dispersal of species through semi-agricultural landscapes. This requirement of 10% should be seen as a bare minimum, which indicates that higher concentrations are preferred. The 10% requirement is applicable for the different species under both the ecoprofiles, however the type of landscape elements that make dispersal possible are different for the two ecoprofiles. For the ecoprofile Badger more adaptation measurements are necessary in order to reach the 10% requirement in comparison to adaptation of the landscape for the species under the ecoprofile Great Crested Newt. This has to do with the fact that the species of the ecoprofile Great Crested Newt can disperse along/through more types of landscape elements than the species of the ecoprofile Badger. However, the ecoprofile Great Crested Newt does require the presence of a pond after every 500meters.

The third sub-question is: “Is the current structure of green-blue veining appropriate for the ecoprofiles and if not what landscape elements are necessary to implement?”. To answer this sub-question there was zoomed in on an appointed focus case study area around the settlement of Lievelde. The current concentration of landscape elements in this area seems rather high at first sight, yet the area is not adequately cohesive for the species under the two ecoprofiles making it currently a difficult or even impossible area to disperse through. For both ecoprofiles some areas have inadequate concentrations of linear landscape elements (<10%) and distances between different patches of landscape elements exceed the max gap distance of both the ecoprofiles. Besides this, a linear network of ponds for the species under the ecoprofile Great Crested Newt is lacking so far. Due to this fact the dispersal between key habitats becomes impossible for the species under the ecoprofile Great Crested

Newt. In order to make this area suitable for dispersal of species under both the ecoprofiles: a network of ponds, links between the current present elements (reducing gap distances) and an overall raise of linear landscape elements (to at least 10% per km^2) are necessary.

The fourth sub-question is: “What landscape services could potentially be provided by green-blue veining?”. To answer this sub-question, landscape services in the focus case study area were analyzed according to three domains; Ecological; Socio-cultural; and Economical. Next, a rating was given to the level of dependency (low-medium-high) of the landscape services on landscape elements. The appointed level of dependency indicates to which amount the landscape service can continue without the presence of the landscape elements in the direct surroundings. The landscape services with a high rating are very dependent on landscape elements and are therefore introduced and/or improved in the region when a green-blue veining network will be realized. By applying this rating, a focus can be laid on the landscape services which are dependent on small-scale landscape elements in green-blue veining.

Four criteria are the basis for a proposed green-blue veining network; following moderate and strong levels of seepage; connecting high concentration areas along the corridor route; connecting key habitat areas of both ecoprofiles; and the possibility of a stepping stone after 7,5km of corridor. With these criteria and the observations during a field visit, a green-blue veining network has been set up as a planning concept, which includes a core zone, a buffer zone, a stepping stone and pond networks. The core zone has a more natural shape, containing minor forms of extensive agricultural, whereas the focus in the buffer zone is limited to only the linear landscape elements along (intensive) agricultural fields. A stepping stone, containing the nature reserve Koolmansdijk, should provide temporary habitat and shelter for the species under the ecoprofile Badger. A pond network should connect the green-blue veining network with surrounding key habitats of the species under the ecoprofile Great Crested Newt.

The development of a cohesive network of landscape elements along agricultural fields generates multiple landscape services such as air quality improvement, a buffer against weather extremes, erosion mitigation, pollination and seed dispersal as well as providing pest regulation. The new 7% regulation under the reformed Common Agricultural Policy 2014-2020 opens up great chances for the development of such a green-blue veining buffer zone.

The fifth sub-question is: “What approach for stakeholder communication should be taken, seen the supply and demand of landscape services?”. Supply of landscape services mainly has to come from the landowners in the area, whereas the demand is coming from the entire society (including land owners). Demand does however trigger the supply of green-blue veining. By focusing on the various benefits of landscape services coming from the linear landscape elements; spatial planners can take a strategic position in collaborative stakeholder meetings, which can help to generate support for a large and multifunctional green-blue veining network as an alternative to the robust corridor strategy.

7.3 Key conclusion

The proposed planning concept for a green-blue veining network should be seen as an example of an alternative to the robust corridor strategy. This does not indicate that the proposed planning concept is the only alternative to the robust corridors. With the applied criteria and the combination with a field visit to the focus case study area, the proposed planning concept was established, yet this concept might be less effective in other areas or with the use of other ecoprofiles. Because the two applied ecoprofiles in this research required some adaptation measurements, such as the development ponds after every 500m, a core zone which provides these key requirements of the ecoprofiles seemed a logic choice. Whether the dividing of the green-blue veining network in a core and buffer zone is also desired with other ecoprofiles is therefore uncertain. Though this research has answered some important questions in respect to the opportunities for the green-blue veining strategy, probably even more questions come up after reading this report. It is hoped that this report encourages spatial planners to put more attention in the green-blue veining concept. Green-blue veining opens up new opportunities for the integration of various aspects coming with spatial planning (such as water management, sustainable agriculture, habitat enhancement, urban livelihoods, business parks etc.). As a way of meeting the challenges which arise in the current politic and economic situation in the Netherlands, green-blue veining offers an integrated strategy for adapting the landscape and meeting the future needs of semi-agricultural, urban and natural environments by enhancing the landscape with both the human interests and enhancement of the natural environment.

By answering the different sub-questions the potential of the green-blue veining strategy has been investigated. With the limitations of this research in mind, it can be said that in general the green-blue veining strategy has a great potential of becoming a worthy alternative to the robust corridor strategy. Though from an ecological point of view, this can essentially only be said for the two ecoprofiles that were used during this thesis. In order to achieve similar levels of functionality as the robust corridor strategy, a wider green-blue veining network should be established. When sufficient attention is given to the development of a for species suitable network of small-scale linear landscape elements, the "veins" can function as a facilitator of dispersal, this by providing the necessary habitat of species in order to cross through agricultural landscapes. Moreover, the green-blue veining strategy opens up many new opportunities for a multifunctional landscape, whereas in the robust corridor strategy the emphasis is on a (single-use) ecological purpose. Especially in the view of the landscape services - which can be utilized for the realization of a green-blue veining network - the strategy seems to have great potential, which has up to now received an inadequate amount of attention in spatial planning practices in The Netherlands.

7.4 Some additional recommendations

In the conclusion above an answer has been given on the potential of landscape elements and landscape services as an alternative to the robust corridor strategy. Some aspects need additional attention by the Province of Gelderland and/or need to be further investigated by researchers. Some extra recommendations are therefore provided;

- In order to facilitate dispersal of species through the matrix, a fine maze of linear landscape elements between fields is essential. To be just as effective as the robust corridor strategy a much wider zone is required, this due to a larger amount of obstacles and less guidance through semi-agricultural landscapes compared to a situation with a robust corridor. How much wider such a zone should be, is beyond the scope of this research. It is therefore strongly recommended to conduct further research on the area requirements for green-blue veining as a replacement of the robust corridor strategy.

- This thesis study focused on dispersal opportunities for species through agricultural landscapes. The case study area contains a dense road network of which some hold a high traffic frequency. Especially the national and provincial roads are major obstacles for the dispersal of species. Although solutions to these barriers are not a part of this thesis report, it is strongly recommended to install fauna passages (such as badger tunnels) underneath some of these barriers. Additional research is recommended to find out exactly where, in what way and how many of these solutions are desired.

- A 10% concentration of fine linear landscape elements per square kilometer is recommended in order to facilitate the dispersal of species under the two ecoprofiles. The obligatory setting aside of 7% of land (per farm holder) for ecological purposes under the new Common Agricultural Policy 2014-2020, might not be sufficient to reach this 10% concentration requirement per square kilometer (depending on the size of a farm). Additional landscape adaptation measurements might therefore be necessary in order to reach the recommended 10% requirement.

- Although 10% concentration of landscape elements is often proposed as a suitable quantity of landscape elements, it must be said that this value is related to the requirements of the two selected ecoprofiles only. For other ecoprofiles, a different concentration of landscape elements might be required. Besides this, the 10% requirement should be seen as a bare minimum. Higher concentrations of landscape elements would enhance the dispersal opportunities of species. It is therefore recommended to apply higher ambition levels with respect to the concentration of linear landscape elements per square kilometer.

- In this thesis study many assumptions had to made, particularly about widths of linear landscape elements (due to ArcGIS data limitations) and about the locations of potential populations of species. Additional research needs to be conducted to find out how wide a landscape element (tree row, hedgerow, embankments etc.) should be, in order to make dispersal possible. Available literature on this topic proved to be rather limited. Besides this, additional research about adequate vegetation types in the undergrowth of landscape elements is required (sort of shrubs, tree sizes, density of bushes etc.). The key habitats which were used in during this thesis study are potential key habitats and thus an assumption. Additional research is necessary to find out, whether these areas actually contain relatively large populations of species in a network to be seen as a key habitat area.

- The design aspect of individual landscape elements in order to provide species dispersal and to provide multiple landscape services, has been beyond the scope of this thesis study. It is therefore recommended to conduct further research into this topic.

- In this study a 1x1km grid has been used to investigate the concentration of landscape elements in the case study area. Due to the available amount of time, a study with a smaller grid size has not been conducted. In order to get a more detailed picture of the concentration of landscape elements the use of a smaller grid size, such as 250mx250m, is recommended.

- The ecoprofile approach has proved to be a suitable instrument to work with during scientific research. During this thesis study some misunderstandings about the meaning of an ecoprofile occurred. It is very tempting to speak about a single species in relation to an ecoprofile. An ecoprofile is not a single species, but is a profile which constitutes out of multiple species. When spatial planners apply this instrument, it is recommended to use a letter, (for example: Ecoprofile A) instead of the name of a species, to avoid any future misinterpretations of this concept.

- Because of the limited available amount of time to conduct this research, the emphasis in this research is very much on the spatial and ecological requirements of a green-blue veining network. How to organize such a network in a bottom-up and collaborative approach has received little attention. It is therefore recommended to conduct further research in this topic.

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Appendix

I Description of used landscape elements

- Tree rows:

Figure 17. Example of a tree row without undergrowth

In the case study area tree rows are often narrow rows of trees such as seen in fig.17, some including small shrubs, that function as a border between properties or farm fields. In agricultural areas some tree rows could be between the lanes for cars and bicycles, or at the border of the street and/or agricultural field, or even a combination of these. A for dispersal suitable tree row corridor contains a large diversity of plants and an array of different vegetation layers, containing dead material on the ground, shelter in the form of small shrubs and smaller trees among the row itself.

- Hedgerows:

A hedgerow is a row of wild shrubs and smaller trees (larger density of shrubs), often as a form of border between properties or fields (fig. 18). A suitable hedgerow also contains different vegetation layers, dead material on the ground and smaller shrubs which provide shelter for species.

Figure 18. A Mixed Hedge/Tree row

- Ditches with embankment:

A ditch functions as drainage along roads and/or fields (fig. 19). Ditches can be seen in and around agricultural areas and often only contain water after rainfall. An area along the sides of a ditch is often not used for crops/grazing and contains a variety of plants and smaller shrubs, which can help species disperse through agricultural land.

Figure 19. Ditch with embankment

- Drains with embankment

Drains are mostly seen along agricultural fields and roads. Most of the drains have steep edges and little vegetation in and along the water body, this to improve the drainage efficiency. A for dispersal suitable drain should provide shelter to species in the form of small bushes on the embankment (fig. 20). This is reached by lowering the channel slope to stimulate the growth of vegetation and to keep some distance between the drain and the crops.

Figure 20. Drain providing dispersal opportunities

- Streams with embankment:

In the case study area most streams have been canalized in order to improve the drainage capacity. A for dispersal suitable stream should provide shelter to species. Streamside vegetation can provide shelter. A zone of riparian vegetation can be created by realizing meandering streams with smooth channel slopes which allows the growth of a variety of plant species (fig. 21 and 22). On higher (dryer) ground small bushes and small trees can increase the dispersal functionality.

Figure 21. Stream with riparian vegetation

Figure 22. Stream providing dispersal opportunities

- Forest

Both larger and smaller remains of forests function as stepping stones and temporary habitat for species. In this study all types of forests have been used, though a mixed forest containing a greater variety of vegetation is more suitable for the selected ecoprofiles.

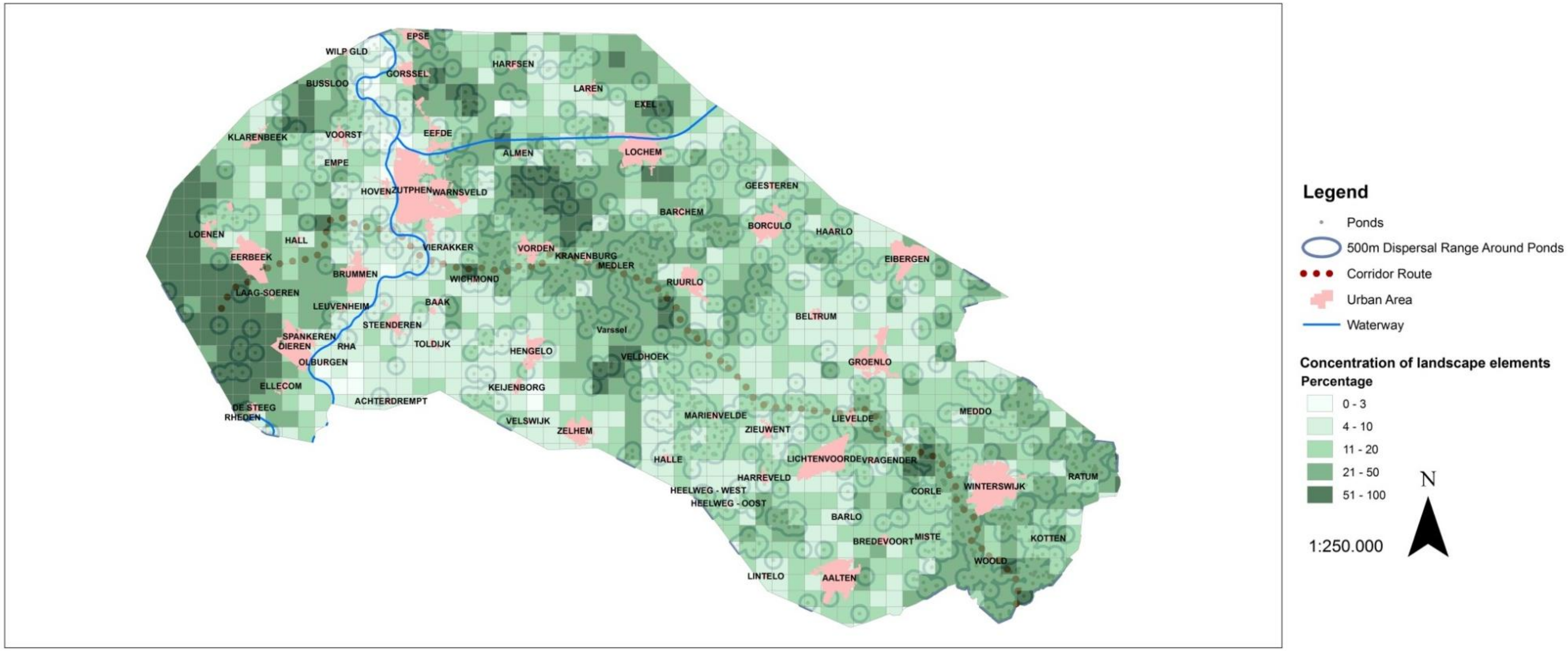
- Ponds

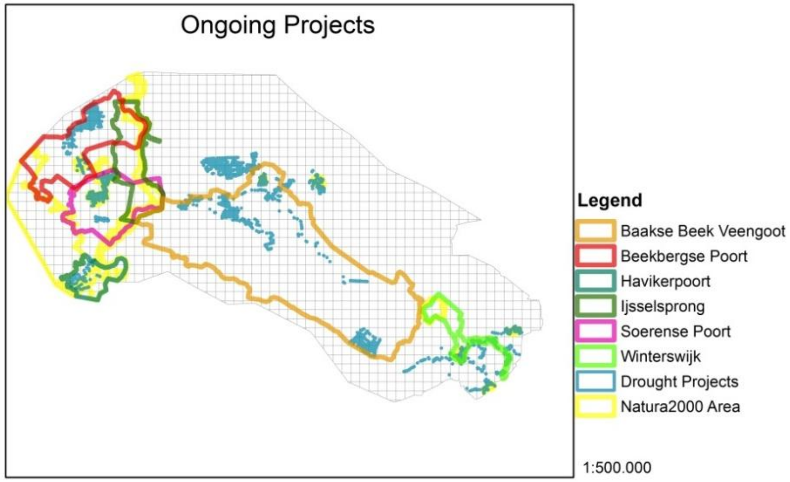
Ponds (fig. 23) provide the necessary stepping stones for the ecoprofile Great Crested Newt. Ponds including a rich and varied vegetation, no or very little fish and enough refuge habitat as shelter during drought or freezing are good for this ecoprofile.

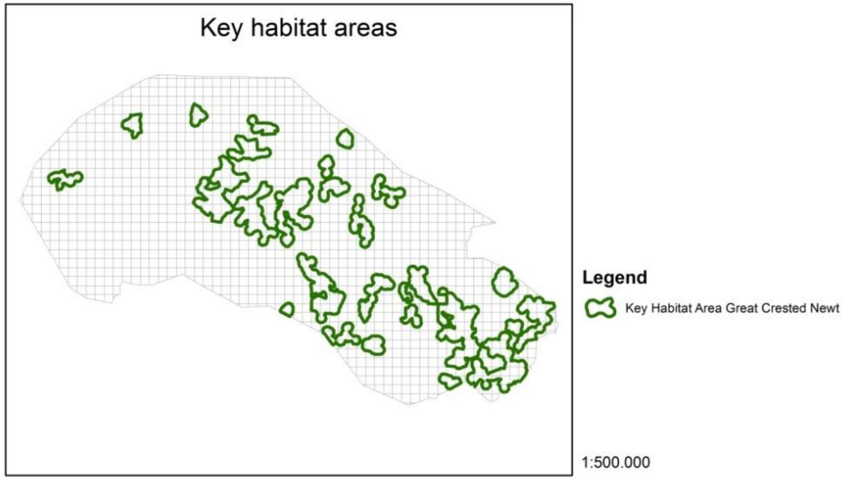
Figure 23. Pond with dispersal opportunities

II Concentration of landscape elements for ecoprofile Great Crested Newt

Concentration of landscape elements for Ecoprofile "Great Crested Newt"

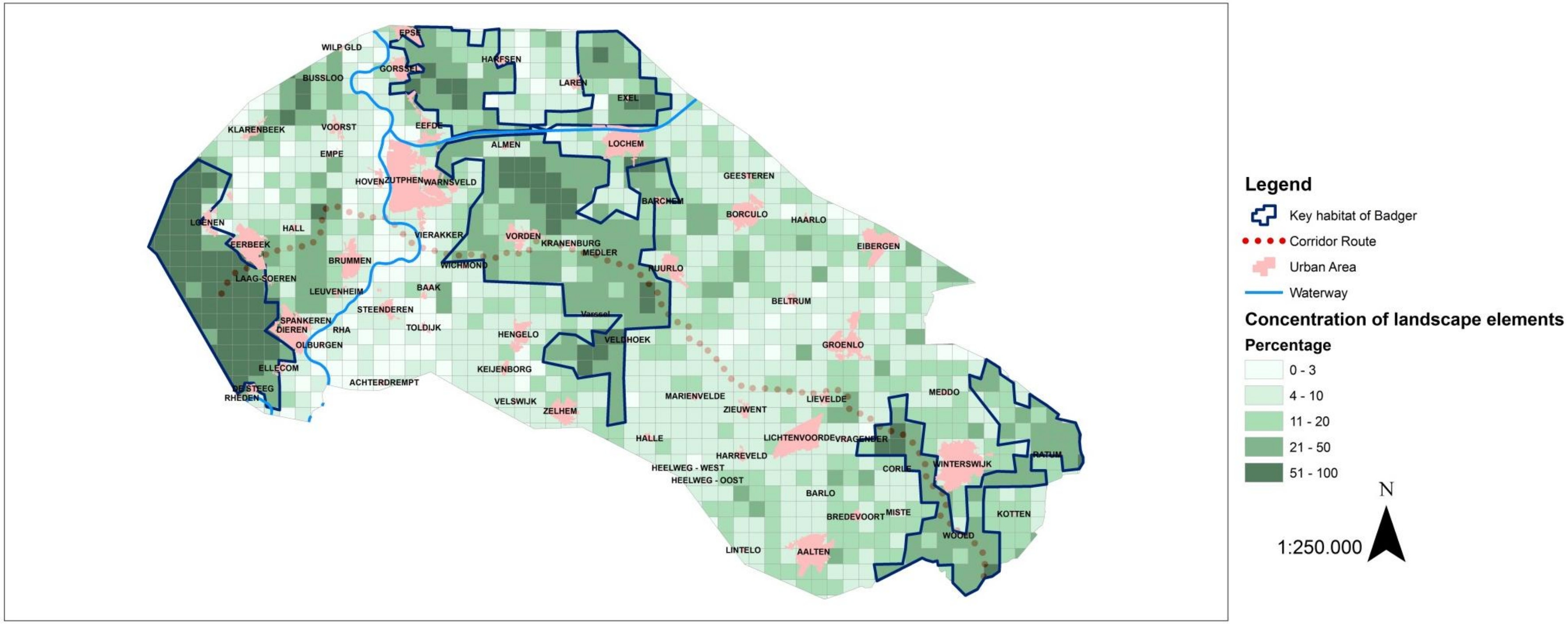




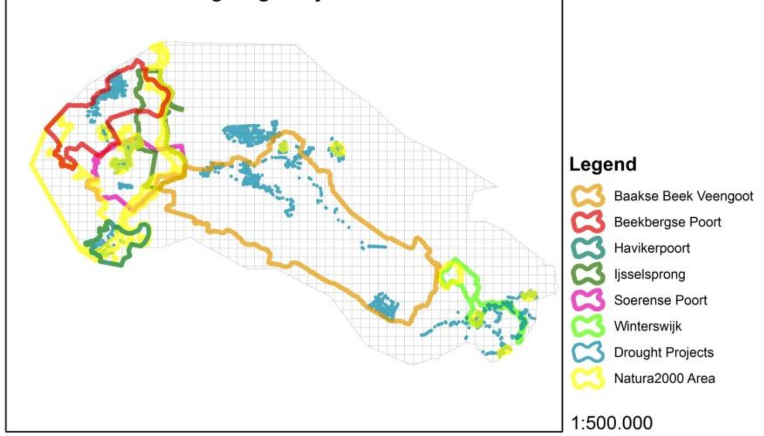


III Concentration of landscape elements for ecoprofile Badger

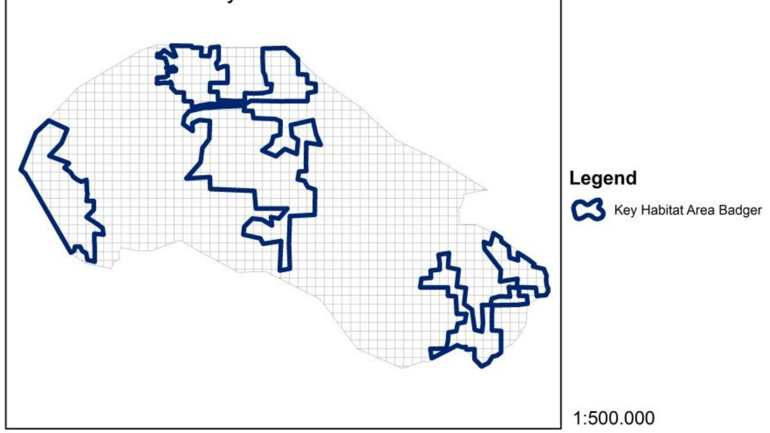
Concentration of landscape elements for Ecoprofile "Badger"



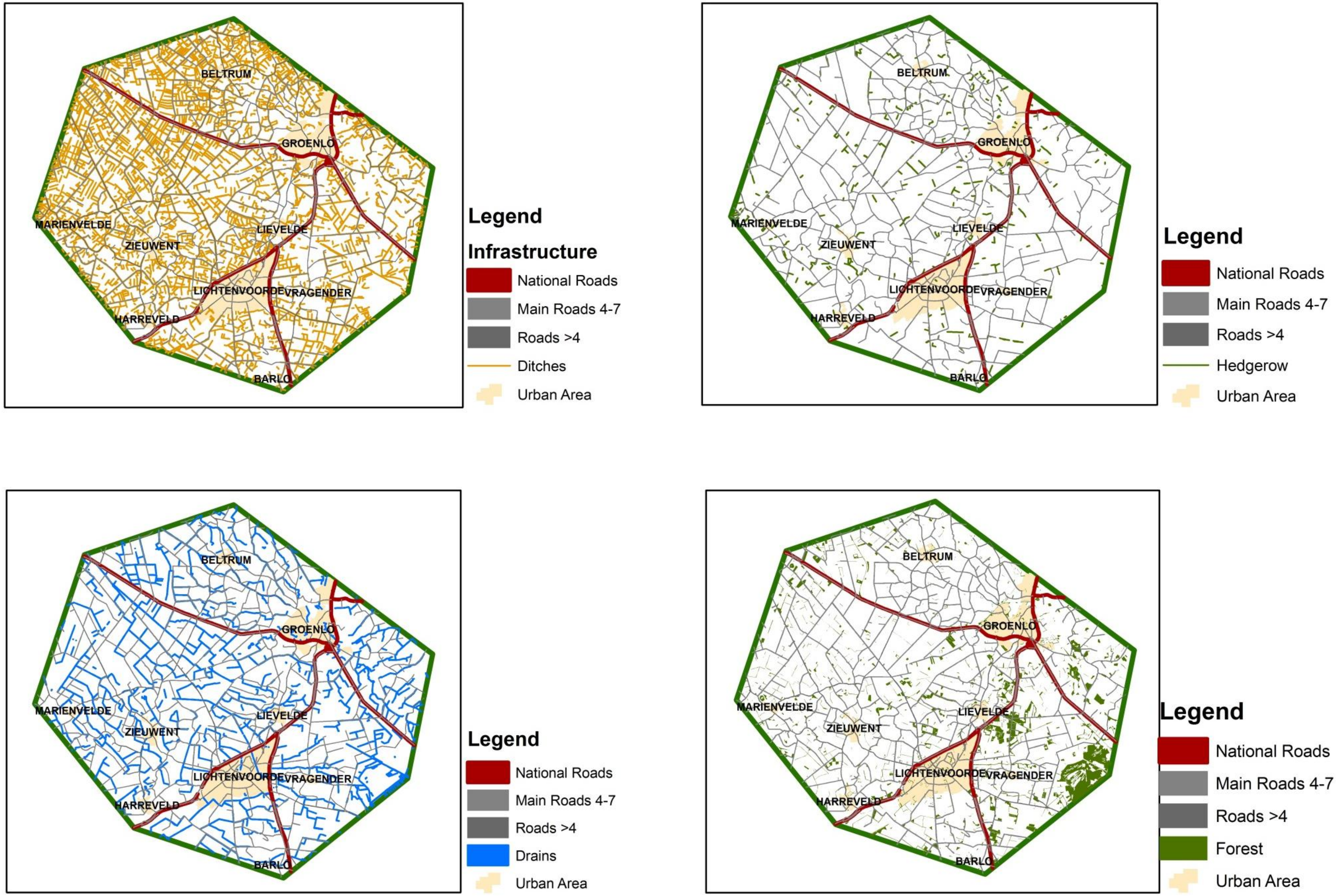
Ongoing Projects

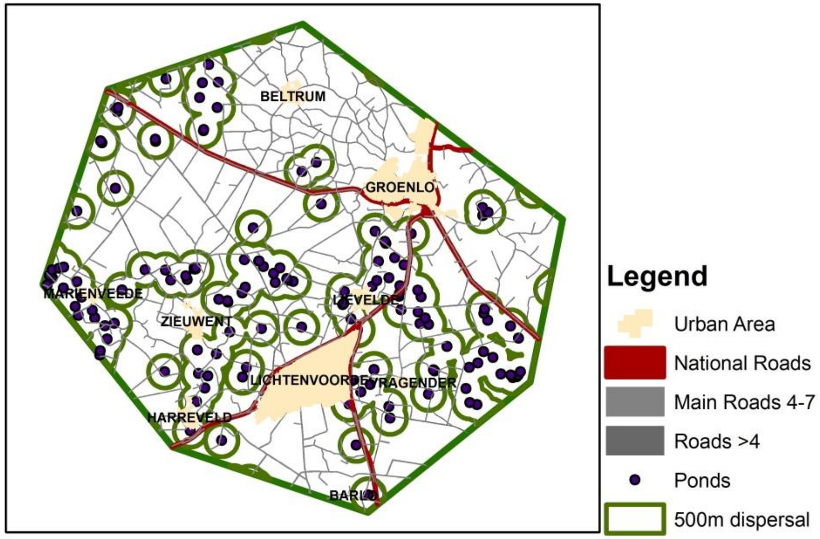


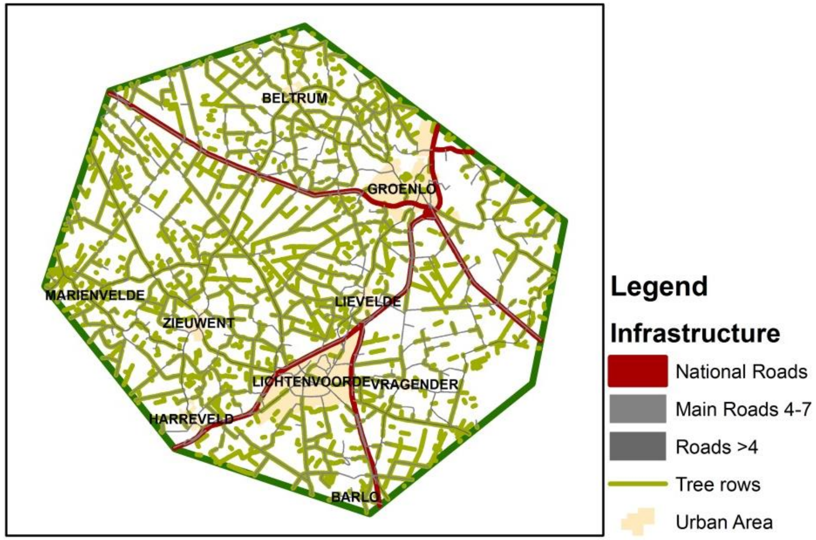
Key habitat areas

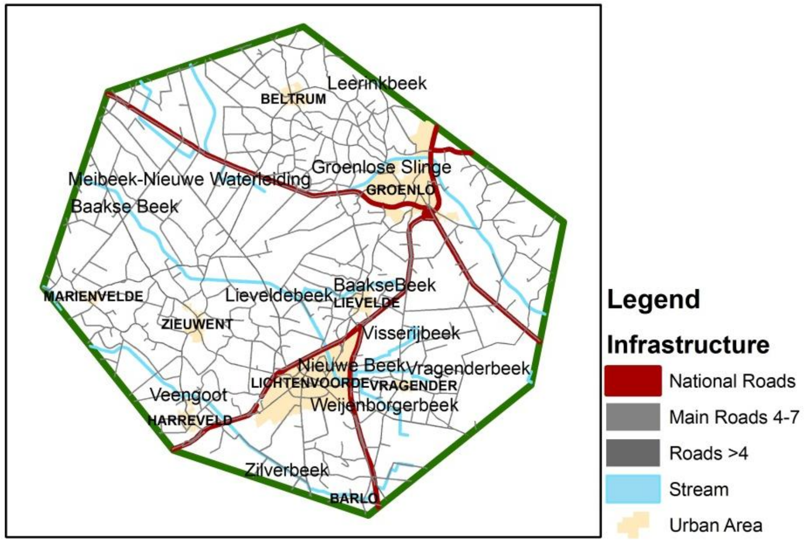


IV Landscape elements in the focus case study area

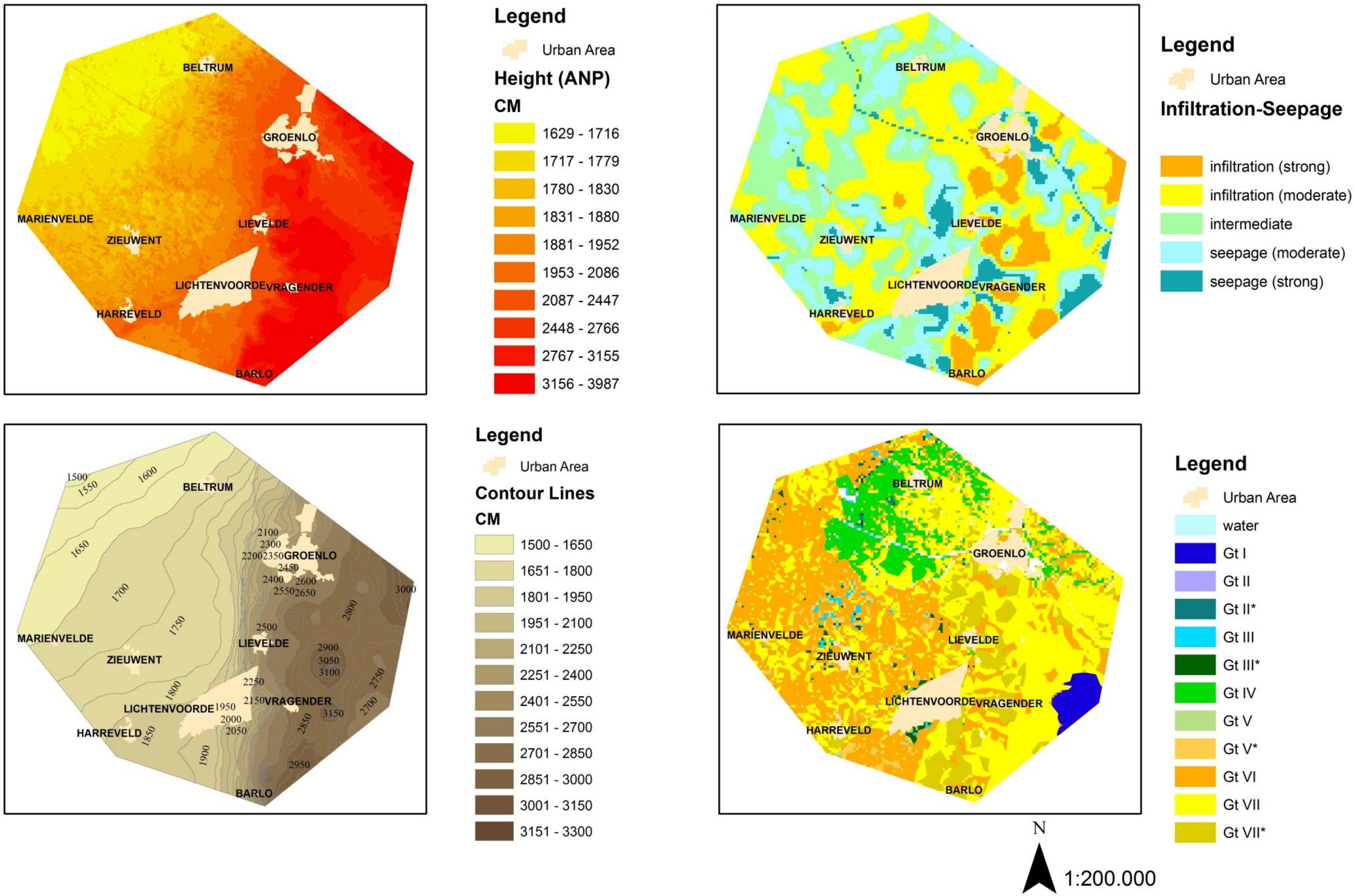



BELTRUM
GROENLO
MARIENVELDE
ZIEUWENT
LIEVELDE
LICHTENVOORDE
VRAGENDER
HARREVELD
BARLO
Legend
Urban Area
National Roads
Main Roads 4-7
Roads >4
Ponds
500m dispersal

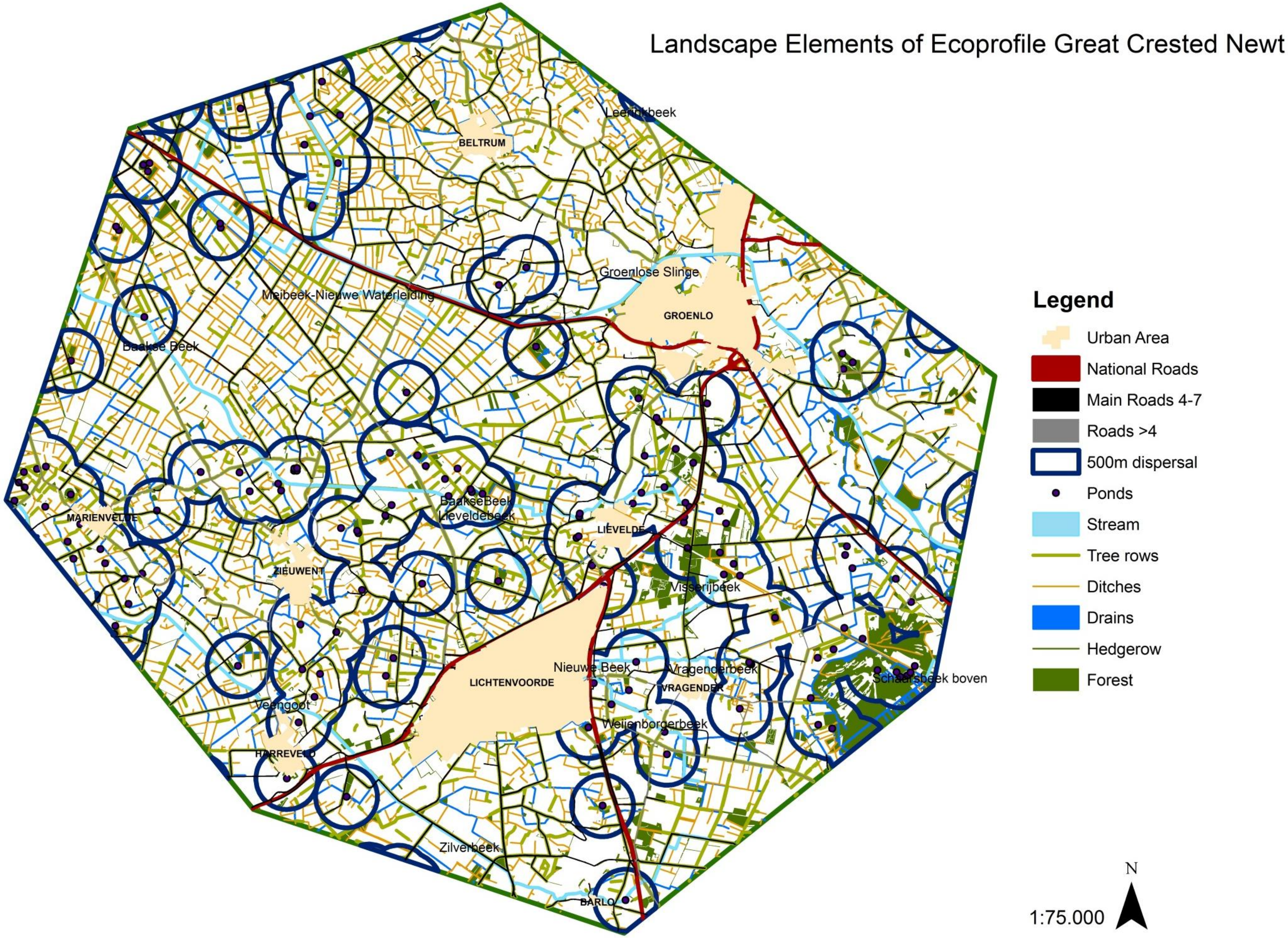

BELTRUM
GROENLO
MARIENVELDE
ZIEUWENT
LIEVELDE
LICHTENVOORDE
VRAGENDER
HARREVELD
BARLO
Legend
Infrastructure
National Roads
Main Roads 4-7
Roads >4
Tree rows
Urban Area


Leerinkbeek
BELTRUM
Groenlose Slinge
GROENLO
Meibeek-Nieuwe Waterleiding
Baakse Beek
MARIENVELDE
Lieveldebeek
BaakseBeek
LIEVELDE
ZIEUWENT
Visserijbeek
Nieuwe Beek
Vragenderbeek
LICHTENVOORDE
VRAGENDER
Veengoot
Weijenborgerbeek
HARREVELD
Zilverbeek
BARLO
Legend
Infrastructure
National Roads
Main Roads 4-7
Roads >4
Stream
Urban Area

V Height, contour lines and infiltration maps of focus case study area



VI
Landscape elements of ecoprofile Great Crested Newt



VII Landscape elements of ecoprofile Badger