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new delta

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ABSTRACT

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On the grounds of the Antwerp Port Authority, economic activities and nature co-exist in close proximity. To give nature a chance of survival, also into the future, the Port Authority, in collaboration with *Natuurpunt*, set itself the goal of establishing a network of ecological infrastructure. With this, a positive contribution is being made to nature objectives. Among the species found in and around the port is the natterjack toad (*Bufo calamita*), a species protected in the EU Habitat Directive. Against this backdrop, the NEW!Delta Project in the framework of the EU Interreg IIIB program offers excellent opportunities for sustainable conservation of the natterjack toad population on the left bank of the Scheldt. To bring this about, the LARCH expert system was used. The results led to a proposal for the measures needed and alternative spatial configurations to ensure the preservation of this protected species.

Key words: *Bufo calamita*, core area, corridor, ecological infrastructure, fragmentation, habitat, key population, LARCH, metapopulation, natterjack toad, Port of Antwerp, viability.

Photographs: Fabrice Ottburg.

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Foreword

Some time ago, the Antwerp Port Authority[1] and *Vzw Natuurpunt*[2] decided to start a collaboration with the goal of establishing an ecological infrastructure network in the Antwerp port area. This collaboration also provided the framework for a learning process that enabled both parties to gain insight into the way in which port activities and nature objectives can be reconciled. For those involved it is certain that this 'interweavability' is to some extent indeed a realistic option, but that, at the same time, a large number of nature responsibilities – the port area is situated in the midst of a special conservation zone – can be achieved only with a model whereby the port area is spatially separated from large nature areas that could potentially experience robust nature development. *Vzw Natuurpunt* and the Antwerp Port Authority view the coexistence of ports and nature as attainable via a two-track policy – on the one hand is the interweaving and on the other is the separation model. In interweaving nature and port functions the accent is on the conservation of species – at the level of Flanders and of Europe. Species conservation is then also the policy area to which this report aims to make its contribution.

Against this background, the NEW!Delta project offers an excellent opportunity to involve a broader audience of stakeholders and interested individuals in achieving the goal – the interweaving of ports and nature – and to do this on the basis of pilot projects and research.

To interweave nature and ports would seem an enormous challenge, especially when it comes to convincing businesses that such an interweaving would not necessarily constitute an extra tax on economic activity. Similarly, the interweaving of nature and ports puts nature conservation regulations to the test. It therefore remains a quest for balance. Nonetheless, the highly dynamic nature of port development offers surprising new perspectives for achieving such a balance. Fauna and flora that is able to thrive in a port environment is, after all, able adapt to its surroundings. But even finding is not offered on a silver platter, at least, not for a species like the natterjack toad.

The port area is an key site in Flanders where the natterjack toad is found. The monitoring studies of the Research Institute for Nature and Forest [3] underline this importance, but also the related threat, since it is merely by accident of circumstance that the species has been able to blossom here. As the economic utilization of the harbor's scarce space intensifies, the species' habitats are under threat of becoming isolated. However, even without economic development, the species – which requires land at an open stage of development – has little chance, unless an active conservation policy is mapped out.
It is here that the NEW!Delta collaborative initiative has demonstrated its value, because it is thanks to this framework that the Antwerp Port Authority and Alterra agreed to take the step to establish a scientific foundation for an active conservation policy. The study before you is the result of that initiative. This study establishes the preconditions that must be met to conserve a viable population of the natterjack toad inside the Left Bank Area of the Port of Antwerp. With this study providing its frame of reference, Antwerp Port Authority, together with the other public actors and stakeholders has discussed the idea of creating a network of stepping stones, corridors and cores. This network – conceived as a whole – should guarantee the long term viability of the natterjack toad population in this area. The map below represents the outcome of these discussions. It will be used as a guiding line for further planning and development.

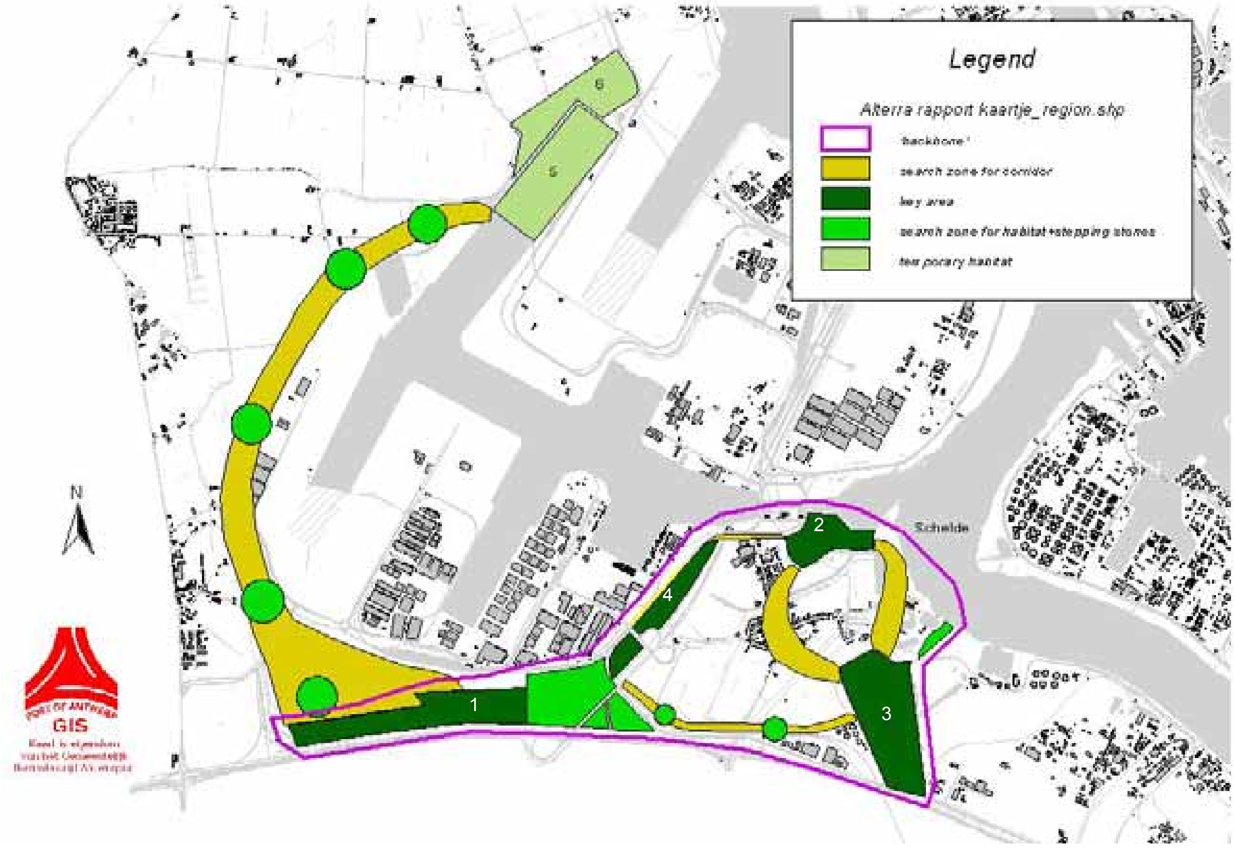
With this, we then also thank all of the people who guided this study, sparing neither time nor effort to bring this report to fruition.

Toon Tessier
Advisor, Antwerp Port Authority

1 The Port of Antwerp is the second-largest European harbor and the fourth largest on a world scale. In 2005 more than 160 million tons of goods were processed there, of which almost half in containers. The port provides work for more than 60,000 employees and is a driver of the Flemish and Belgian economy. See ***www.portofantwerp.be*** for more information. The Antwerp Port Authority is an autonomous municipal company that ensures the management of the Antwerp port.

2 *Vzw Natuurpunt* is the largest nature NGO in Flanders which among other activities manages a large proportion of the Flemish nature reserves. See ***www.natuurpunt.be*** for more information.

3 The Research Institute for Nature and Forest (INBO) is a scientific institute of the Flemish Government in Belgium. See also ***www.inbo.be***



Map: 'Backbone' and temporary habitats for sustainable conservation of the natterjack toad on the Left Bank of the port of Antwerp. 1) Haasop, 2) Saind-raised lands north of Lisdodde-Melkader, 3) Groot Rietveld, 4) Steenlandpolder, 5) Filled-in part of Doel dock and 6) Temporary MIDA lands.
Remark: in this figure the positioning of the 'backbone' and the temporary living areas are indicated after implementation of the planned port developments (known off in December 2005). Living areas that will disappear because of planned port developments are no longer reflected in this figure.

Photo 1. Example of a natural site combine with a high industrial area in the Port of Antwerp.

Summary

In the framework of the European program Interreg IIIB NW Europe, the project NEW!Delta was implemented under the leadership of the Dutch Province of South Holland. This project aims to advance the sustainable development of the NW European coastal areas, estuaries and ports so as to best serve nature conservation. It seeks a balance between ecology and economy.

Within Theme 3 of NEW!Delta '*Creation and restoration of coastal and estuarine habitats*', the knowledge institute Alterra, of Wageningen University and Research Centre, joined in collaboration with the Antwerp Port Authority (APA). Among the species found in and around the Port of Antwerp is the EU Habitat Directive-protected natterjack toad (*Bufo calamita*). The goal of the joint effort is, by applying the LARCH expert system, to arrive at a proposal for a spatial configuration of areas that can support a viable population of natterjack toads in the port. The Antwerp Port Authority would like to achieve this by making investments in habitat patches and with the formulation of a species protection plan.

The LARCH (Landscape Ecological Analysis and Rules for the Configuration of Habitat) expert system is based on the concept of metapopulations, and calculates for fragmentation-sensitive animal species the required area of habitat required and the persistence of habitat networks. The type of conclusions reached in the LARCH analysis for the natterjack toad relate primarily to the spatial configuration of the left bank area of the Scheldt in the vicinity of the Port of Antwerp. As such, the findings provide crucial insights into the port area's potential for the natterjack toad.

Five key steps were carried out with LARCH, leading to concrete proposals on 'how to deal with the natterjack toad in the vicinity of the Port of Antwerp on the left bank':

1. To determine whether a viable natterjack toad network was possible, the current status of the species was first brought into focus;
2. With the distribution picture known, it was established whether there was a metapopulation structure to speak of and, if so, what its spatial configuration was: 'Is there just one population network, or are there more? And where are these located?';
3. The effects of economic changes in the port area on the existing natterjack toad networks were incorporated;
4. In consultation with the Research Institute for Nature and Forest (previously the Institute for Nature Conservation), with *Natuurpunt* (the association for nature and landscape in Flanders) and the Antwerp Port Authority, alternative solution options were offered. These options were validated by stakeholders at an expert meeting and thereafter adapted (to local knowledge, information and support);
5. The different options were worked out further in spatial models and written reports.

To proceed through the five steps, ecological insights were needed on the concerned species, such as dispersal/migration distances, population density, current distribution and potential habitat patches. These are described in Chapter 3 'Species Profile Natterjack Toad'. That chapter also substantiates the following rule of thumb on what is needed to sustainably conserve a single population: 'For a key area (population) of 200 adult natterjack toads, 5.5 ha of land habitat and 1.5 ha of breeding habitat is needed: this, in total, is 7 hectares.'

Conclusion: The current population of natterjack toads occurs in three different networks, of which the most western network (in Haasop and vicinity) is viable. The total population size on the left bank of the Scheldt in 2003 and 2004 was assessed at 1250 calling males in a total area of 555 ha.

It turned out to be possible to accommodate a viable population of natterjack toads in the port alongside economic activities. To achieve that, the choice was made to initially establish a viable population within the boundaries of the port area. This is to be done in the so-called 'backbone', located in the southern part of the port area. The authors suggest that four large core areas be established, together encompassing some 200 ha, and that these be connected with one another via mitigating measures such as stepping stones and corridors. In each core area, a minimum of 1 key area (population) of the natterjack toad can be sustained. This minimum variant could potentially accommodate 800 natterjack toads. However, the variant preferred in this report offers space for 1400 animals.

Recommendations: Beyond assessing the ecological aspects related to the natterjack toad, this study made no attempt to prioritize other bottlenecks. In developing the networks, however, it is advisable to take stock of these. Further, there are also opportunities outside the ‘backbone’ to facilitate habitat for the natterjack toad. The Antwerp Port Authority, together with private landowners, should be able to stimulate the development of nature areas for the natterjack toad on private property (for example, with temporary ecological infrastructure or permanent breeding habitat).

To strengthen the final ‘backbone’, perhaps with external initiatives, formulation of a Plan of Action is advisable. In broad lines, this plan could encompass the following: 1) Location of key (core) areas; 2) Location of mitigating measures such as tunnels, screens and the like; 3) Location of linkage corridors; and 4) Guidelines for implementation (e.g. stipulating that activities be carried out only outside of the breeding and winter period).

Beyond a plan of action for implementation, it would also be advisable to draw up a management plan. This management plan could form part of a species conservation plan for the port as a whole. Finally, it is advisable that developments be monitored so as to keep abreast of the current trend in the conservation of the species.

Samenvatting

In het kader van het Europese programma Interreg IIIB NW Europa wordt het project NEW!Delta uitgevoerd o.l.v. de Provincie Zuid-Holland. Dit project beoogt de duurzame ontwikkeling te bevorderen in Noordwest-Europese kustgebieden, estuaria en havens zodat de bescherming van de natuur het meest is gediend. Er wordt een evenwicht gezocht tussen ecologie en economie.
Binnen thema 3 van NEW!Delta 'Aanleg en herstel van kust- en estuarine habitats' werkte het kennisinstituut Alterra, Wageningen University and Research Center samen met het Gemeentelijk Havenbedrijf Antwerpen (GHA). Op de terreinen in en rondom het GHA komt o.a. de bij EU Habitatrichtlijn beschermde rugstreeppad (*Bufo calamita*) voor. Doel van de samenwerking is met toepassing van het kennissysteem LARCH (Landschapsecologische Analyse en Ruimtelijke Configuratie van Habitat) te komen tot een voorstel van maatregelen voor een ruimtelijke configuratie van gebieden ter instandhouding van een duurzame populatie rugstreeppadden in de haven. Het GHA wil dit bereiken door investeringen in habitatplekken en het opstellen van een soortenbeschermingsplan.

Het kennissysteem LARCH is gebaseerd op het concept van metapopulaties en berekent voor versnipperinggevoelige diersoorten de benodigde habitatgrootte en de duurzaamheid van hun habitatnetwerken. Het type uitspraken dat m.b.v. LARCH over de rugstreeppad wordt gedaan, betreft vooral de ruimtelijke structuur van de linker Scheldeoever van het Antwerpse havengebied. Het geeft daarmee een belangrijk inzicht in de potentie van het havengebied voor de rugstreeppad.

Er zijn vijf belangrijke stappen doorlopen met LARCH die leiden tot concrete voorstellen hoe men moet omgaan met de rugstreeppad in het Antwerpse havengebied op de linkeroever.

1. De huidige situatie van de rugstreeppad is in beeld gebracht om te achterhalen of een duurzaam netwerk voor rugstreeppadden mogelijk is;
2. Op grond van het vastgestelde verspreidingsbeeld is nagegaan of er sprake is van een metapopulatiestructuur en indien dit het geval was, is de ruimtelijke configuratie bepaald: gaat het om een of meer populatienetwerken en waar bevindt of bevinden deze zich;
3. De effecten van de economische veranderingen in het havengebied op de aanwezige netwerken van de rugstreeppad zijn verwerkt;
4. In samenspraak met het Instituut voor Natuur- en Bosonderzoek (voorheen Instituut voor Natuurbehoud), met Natuurpunt (Vereniging voor natuur en landschap in Vlaanderen) en het GHA zijn oplossingsrichtingen aangedragen. Deze oplossingen zijn tijdens een overleg met deskundigen getoetst door stakeholders, en daarna aangepast (lokale kennis, informatie, draagvlak);
5. De verschillende oplossingsrichtingen zijn verder uitgewerkt in ruimtelijke beelden en adviezen.

Om de vijf stappen te doorlopen zijn voor de betrokken soort ecologische inzichten nodig zoals dispersie-/migratie-afstanden, populatiedichtheden, huidige verspreiding, en potentiële habitatplekken. Deze worden beschreven in hoofdstuk 3 'Soortprofiel Rugstreeppad'. Daarin wordt ook de onderstaande vuistregel beargumenteerd die nodig is om één duurzame populatie te handhaven: 'Voor een duurzaam sleutelgebied(populatie) van 200 rugstreeppadden is 5,5 ha landhabitat en 1,5 ha voortplantingshabitat nodig. Samen is dit 7 ha'.

Conclusie: de huidige populatie rugstreeppadden komt voor in drie verschillende netwerken, waarvan het meest westelijk gelegen netwerk (Haasop en omgeving) duurzaam is. De totale populatieomvang op de linker Scheldeoever in 2003 en 2004 is vastgesteld op 1250 roepende mannetjes op een totaal areaal van 555 ha.
Het blijkt mogelijk te zijn om naast de economische activiteiten een duurzame populatie rugstreeppadden te herbergen. Om dat te realiseren is ervoor gekozen om in eerste instantie in een duurzame populatie binnen de grenzen van het havengebied te voorzien. De uitvoering daarvan ligt in de zogenoemde 'backbone', gelegen in het zuidelijke gedeelte van het havengebied. De auteurs stellen voor hier vier grote kerngebieden te realiseren die gezamenlijk rond de 200 ha beslaan, en die met elkaar worden verbonden via mitigerende maatregelen zoals stapstenen en corridors. In elk kerngebied kan zich minimaal een sleutelgebied(populatie) voor de rugstreeppad handhaven. Deze minimumvariant zorgt voor een potentieel van 800 rugstreeppadden. Echter, de voorkeursvariant in dit rapport biedt ruimte aan 1400 dieren.

Aanbevelingen: naast het beoordelen van de ecologische aspecten in dit onderzoek m.b.t. de rugstreeppad heeft er geen prioritering van overige knelpunten plaatsgevonden. Het is raadzaam om hiermee rekening te houden bij de ontwikkeling van de netwerken.
Verder liggen er mogelijkheden om de rugstreeppad ook buiten de 'backbone' te faciliteren. Het GHA zou in samenwerking met particuliere eigenaren de ontwikkeling van private natuur voor de rugstreeppad kunnen stimuleren; bijvoorbeeld via een tijdelijke ecologische infrastructuur of een permanent voortplantingshabitat.

Om de uiteindelijke 'backbone' eventueel met initiatieven erbuiten te versterken, is het raadzaam om een Plan van Aanpak op te stellen. Op hoofdlijnen zou dit plan het volgende kunnen omvatten: 1) Ligging van sleutel(kern)gebieden; 2) Ligging van mitigerende maatregelen zoals tunnels, schermen e.d.; 3) Ligging van verbindende corridors; en 4) Voorschriften voor de wijze van uitvoering (bijvoorbeeld alleen werkzaamheden uitvoeren buiten de voortplantings- en overwinteringsperiode).
Naast een Plan van Aanpak voor de uitvoering wordt ook aanbevolen om een beheerplan voor de rugstreeppad op te stellen. Dit beheerplan kan onderdeel uitmaken van het soortenbeschermingplan voor de gehele haven. Tenslotte is het raadzaam om de ontwikkelingen te monitoren om zo de trend en de staat van instandhouding van de soort te volgen.

Résumé

Dans le cadre du programme européen Interreg IIIB Europe nord-ouest, la province de la Hollande Méridionale a effectué le projet NEW!Delta. Ce projet vise à la promotion d'un développement durable dans les zones côtières, les estuaires et les ports de l'Europe du nord-ouest au profit de la protection de la nature. On cherche un équilibre entre écologie et économie.

Le thème 3 de NEW!Delta concernant l'aménagement et la restoration d'habitats côtiers et estuariens a fait l'objet d'une recherche commune entre l'Institut Alterra de l'Université de Wageningen et Centre de Recherche et l'Autorité Portuaire d'Anvers (APA). Dans la zone portuaire on trouve le crapaud calamite (*Bufo calamita*) qui est protégé entre autres par la Directive sur l'habitat de l'Union Européenne. La collaboration a pour but de proposer à l'aide du système de connaissance LARCH un certain nombre de mesures portant sur la configuration du territoire pour la conservation d'une population durable de ces crapauds. La APA veut arriver à ses fins en faisant des investissements dans les habitats et en rédigeant un plan de protection de l'espèce.

Le système de connaissance LARCH est basé sur le concept de méta populations et calcule pour les espèces susceptibles de dispersion la surface d'habitat requise et la durabilité de leurs réseaux d'habitat.

Avec LARCH on a parcouru cinq étapes qui ont abouti à des propositions concrètes pour le crapaud calamite sur la rive gauche de la région portuaire d'Anvers.

1. On a esquissé la situation actuelle du crapaud calamite afin d'établir si un réseau durable est possible.
2. Avec la dispersion établie on a vérifié s'il y a une structure de méta population et si c'était le cas, on a déterminé la configuration du territoire: s'agit-il de un ou de plusieurs réseaux de population et où est-ce qu'il(s) se trouve(nt)?
3. Les effets des changements économiques dans la région portuaire sur les réseaux actuels du crapaud calamite ont été incorporés.
4. En concertation avec l'Institut de Recherche de la Nature et de la Forêt (anciennement Institut de Conservation de la Nature), le Natuurpunt (Association pour la nature et le paysage en Flandre) et la APA, on a proposé des solutions qui ont été mises à l'épreuve pendant une session experte et adaptées ensuite (connaissance locale, information, base).
5. Les différentes solutions ont été élaborées en images spatiales et en recommandations.

Afin de parcourir ces cinq étapes il faut avoir des données écologiques sur l'espèce en question, telles que les distances de dispersion et de migration, la densité de population, la dispersion actuelle et les endroits d'habitat potentiels. Ces sujets sont traités dans le chapitre 3 où il s'agit aussi de la règle empirique pour maintenir une population durable: 'Pour une population durable de deux cents crapauds calamites il faut 5,5 ha d'habitat de terre et 1,5 ha d'habitat de reproduction ce qui fait 7 ha au total.'

Conclusion: La population actuelle de crapauds calamites se trouve dans trois réseaux dont celui situé à l'ouest (Haasop et ses environs) est le plus durable. La population totale sur la rive gauche de l'Escaut en 2003 et 2004 s'élevait à 1250 mâles coassants sur une superficie de 555 ha.
Il s'avère possible d'abriter une population durable de crapauds calamites à coté des activités économiques. Pour réaliser cela on a décidé en premier lieu de héberger une population durable au sein de la région portuaire dont la réalisation se trouve dans ce qu'on appelle la 'colonne vertébrale' ('backbone'), situé dans le sud de la région portuaire. Les auteurs proposent d'y établir quatre aires clés, couvrant en somme environ 200 ha, qui sont reliés au moyen de mesures atténuantes / mitigeantes telles que des tremplins et des corridors. Dans chaque aire clé au moins une population de crapauds peut se maintenir ce qui fait un potentiel de huit cents exemplaires. Cependant la variante préférentielle dans notre compte-rendu peut accueillir 1400 exemplaires.

Recommandations: Etant donné que nous avons fait entrer en ligne de compte seulement les aspects écologiques concernant le crapaud calamite, les autres points chauds n'ont pas été mis en priorité. C'est pourquoi il faut en tenir compte en ce qui concerne le développement des réseaux.
En plus, il y a des possibilités d'une mise en sûreté du crapaud en dehors de la 'colonne vertébrale'. En collaboration avec des propriétaires privés, la APA pourrait encourager le développement de nature

privée pour le crapaud calamite, par exemple au moyen d'une infrastructure écologique temporaire ou d'un habitat de reproduction permanent.

Afin de renforcer la 'colonne vertébrale' finale avec au besoin des initiatives à l'écart, il est recommandable de rédiger un plan particulier d'aménagement (PPA). Une esquisse d'un tel plan pourrait comprendre: 1. Situation des aires clés; 2. Situation des mesures mitigeantes telles que tunnels, écrans etc.; 3. Situation des corridors reliés; 4. Règles pour la réalisation (par exemple, les travaux ne sont permis qu'en dehors de la période de reproduction et d'hivernage).
A côté du plan particulier d'aménagement, il est à conseiller de rédiger un plan de gestion pour le crapaud calamite. Ce plan pourrait faire partie intégrante d'un plan de protection des espèces pour toute la région portuaire. Pour finir, il convient de surveiller l'évolution afin de suivre ainsi l'orientation et la perpétuation de l'espèce.

1 Introduction

The subject of this study is embedded in the broader framework of the NEW!Delta project, particularly in Theme 3 Creation and Restoration of Coastal and Estuarine Habitats.

The NEW!Delta-project4 balances improving the living environment on the one hand and safeguarding economic growth on the other. Against the backdrop of the European Bird and Habitat Directives, the NEW!Delta project strives to incorporate protection of the Natura 2000 areas and conservation of species as integral components of the economic development of (sea)ports and estuaries in Northwestern Europe. At the same time, the NEW!Delta project offers opportunities for other social, economic and maritime developments. Half of its financing is provided by the European Interreg IIIB program, with the other half made available by the project partners themselves.

Theme 3 of the NEW!Delta project, Creation and Restoration of Coastal and Estuarine Habitats, envisions an exchange of expertise among project partners on techniques for creating nature and on project implementation, and it also foresees investments in nature restoration, including investments in elements of the ecological infrastructure network in the Port of Antwerp.

It is in this framework that the Antwerp Port Authority joined in collaboration with the knowledge institute Alterra, of Wageningen University and Research Centre. The objective of this collaboration was by applying Alterra's LARCH expert system to arrive at a proposal of measures necessary and favorable spatial configuration of areas so as to conserve a viable population of natterjack toads in the port area on the left bank of the Scheldt. After all, the Antwerp Port Authority aims, in the long term, to support the sustainable conservation of the natterjack toad by making investments in habitat patches and by formulating a species conservation plan.

This study is also framed in another, broader project, called 'Making the Port of Antwerp more natural'. This is a joint effort involving the Antwerp Port Authority and Vzw Natuurpunt, which has as its target the demarcation of 5% of the territory of the Port of Antwerp on the left and right banks as Ecological Infrastructure (E.I.). Here 'ecological infrastructure' is understood to mean small, interweavable nature elements as defined in the Flanders Spatial Structure Plan.

The Antwerp port is an economic area of vital importance to the economic well-being of Flanders and of the surrounding regions. But at the same time, the Antwerp port area is situated in an ecological space that is of primordial importance for the conservation of numerous plants and animals of interest in Flanders and internationally. Its position on the Scheldt is a major factor here. A number of special conservation sites have therefore been set off in and around the port, which has given a compulsory character to the conservation and development of these natural structures, and the living environments and habitats they provide. This has added to the already enormous challenge of reconciling the two ambitions – port and nature development – in a sustainable way.

[4] See ***www.newdelta.org*** for additional information.

Photo 2. The Antwerp port is a highly dynamic area of vital importance to the economic wellbeing of Flanders and the surrounding regions.

The development of an ecological infrastructure network must be viewed as just one of the instruments with which to realize this twofold ambition.

In 1997, the Flanders Spatial Structure Plan set out in broad lines the objectives regarding ecological infrastructure in the Flemish seaport areas.5 In 2001 the Antwerp Port Authority decided to join in collaboration with two non-governmental organizations: Natuurpunt Wase Linkerscheldeoever (NatuurpuntWAL) and Natuurpunt Antwerpen Noord. The aim of this collaborative initiative, called ‘A More Natural Port of Antwerp’ is to create an ‘Ecological Infrastructure network’ and to do so starting from a commitment to bringing about the sustainable coexistence of the port and nature development.6

In conformance with the Flanders Spatial Structure Plan, the E.I. network for the Antwerp seaport area is to play a supporting role with respect to the network of natural structures surrounding the Antwerp port area. In practice, the E.I. will primarily encompass nature attributes that came or come into being as a side effect of the port’s ongoing infrastructure development. It then also relates, for the most part, to **pioneer situations** and habitats in **dynamic** milieus, such as sand-raised terrains, barren brackish lands, rough overgrown terrains, pools, etc.

More specifically, the E.I. network in the Antwerp port area will fulfill four functions:

[5] The Flanders Spatial Structure Plan requires that a maximum of 5% of all seaport area be spared as ecological infrastructure. The 5% objective is not set per seaport area, but for all the seaport areas together. In the *LIN-dienstorder* (this is a open letter from and for the officials responsible), concerning the operationalization of ecological infrastructure in seaport areas, it is again suggested that the 5% objective should be viewed more as a target than as a strict norm. Irregardless of the plans and intentions of other seaports, on 10 July 2002, the Antwerp Port Authority Board of Trustees undertook to adopt the 5% objective as the target for the Antwerp port area.

[6] In 2002 the Antwerp Port Authority and the Association for Land and Industrial Policy for the Left-Bank Area signed, together with *Vzw. Natuurpunt*, a charter committing themselves to this goal of sustainable coexistence. The Association for Land and Industrial Policy is inter-communally mandated to distribute lands for industry in the Antwerp port on the left bank of the Scheldt.

1. Regarding the aim of establishing and safeguarding the long-term integrity of the special conservation zones SPAs (Special Protection Areas) 3.6 and 2.2, the E.I. network will contribute indirectly to the function of forage- and resting places for the relevant bird species. This contribution is regarded as purely supportive.

2. In addition, the E.I. is also supposed to function as an independent network in itself, whereby the network in its entirely contributes to the sustainable conservation and protection of the species listed in Appendix IV of the Habitat Directive (Appendix III of the Flemish Nature Decree) that are typical of the Antwerp port area. This includes, among others, the natterjack toad, which occurs in the port thanks to its dynamic character and the continual availability of sandy pioneer locations with pools and the various bat species that hunt above the surface of the water and arid, open habitats.

3. The network also shares this function, but then for conservation of important species (flora and fauna) at the level of Flanders, for species dependent on primary habitats that are permanently or intermittently found in the port, though perhaps on a modest scale: 1) pioneer situations, 2) dry grasslands, 3) small pools and marshes, 4) shrublands and woods, and 5) buildings and docks. Qualitative and quantitative objectives regarding habitable areas for these species, within the E.I. network, nonetheless still need to be formulated, and these used in marking off the seaport area.

4. Finally, the E.I. is significant for the Mediterranean Gull (*Larus melanocephalus*) (Appendix I species), which to breed remains dependent on port-specific habitats. At this time, the Mediterranean Gull has a population on the embankment made of silt (right bank), but an alternative zone on the right bank is also set to be established and maintained for this species as permanent E.I.

The ecological infrastructure network must therefore – ideally speaking – deliver a contribution in four manners to the objective of sustainable co-existence of port and nature (development).

Within the framework of Theme 3 of the NEW!Delta project, various initiatives have already been made that focus on the aims set out under 1, 3 and 4.

In this report we shed light on objective 2. In particular, we investigate what criteria the ecological infrastructure network **on the left bank of the Scheldt** must fulfill in order to be able to sustain the conservation of the **natterjack toad** in an area that, first and foremost, is intended to allow for port development and exploitation. In other words: *"How can one conserve the natterjack toad for the future in such a highly dynamic and primarily economic area as the Port of Antwerp?"*

With this report in hand, the Antwerp Port Authority, in collaboration with other public actors including the Region of Flanders and the Association for Ground and Industrial Policy for the Left-Bank Area of the Scheldt, would like to establish and maintain an ecological network[7] that also responds to this specific objective. The ecological infrastructure network must therefore at concurrently become a 'backbone' that ensures that a viable population of natterjack toads can be maintained in the port area. Here 'backbone' structure is understood to mean a cohesive unit made up of 'permanent' living areas for the natterjack toad. The creation of such a unit should ensure the safeguarding of the Antwerp port area as a home for the natterjack toad into the future. Thus, with the ecological infrastructure network, the Antwerp Port Authority and the other actors would like to make a contribution to bringing about a favorable state of conservation of the natterjack toad at the level of Flanders.[8]

Due to considerations of a practical nature, Alterra has initially concentrated on the section of the port located in the left-bank area. This landscape is marked by port development but, partly for this very reason, has come to provide a living environment for natterjack toads.

Following a description of the LARCH expert system, the characteristics of the natterjack toad are detailed. Thereafter, the LARCH method as applied to the natterjack toad is described. Afterwards, the results of the research are examined along with what they can deliver for the left bank of the port.

[7] See appendix 1 list of terms.

[8] It should be noted here that the objectives regarding the favorable state of conservation of the natterjack toad are to be set at the level of Flanders.

Finally, the findings are summarized in the conclusions section and a few recommendations are made. Figures one through three provide a topographical overview of the port grounds and the land parcels located there.

Figure 1. The West Scheldt, showing the location of the Port of Antwerp area on the Scheldt's left bank (Source: www.Proses.be).

Figure 2. Topography of the Port of Antwerp on the left and right banks of the Scheldt (Source: Antwerp Port Authority).

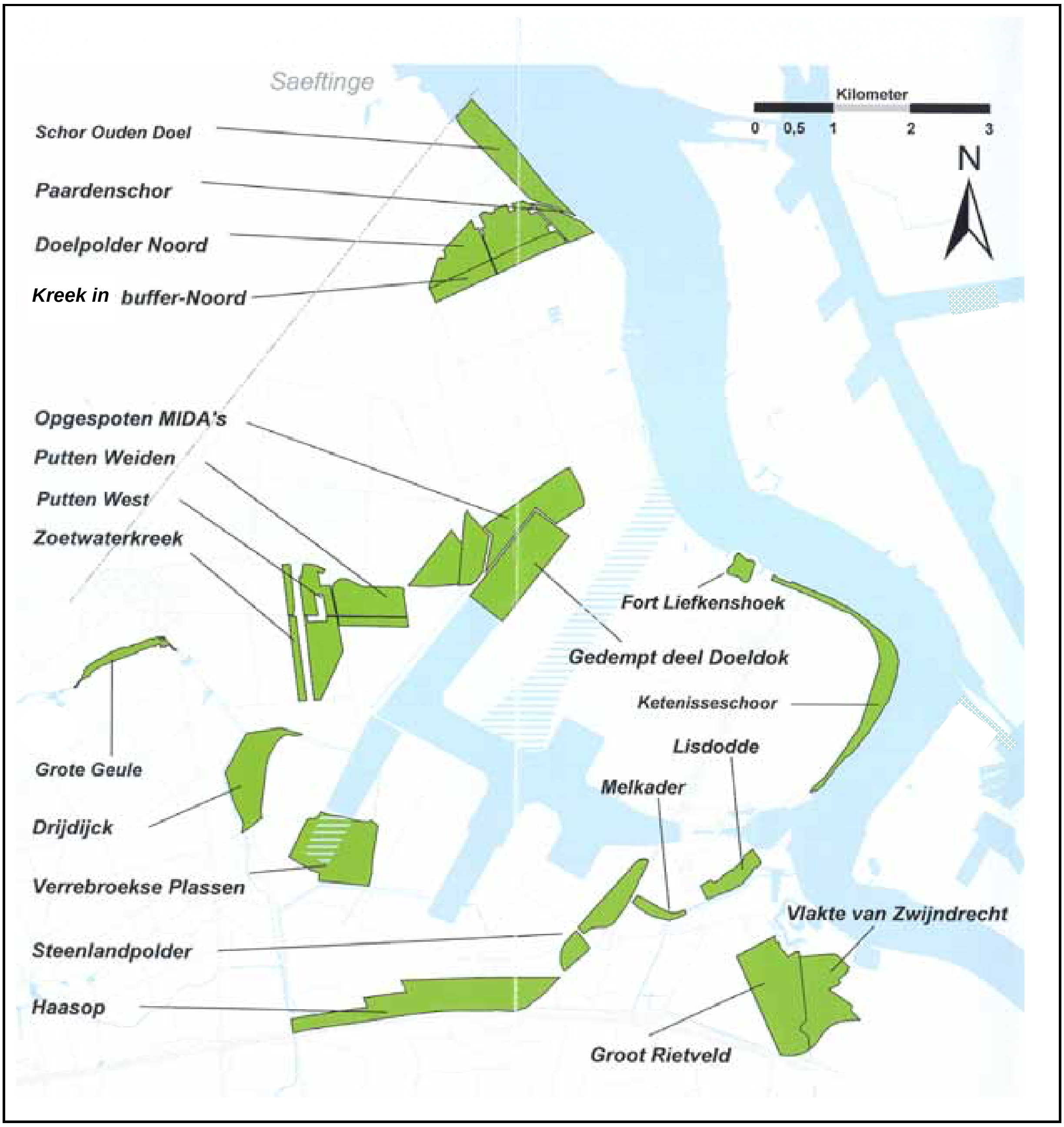


Figure 3. Topography of the left bank of the Scheldt in the Port of Antwerp (Van den Abeele 2005). MIDA' s stand for 'Maritiem Industrial Development Area'.

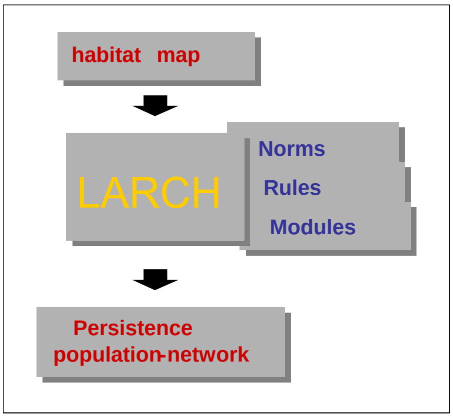
2 LARCH

2.1 The LARCH analysis method in general

This study makes use of the LARCH spatial expert system (figure 4), where the acronym stands for Landscape Ecological Analysis and Rules for the Configuration of Habitat.[9] The expert system is based on the concept of metapopulations and calculates, for fragmentation-sensitive animal species, the persistence[10] of their habitat networks. Furthermore, LARCH determines the viability of metapopulations based on both carrying capacity and the spatial configuration of the living areas (Snep *et al.* 2000, Schotman 2002). The system has already been employed successfully in many landscape ecology studies. Analyses in port areas using LARCH are nonetheless still quite new. One earlier study was done of butterflies and birds in the Rotterdam Port area (Snep *et al.* 2001).

LARCH has the following features (Foppen & Chardon 1998):

- It determines the potential of habitat patches to form networks so that viable (meta)populations can be accommodated. It is therefore based on habitat and not on whether or not a certain species currently occurs (Opdam *et al.* 2003);
- It is based on a selection of species which are sensitive to fragmentation of habitat networks (Vos *et al.* 2001);
- Its starting point is norms for key areas, corridors and stepping stones, and distances between them, which are based on empirical studies as well as simulation models (Verboom *et al.* 1997, Foppen *et al.* 1998, Verboom *et al.* 2001);
- It is based on *expert judgment* and information from the literature about dispersal distances.



With the expert system various spatial analyses can be conducted related to a landscape. It looks at the landscape 'through the eyes of the animal species' and in doing so, enables various conclusions to be drawn about the suitability of a landscape for a species or species group.

Figure 4. LARCH flowchart showing input and output.

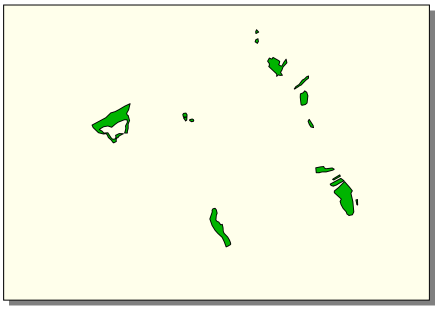
LARCH determines the persistence of habitat networks. A habitat network is an area in which habitat patches are located at such a distance from one another that, for the species concerned, they can be viewed as interconnected (i.e. the distance between the habitat patches is smaller than the dispersal distance of the species). Therefore, together the individual pairs of the species form a metapopulation (or network population). The composition of the ground cover present in the landscape is analyzed, and this data is transferred to a habitat map. The map then provides information about the location of potentially important habitat patches within and possible outside the study area. This information can play a key role in answering the question: 'Where can investments best be made in terms of land purchases and outfitting?', and also for the management of lands for conservation of a specific species and its typical living environment.

2.2 Calculation method LARCH

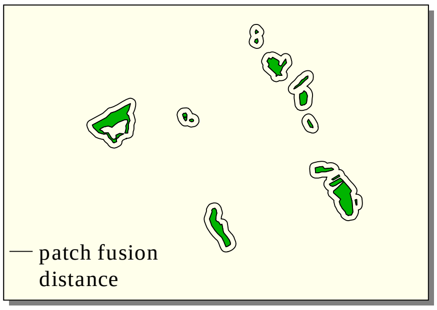
The modeling of a species in LARCH requires good insight into the (population) ecology of that species. In addition to information about habitat requirements, data are also needed regarding the home range, dispersal distance, norms for persistence and the like. The spatial analyses that are carried out with the LARCH expert system therefore become fairly complex. Four analysis steps can be distinguished, as

[9] For a detailed description of the methodology of the LARCH model instrumentation refer to Pouwels *et al.* (2002) and Verboom & Pouwels 2004.
[10] See appendix 1 list of terms.

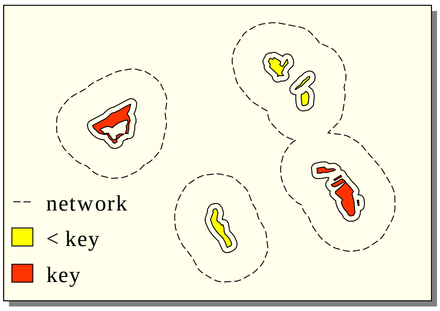
follows: 1) identifying the (potential) living areas of the species within the study area, 2) detecting local populations, 3) identifying habitat networks and 4) determining the persistence of habitat networks. To explain as clearly as possible how this works, the figure below details each of the steps using a random area as example.



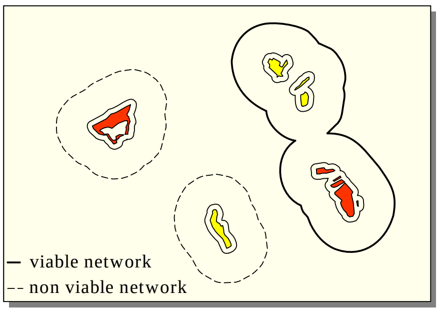
Step 1: the habitat map
The ground-cover type map is converted into a habitat map for each species. For each type of ground cover it is known whether and to what extent the species can utilize that habitat: for preferred habitat, less surface area is needed to accommodate a pair than for marginal habitat. Based on the surface area per ground-cover type (irregardless of whether these areas are currently occupied or vacant), potential living areas for the species can be demarcated. Per habitat patch the capacity of that patch to support the species is determined. This 'carrying capacity' is the maximum density that a species can achieve with a certain ground-cover type. The quality of the habitat patch is thus related to both the type of ground cover and the surface area dimensions and is rated in categories from 'marginal', via 'sub-optimal', to 'optimal habitat'.



Step 2: detecting local populations
Animals move around within a certain space in the course of their daily activities (foraging, resting, sleeping and the like). The space in which these movements occur is called the 'home range'. Movements within the home range determine which of a species have regular contact and thus belong to the same local population. Home ranges that border on one another thus form the network of habitat patches that belong to a local population. The maximum distance traveled within a home range provides an indication of potential exchanges between habitat patches. Individuals of the species for which the home ranges overlap are counted as members of the same local population.



Step 3: identifying habitat networks
For the local populations, LARCH calculates whether they are large enough for a pair of the concerned species to be formed. It also examines the extent to which local populations can function as a key population.
Some individuals exhibit a greater willingness to travel distances or cross obstacles in order to colonize a new habitat patch (dispersal). Via dispersal, thus, an animal can end up in another local population. Like a local population is made up of a network of habitat patches, separated by a maximum distance as determined by the home range, the local populations are similarly linked into a network of metapopulations within that dispersal distance. Via dispersal, exchange takes place among the local populations within the network.



Step 4: determining the persistence of the habitat network
The persistence of the habitat networks for the species is determined on the basis of insights into the metapopulation dynamics of the concerned species. Depending on the size of the network and the spatial configuration (mutual distance, linkages) and the size of the separate habitat patches a network can be categorized as 'not viable, 'viable' or 'strongly viable'. The chance of a 'viable network' dying out is less than 5% in 100 years; a strongly viable network has less than 1% chance of dying out in 100 years (Verboom & Pouwels, 2004).

2.3 Evaluating ecological networks

To evaluate ecological networks, persistence norms are used that are derived from field data, literature and simulation models (assumptions), as well as from the norm for key areas (Verboom *et al.* 1997, 2001). These norms are species-specific (table 1). Three types of ecological networks are distinguished: 1) networks with a 'Minimum Viable Population' (MVP),[11] 2) networks with a key area and 3) networks without a MVP and key area. Each type of network must have a sufficient amount of habitable area, for a viable population of a species to occur. The total amount of habitable area required increases as the extent of fragmentation rises (figure 5).

Table 1. Overview of the norms for type of networks (from Verboom et al. 1997, Van der Grift et al. 2003). MVP = 'Minimum Viable Population'; RU = Reproductive Unit (appendix 1).

Species group	Key area (number of RU)	Norm network with MVP (number of RU)	Norm network with key area (number of RU)	Norm network without MVP and key area (number of RU)
Lizards	100	150	250	400
Amphibians	500	750	750	1000
Natterjack toad[12]	200[13]	300	500	800

These norms are used to indicate the persistence of networks in three categories (see table 2). For strongly viable networks the chance of dying out is less than 1% in 100 years. For environmentally sensitive species can be said in general that more RU's are necessary for a viable network.

Table 2. Degree of viability.

Value as compared to the norm	Degree of viability	Chance of dying out in 100 years
0.001 – 1	not viable	> 5%
1 – 5	viable	≤ 5%
≥ 5	strongly viable	≤ 1%

As long as the value obtained for a species in a specific area, such as that for the natterjack toad population on the left bank of the Scheldt in the Port of Antwerp, is greater than or equal to the norm ('value as compared to the norm' of between 1 and 5 or greater than 5), the population under study is viable. The higher the value, the more viable the population. However, if the value is below the norm, the population under study is not viable.[14]

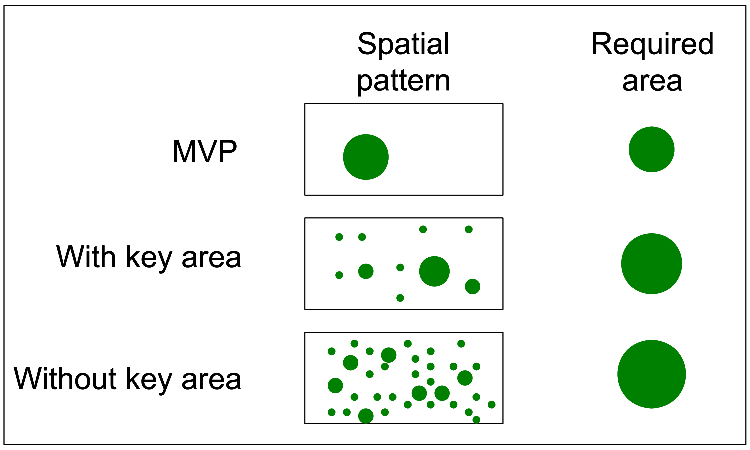


Figure 5. Schematic examples of the surface area of habitable area required in a network for viable occurrence with respect to three types of networks.

An MVP could constitute an isolated population that is viable. The key requirement for the conservation of an MVP is that optimal management must be carried out at all times. After all, such a situation has no spreading of risk to the species concerned. All individuals are located in the same area (at the same location), meaning that there is a relatively large chance of its dying out as a result of a catastrophe. For

[11] See appendix 1 list of terms.
[12] Norm adjusted in comparison with Verboom *et al.* (1997) after expert consultation (Ottburg & Pouwels).
[13] Table 1 uses RU's and numbers of specimens. Because in this study current numbers are available only on the basis of calling natterjack toad males therefore is decided that 1 calling male stand for 1 RU.
[14] In the framework of this report, a viable population is defined as a population for which the extinction probability is smaller than 5% in 100 years.

the other two illustrations in figure 5 – 'with key area' and 'without key area' – there is a spreading of the risk, because the species occurs in a number of partial populations belonging to a single network. Therefore the chance of its dying out, because of catastrophe, is smaller. For the LARCH analysis of the natterjack toad on the left bank in the port area, the norms (table 1) are applied as associated with a network with a key area (figure 5).

3 Species profile natterjack toad

3.1 Characteristics

The natterjack toad (*Bufo calamita*, Laurenti 1768) is a medium-sized amphibian with a maximum body length of eight centimeters. It is very similar in shape to the common toad (*Bufo bufo*), from which it can be distinguished by the presence of a yellow stripe down its back. There is also the greenish-yellow iris, which differs from that of the common toad, which has a brownish-orange iris (Stumpel & Strijbosch 2006). Behind the eyes, on the head and neck, are pairs of large glands (parotoids). These are somewhat raised, making them distinctly visible. Because these glands are arranged in parallel on the natterjack toad and fan out towards the rear in the common toad, the species, again, can be distinguished from one another. The sounds the two species produce during the mating season also differ dramatically from one another. The natterjack toad has a loud call that carries out over a far distant. It's riming of a metallic likely Geiger counter sound as 'èrr…èrr…èrr'. The mating call of the common toad is a soft en long 'quààk-quààk-quààk' (Nöllert & Nöllert 1992, Stumpel & Strijbosch 2006).

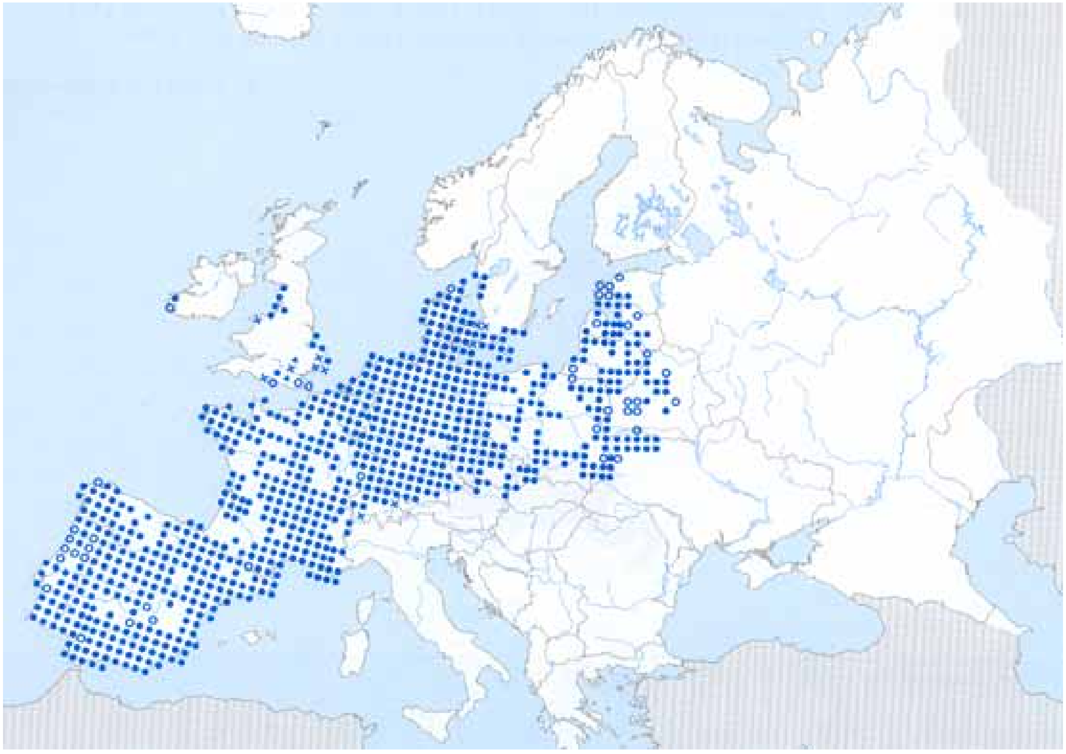
The color of natterjack toads can vary from light yellow to dark green with an irregular mottled pattern. The parotoids are usually orange and the warts often red. The belly is dirty white, set off with small dark spots. In adult males the throat, which can be greatly inflated during croaking, is colored blue to violet in the mating season. The mating season can last up to four months, starting in late April, reaching its climax in May and June (Sinsch 1998).

Natterjack toads do not hop, but they can run fast 'as a mouse'. In addition, the species is an excellent digger. It is seldom active during the day, preferring to occupy holes, self-dug or those left behind by other animals, such as underground mouse passageways and rabbit holes. At dusk, natterjack toads become active and go out in search of food.

The eggs of the natterjack toad are deposited on the bare bottom of the breeding water, in strings usually just one egg in width. Unlike the common toad, this happens late in the season, namely, in May and June and even into August. The larvae of the natterjack toad (tadpoles) can be recognized by the construction of the mouth parts, but these features are visible only under strong magnification. As they grow larger, the larvae are usually black with a light spot on their throat, but they remain difficult to distinguish from those of the common toad. Because of the later breeding season, toad larvae found late in the season is almost always that of the natterjack toad.

3.2 Distribution

In Europe the natterjack toad is found in seventeen countries. From the southwest the distribution area runs via central Europe to the northeast (figure 6). In southwest and northeast of Europe the natterjack toad is still found in its natural habitat along rivers. In the central part of Europe, this natural habitat is almost completely absent, and the species is found mainly in secondary habitats such as crevices, clay pits and sand quarries (Gasc *et al.* 1997).



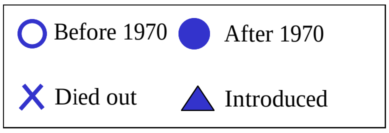


Figure 6. European distribution of the natterjack toad (Gasc et al. 1997).

This report discusses the distribution of the natterjack toad in Belgium only for the Regions of Flanders (figure 7). In the province of West Flanders its distribution is limited to the coastal dunes, where the species occurs only in the far southwest. In East Flanders there is a limited incidence in Waasland, in sandy areas as well as in clay pits. The species is more common in the provinces Antwerp and Limburg, especially in dry sandy areas and in sand-raised meadows (Bauwens & Claus 1996). In the province of Flemish Brabant, isolated pockets of the species occur (***www.natuurpunt.be***).

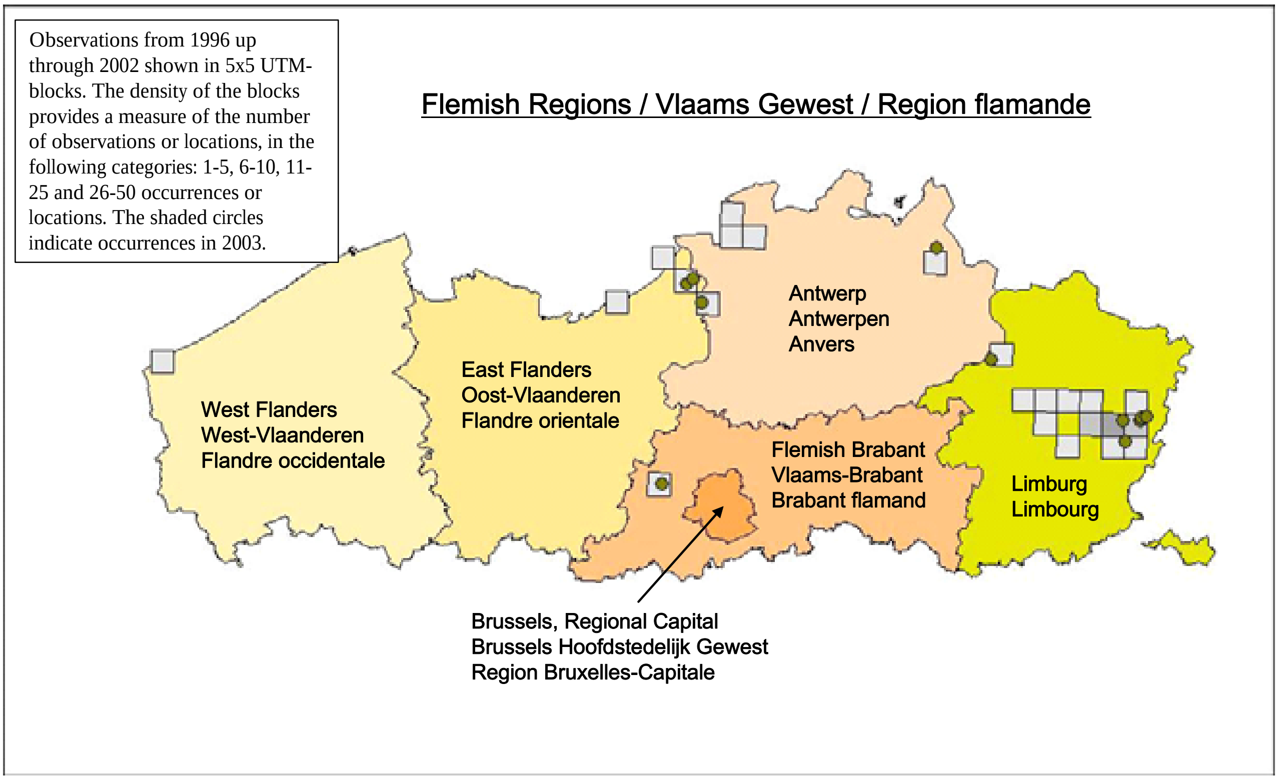


Figure 7. Distribution of the natterjack toad in Flanders **(***www.natuurpunt.be***).**

Anthropogenic influences, such as scale increases in agriculture, habitat fragmentation by construction of infrastructure and housing, but especially loss of habitat due to changing land use, have led to a decline in the population of the natterjack toad in Belgium and an overall thinning of the distribution picture.

3.3 Habitat

The natterjack toad is found mainly in pioneer situations, especially in habitats where the ground warms up quickly. The species disappears as the vegetation succession gets under way (marginal habitat) and the land cover grows more closed. In its natural habitat on flood plains and coastal areas, river dynamics and wind erosion maintain the pioneer habitat at a fairly constant stage of development. The natural habitat (optimal habitat) consists of, among others, along the banks of (often meandering) rivers (Peek 1986). In the modern cultural landscape, the natterjack toad, as a culture follower, is also able to (temporarily) persist in sub-optimal habitats, such as construction sites, crevices and in meadow drainage ditches (Van Eekelen 2005), a type of habitat that is also found on the sand-raised terrains in the port area. In such habitats, the natterjack toad adopts a more mobile lifestyle and travels longer average distances.

The natterjack toad knows a great variety of habitats (Beebee & Denton 1996, Stumpel 2004): heath meadows, coastal dunes, perimeters of salt marshes, marshes in river forelands, crevices and excavation terrains. The heath meadow is a stable system, where there is relatively little fluctuation in population numbers. Yet such fluctuation is all the more in the other habitats. In determining the population size required for a viable key area it is important to relate this to the area's topographical characteristics.

Larger numbers of natterjack toads can be found in varied landscapes that are open in character, with little or no vegetation and sandy soils (Van der Coelen 1992). Here the species can dig itself in for the winter and the nocturnal animals also have places to shelter during the day (Arntzen 1981). The breeding waters (pools/ponds) are often shallow and sometimes dry up.

Photo 3. Examples of reproduction waters for the natterjack toad within the boarders from the Port of Antwerp.

The various pools available to a single partial population can differ from one another to such an extent that each pool has a different risk of not producing offspring. Only where a larger number of pools is available (a high pool density) will a viable population be able to persist. The species has few requirements of its breeding waters, except that it must be a pioneer situation. Breeding waters are often small, shallow (up to 15 cm) and have a bare underground. These might also be flooded wet/marshy grasslands and reed meadows. The species tolerates salt to a certain extent. The natterjack toad has different requirements for its living environment at different times of the year. As summer habitat, the presence of a pioneer situation and sandy soil is of vital importance. Further, the species is also found in orchards and woods (Peek 1986).

Because the natterjack toad occurs in temporary pools, its breeding habitat must be sought in habitats that offer these conditions. Pools that are appropriate for other amphibians are often inadequate for the natterjack toad. Unlike most other amphibian species, the natterjack toad prefers shallow, still breeding waters with a maximum depth of up to 70 cm, very gentle banks and no shadow (they do not necessarily always have to contain water).

Foto 4. The Natterjack toad can be distinguished by the presence of a yellow stripe down its back.

3.4 Home ranges

The home range[15] of the natterjack toad varies quite widely. Surface areas mentioned range from 179 to 4900 m^2 to from 1.5 to 2 ha (Peek & Westphal 1989). Distances between breeding areas and summer habitat can rise to a maximum of 1000 m (Miaud 2000). The larger distances that natterjack toads can travel relate to dispersal or migration.

3.5 Population structure and maximum density

In general, some 10 to 50 males are found in a chorus of natterjack toads (Günther 1996). A chorus of more than 100 male animals is rare, and it is extremely rare to find more than 1000 calling males, dependent on the type of habitat.

Kuzmin (1995) reported for natural habitats Belarusian and Lithuanian densities of, respectively, 25–200 and 2–100 animals per ha. In The Netherlands, cases are known of artificial situations where the species is able to attain densities of 50 to 100 animals per ha (Van Eekelen 2005). These cases were a cemetery and the grounds of a potted-plant business with greenhouses. Stumpel (2004) reported a Dutch population of 1000 animals.

Based on the above, we can conclude that a core population, in LARCH terminology better known as a 'key area', for natterjack toads must be composed of a minimum of 200 adult animals, with the prerequisite that a minimum of 4 ha optimal land habitat be available. But because the land habitat cannot always be optimal due to the vegetation succession, it is recommended that an extra 1.5 ha be employed as safety margin.

In Great Britain an association has been found between the quantity of breeding waters and the number of natterjack toads found. In this respect, Kuzmin (1995) gives an estimate of 2 to 100 calling animals per ha water surface. In The Netherlands, higher densities of reproducing animals are known. For instance, in Heerenven at Wellerlooi, an area about 1.5 ha in size, a maximum of 233 egg strings and 160 natterjack toads were found along dozens of meters of a drainage ditch near Alkmaar.

[15] For definition see appendix 1.

A surface area of 1.5 ha breeding habitat spread out across various water bodies would then also appear adequate to support a viable population of 200 adult animals with a sex ratio of 1 (Van Eekelen 2005). Conclusion:

FOR A VIABLE KEY AREA/PATCH (POPULATION) OF 200 ADULT NATTERJACK TOADS, 5.5 HA OF LAND HABITAT AND 1.5 HA OF BREEDING HABITAT IS NEEDED: THIS, IN TOTAL, IS 7 HECTARES.

The above rule of thumb represents the requirements for a key area, for which the local chance of dying out is not yet discounted. It is to this rule of thumb that the LARCH assumptions, including the chance of the local population dying out, are applied. The outcome reveals when a (network) population is viable, assuming that there is a bridging of obstacles.[16]

3.6 Dispersal

As a species well adapted to pioneer situations, the natterjack toad possesses a good dispersal ability. Little is known about specific distances. During the breeding season individuals may be enticed up to a kilometer away by the penetrating mating call (Peek 1986).

From known breeding waters, the natterjack toad can colonize new breeding waters located some kilometers distant (Van der Coelen 1992). J. Reinhold (verbal report) indicated that places located up to more than three kilometers from one another can belong to the same network and that natterjack toads have been known to bridge distances of three kilometers.

3.7 Obstacles within the port area

In a natural situation, the different partial habitats that serve as the summer- and winter living environment of the natterjack toad are found in a contiguous space. In highly dynamic areas with a lot of activity, such as the Port of Antwerp, the living environment of the natterjack toad is fragmented.
To be able to reach the various partial habitats and partial populations, the animals must cross roads and rails. In this respect, highways and busy main roads can be viewed as insurmountable obstacles. On secondary (less busy) roads, the chance of reaching the other side is considerably larger, but even so, will be many victims among the crossing natterjack toads. Over railways there is a greater chance of survival than over the roads.

In addition to the existing roads and railways, the steep quays of the docks represent insurmountable obstacles. Once in the water, natterjack toads cannot crawl up along the steep quay walls to subsequently reach the bank. Unless some form of assistance is offered, for example, by constructing exit ramps (places where the animals can crawl out of the water), animals that fall into the water are sure to drown. On the left bank of the Scheldt, the Doel Dock and Verrebroek Dock have uniform gently sloping quay walls on which natterjack toads that fall in the water can climb back up onto land. For the other docks, however, this is not the case. Other obstacles are also present in the port area, such as (cement) fencing, gutters along the railways, etc.

[16] See appendix 1.

Photo 5. Left, an example of a steep quay on the docks representing an insurmountable obstacles for natterjack toads that fall into the water and drown. Right, a gently sloping embankment on which natterjack toads that fall in the water can climb back up onto land. Source right photo: Antwerp Port Authority.

Since in this type of habitat the natterjack toad is strongly dependent on its dispersal ability for its survival, consideration must be given to the barrier effect of roads and other infrastructure. At the network- and local population level, civil infrastructure erects barriers to the natterjack toads. In the LARCH process this is taken into account.

3.8 Guidelines for construction and maintenance of breeding waters

If the natterjack toad's survival is dependent on secondary habitat, because its natural habitat has wholly or partially disappeared, then we must, in addition to the land habitat, take into account the requirements of the species for its breeding waters or 'pools'.

Various publications describe the conditions necessary for a pool to provide a suitable breeding spot for amphibians in general (Crombaghs & Hoogerwerf 1992, Berends 1993, De Jong 1994, Beenen 1998, Hanekamp 2004).

The natterjack toad has specific requirements of its breeding waters. The points below outline guidelines for creating and/or conserving breeding waters (Beenen 1998):

- Still water. The waters do not have to be permanently filled, but they do need to be filled until the end of June;
- Soft water. Not very acid waters, with a minimum pH of 5.5 and a preference for a pH above 6.5;
- No shadow;
- In general many shallow areas. Maximum depth of the pool in the summer of up to 60 to 70 cm;
- Gentle banks. Very gradually inclined waterline;
- Minimal or no growth of water plants;
- Preference for no covering of the water surface by floating vegetation;
- Little competition from fish. The best breeding waters are those where there are no fish.

3.8.1 Guidelines for land habitat

Section 3.3 'Habitat' already discussed the types of habitats where natterjack toads occur.

With regard to secondary breeding waters, such as pools, it should be remarked that the area surrounding the ideal pool has no or very little upright growth, it should get ample direct sunlight and have a loose sandy bottom that can be dug into.

3.8.2 Management interventions and maintenance

Maintenance work on the pools should always be carried out between October and early March, since natterjack toads spend the winter elsewhere this ensures that they avoid any harm. However, it is also important to consider other flora and fauna values. To implement management interventions with as little damage as possible to flora and fauna it is advisable that management measures be incorporated into a nature calendar related to the species concerned.

Management tasks carried out on the land habitat, such as the cleaning of the breeding waters or the setting back of the vegetation succession, should always be implemented in phases. Large portions of the terrain must be left undisturbed. Natterjack toads live on the land throughout the whole year, including in the breeding season. The phased approach therefore helps to safeguard the population from too much damage.

4 LARCH in relation to the natterjack toad on the left bank of the Scheldt in the Port of Antwerp area

The type of findings that can be expected from LARCH regarding the natterjack toad in this study relate mainly to the spatial configuration on the left bank of the Scheldt in the port area. It thus provides key insight into the **potential** of the port area as a home for the natterjack toad.

In the LARCH analysis, five steps were carried out that should lead to concrete proposals for dealing with the natterjack toad on the left bank of the Port of Antwerp. The analysis makes use of distribution data on the natterjack toad from 2003/2004, the current port infrastructure and the planned port developments known off in December 2005 (including the construction of Deurganck Dock and industrial development plans). The following materials were utilized:

- Basic map of the Antwerp Port Authority, scale 1:35,000. The data collected during the field visit were incorporated onto this map. The fieldwork was carried out in collaboration with the Research Institute for Nature and Forest;
- Map of the suitable habitat patches for natterjack toads on the left bank (Source: Natuurpunt-WAL);
- Digital GIS map files originating from the Antwerp Port Authority detailing:
  - port grounds;
  - infrastructure and buildings;
- Information from the Antwerp Port Authority about port development on the left bank (internal report 18 April 2005);
- Information from the Antwerp Port Authority about developments in the Waasland Port area relevant to the natterjack toad (internal report 6 October 2005).

The LARCH analysis therefore not only takes into account the situation as it now stands (numbers of natterjack toads and existing port infrastructure), but also considers the planned future configuration of the port infrastructure.

STEP 1 (figure 8).
To determine whether a viable network of natterjack toads is possible within this area, the current status of the natterjack toad must first be brought into view.

For this, a picture was developed of where the natterjack toads were located, in collaboration with the Research Institute for Nature and Forest in Brussels on the basis of their literature and archive data (Gyselings *et al.* 2004) and a field visit by Alterra and the Research Institute for Nature and Forest in 2005 (17 May). Per location, the numbers of animals were determined on the basis of calling males during evening counts in the chorus period.

STEP 2 (figure 9).
The resulting distribution picture served to show whether there was a metapopulation structure and, if this was the case, to establish its spatial configuration. Were we dealing with one or more population networks? And where were these located? To determine this, the LARCH expert system was utilized.

STEP 3 (figure 11).
The consequences of construction of the Deurganck Dock and expansion of the North Waasland Port industrial area[17] on the ecological networks of the natterjack toad were then investigated using LARCH.

For this, the Antwerp Port Authority provided information about future port development on the left bank of the Scheldt, with 'future port development' encompassing all approved projects and policy plans. The intention was to gain an idea about how the port could evolve over the coming 10 to 15 years.

[17] This is not a name in common usage. It is used in this report to refer to the area between Deurganck Dock and the Waasland Canal.

STEP 4 (figures 12 and 13).
In consultation with the Research Institute for Nature and Forest, with *Natuurpunt* and with the Antwerp Port Authority, alternative solution options were presented by Alterra, which were **validated** by a broader audience (at an expert meeting).[18]

STEP 5 (figures 13 and 14).
The different alternatives were worked out in more detail in spatial models and written reports.

Note: Only on public lands can appropriate management for the natterjack toad be guaranteed in the long term. **The 'backbone' structure is therefore situated entirely on public property.** This approach offers an adequate degree of certainty that a persistent population can be realized. In addition, supplementary measures could also be taken on business properties for the benefit of the natterjack toad. Such initiatives, however, are not included in the analysis of the 'backbone' structure and thus function only as a reserve for the system.

[18] Consultation with the Institute, *Natuurpunt*, the Antwerp Port Authority and Alterra on 21/09/2005 and 17/10/2005. Expert meeting with all involved actors on 19/12/2005.

5 Results

5.1 Current status of the natterjack toad within the port area on the left bank of the Scheldt

The natterjack toad is found in the port area on the left bank of the Scheldt on sand-raised lands that have yet to be further developed, in nature compensation areas (the Vlakte van Zwijndrecht and Groot Rietveld) and in business areas in use for industrial activities (67 ha).

Figure 8 shows the lands within the port area where the various partial populations of natterjack toads are located. The map uses data from 2003/2004 plus data from a field visit in 2005. Based on these, the number of natterjack toads per year is estimated at 1250 calling males that occur on 555 ha.

In the figure, the surface area is given in hectares per area. Note: These are gross surface areas, since they indicate a whole area or site and not only the habitat patches that are suitable for the natterjack toad! These surface area values should not be confused with those from the rule of thumb in section 3.5, which assumes surface areas of suitable habitat patches (net surface areas).

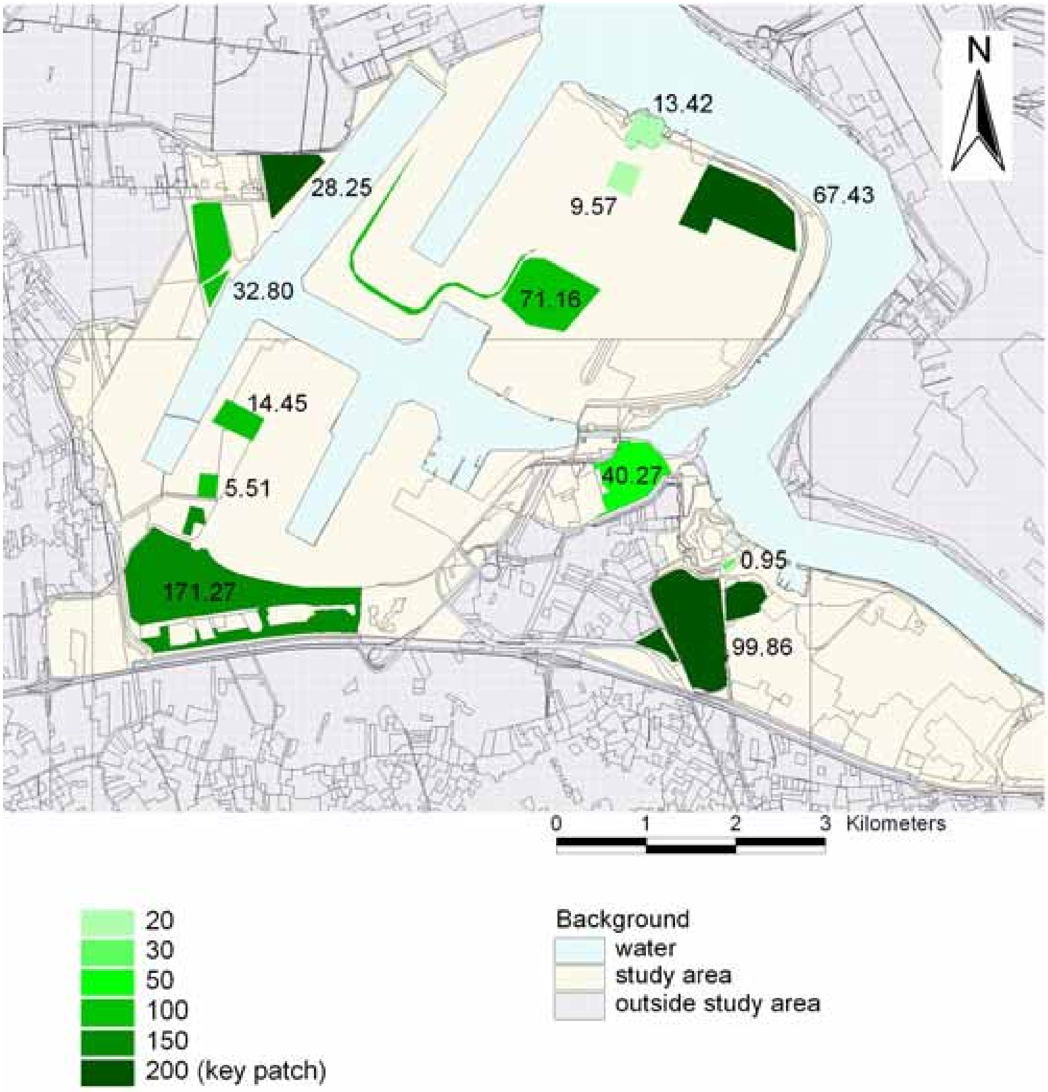


Figure 8. Distribution picture of natterjack toads on the basis of the number of calling males during the mating season in 2003 and 2004 on the left bank of the Scheldt in the Port of Antwerp area. The numbers in the figure are hectares. The numbers in the legend are the individual calling males of natterjack toads fixed in every area.

5.2 Ecological networks of the natterjack toad within the port area on the left bank of the Scheldt in de current situation

Once the dispersal distances (3 km) of the natterjack toad and the presence of obstacles in the port area are taken into consideration, it turns out that three (isolated) populations of the natterjack toad are located on the left bank of the Scheldt (figure 9). The networks are separated from one another by obstacles in the form of infrastructure, the steep quays of the various ports (docks), and urban and industrial building.

The numbers of natterjack toads observed (males only) in the three separate networks are as follows:

- Network 1: 350 animals;
- Network 2: 650 animals;
- Network 3: 250 animals.

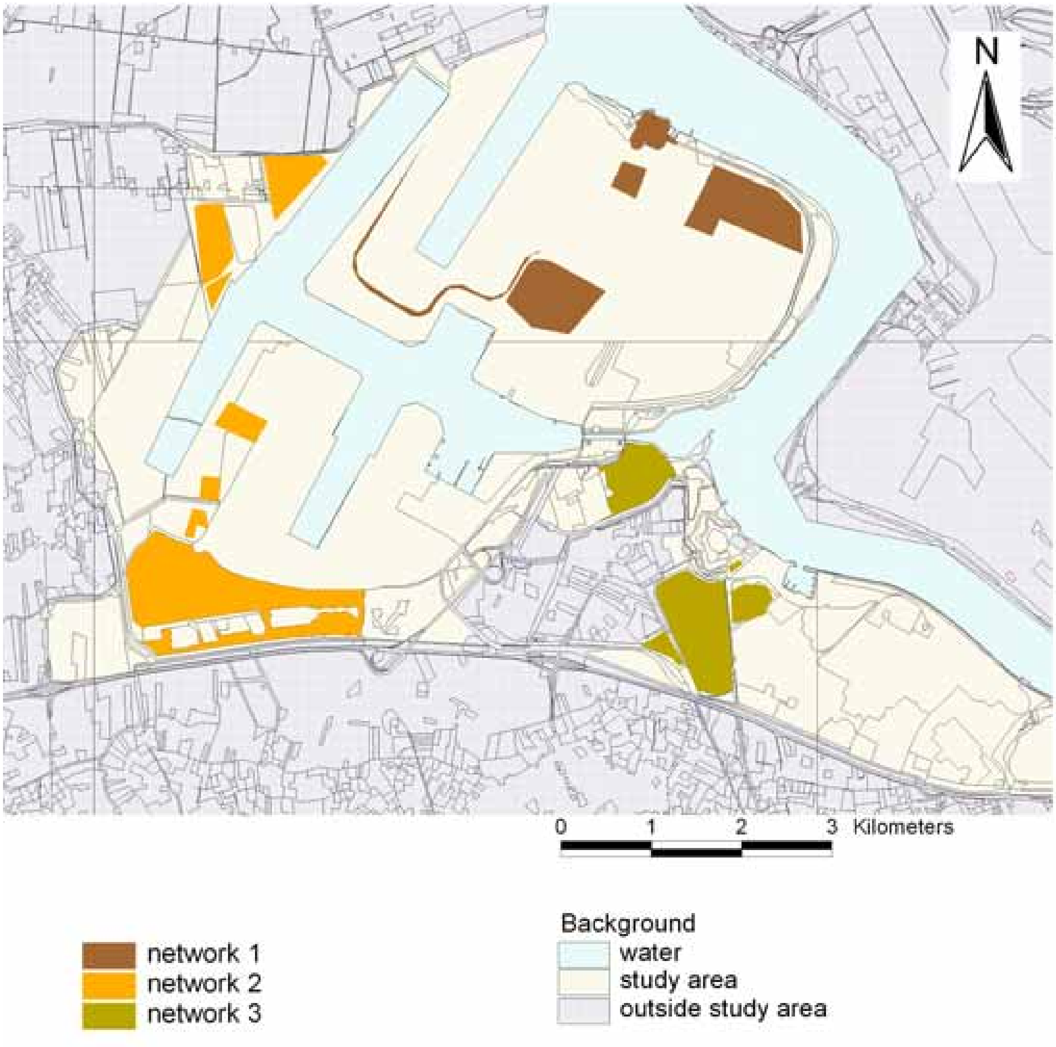


Figure 9. Three population networks of the natterjack toad can be distinguished on the left bank of the Scheldt.

Without considering ongoing port activities and the barrier effect of infrastructure in the port area, all three of the networks are viable: each network contains a key population of 200 natterjack toads, which is connected to a minimum of one up to a maximum of four partial populations.

However, once the ongoing port activities and the barrier effects of infrastructure are taken into account, three isolated population networks are found on the left bank in the current situation. The lack of connectivity between the three networks influences the persistence of the networks (see figure 10).

Network 1
The standing norm for a network with a key area of natterjack toads is 500 animals (RUs) (table 1, section 3.3). In the current situation, this norm is not fulfilled, because network 1 accommodates only 350 natterjack toads. As a result, network 1 is not viable.

When areas where natterjack toad occurs are labeled as non viable in this report, it does not mean that the natterjack toads that live there at this point in time will immediately disappear. Even though these areas or this subpopulation is not viable, because the chance of it's dying out is larger than 5% in 100 years, natterjack toads may well occur here for years, perhaps even dozens of years into the future.

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Network 2
In network 2 a total of 650 natterjack toads are found, for which the key population is now situated in the northern part of the network, to the west of Doel Dock. This network does fulfill the norm of 500 animals in a network with a key area (table 1, section 3.3). This means that network 2 is viable at this point in time.

Network 3
Network 3, in the current situation, is home to 250 natterjack toads. This does not meet the norm of 500 animals in a network with a key area (table 1, section 3.3). This means that network 3 is not viable.

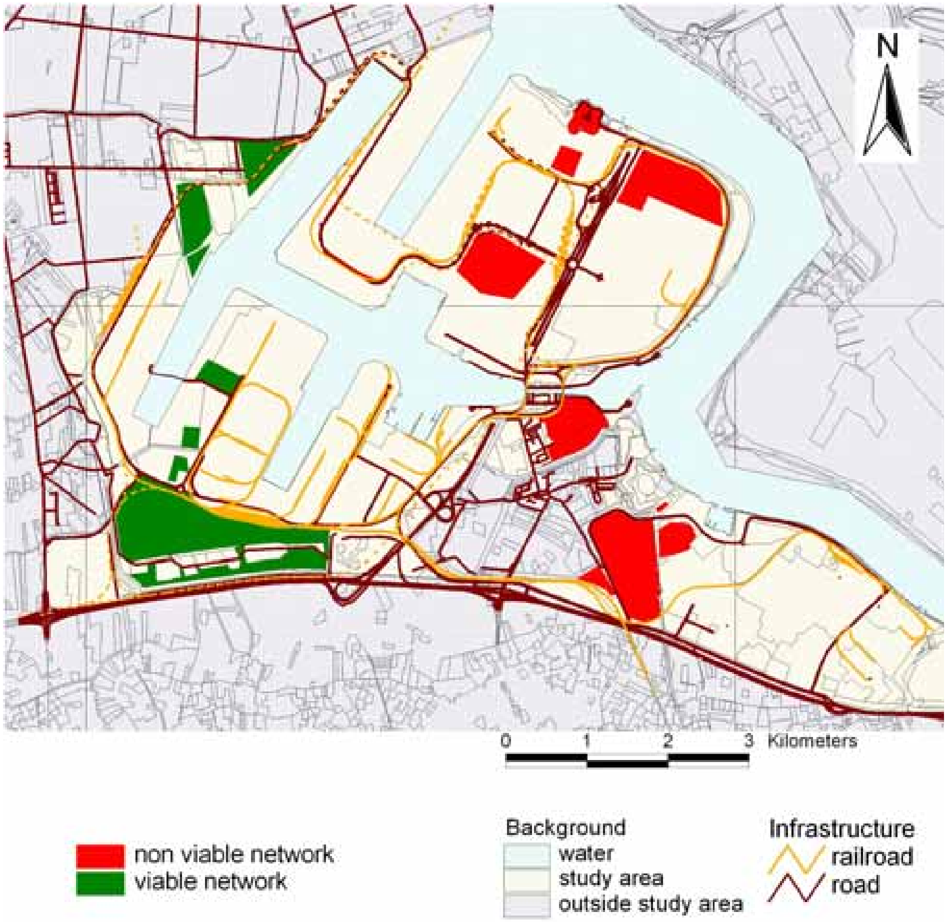

Figure 10. Viability of the ecological networks of the natterjack toad on the left bank of the Scheldt in the current situation.

5.3 Expected future status of the natterjack toad within the port area on the left bank of the Scheldt after implementation of port development plans

The Antwerp port area, particularly the vicinity of Waasland Port, is extremely dynamic in character. Numerous industrial and infrastructure projects are currently under way in the area or are being planned for the (near) future. These planned port developments will lead to a shrinkage of the habitable area currently available to the natterjack toad. Moreover, development of new industrial areas and construction of port infrastructure poses the additional threat of further isolation of the habitable areas that remain. It is therefore inevitable that as the port area on the left bank is more intensively utilized in the future, without protection measures, the survival of the natterjack toad in the area will be further jeopardized.

On the basis of current port developments plans (based on information from the Antwerp Port Authority about known projects and current policies) the expected future status of the natterjack toad population for all three networks was investigated (figure 11).

Network 1
In the vicinity of North Waasland Port a key area composed of 200 calling males is currently present to the east of Fort Liefkenshoek. This population will eventually disappear as a result of industrial expansion. In preparation for the planned industrial development (paving) of the area, the Flemish government had the natterjack toads caught and removed to the Vlakte van Zwijndrecht in 2005. In addition, the construction of a second lock between Deurganck Dock and the Waasland Canal will render this network completely isolated from the other networks.

The loss of the key population of 200 animals means that the number in this network falls to 150 natterjack toads. The standing norm for a network without a key area is 800 animals (RU) for natterjack toads (table 1, section 3.3). This means that network 1 is not viable in the future situation either. Future viability is even lower than that for the current situation. This means that the remaining partial populations in the vicinity will be less stable and have a greater chance of dying out.

Network 2
The key population of network 2 is currently located to the west of Doel Dock. As a result of planned port developments, the existing habitat will, in time, drastically shrink. As a result, network 2 will lose its key area of 200 animals. A number of partial populations within the network will also disappear in the future. The construction and exploitation of the third phase of the Verrebroek Dock will lead to the loss of the three partial populations to the west of the dock. The development of the Waasland Logistics Park will result in the disappearance of the population to the north of Haasop.

For natterjack toads, the standing norm for a network without a key area is 800 animals (RU) (table 1, section 3.3). In the expected future situation this norm is not fulfilled, meaning that network 2 in the future situation is not viable. This does not mean that the natterjack toads will immediately disappear.

The port development plans imply not only a reduction in size of the habitable area available to the natterjack toad within network 2. Due to its highly dynamic nature, port developments also often offer surprising prospects for establishment of new (temporary) living environments. From this perspective, the sand-raised MIDA (Maritime Industrial Development Area) zones and the filled-in part of the Doel Dock could be viewed as two new living environments for the natterjack toad. These habitable areas are temporary in nature, however, since they will eventually be claimed for port activities.

Network 3
Within network 3 a key population (200 animals) is now located at the Vlakte van Zwijndrecht. This population will disappear in the future. This is because the Vlakte van Zwijndrecht is actually a temporary compensation area in line with the Bird Directive and is planned to be maintained only up to and including 2007.

The loss of the 200-animal key population means that the number in this network will decline to some 50 natterjack toads. As a result the degree of viability of network 3 will drop relative to the current situation. Here again, regardless of the weakened viability of the network, natterjack toads could occur in favorable habitat patches in the area for years. However, the remaining partial populations will be less stable and have a larger chance of dying out than in the current situation.

Photo 6. The photo shows the temporary compensation area the Vlakte van Zwijndrecht in line with de Bird Directive

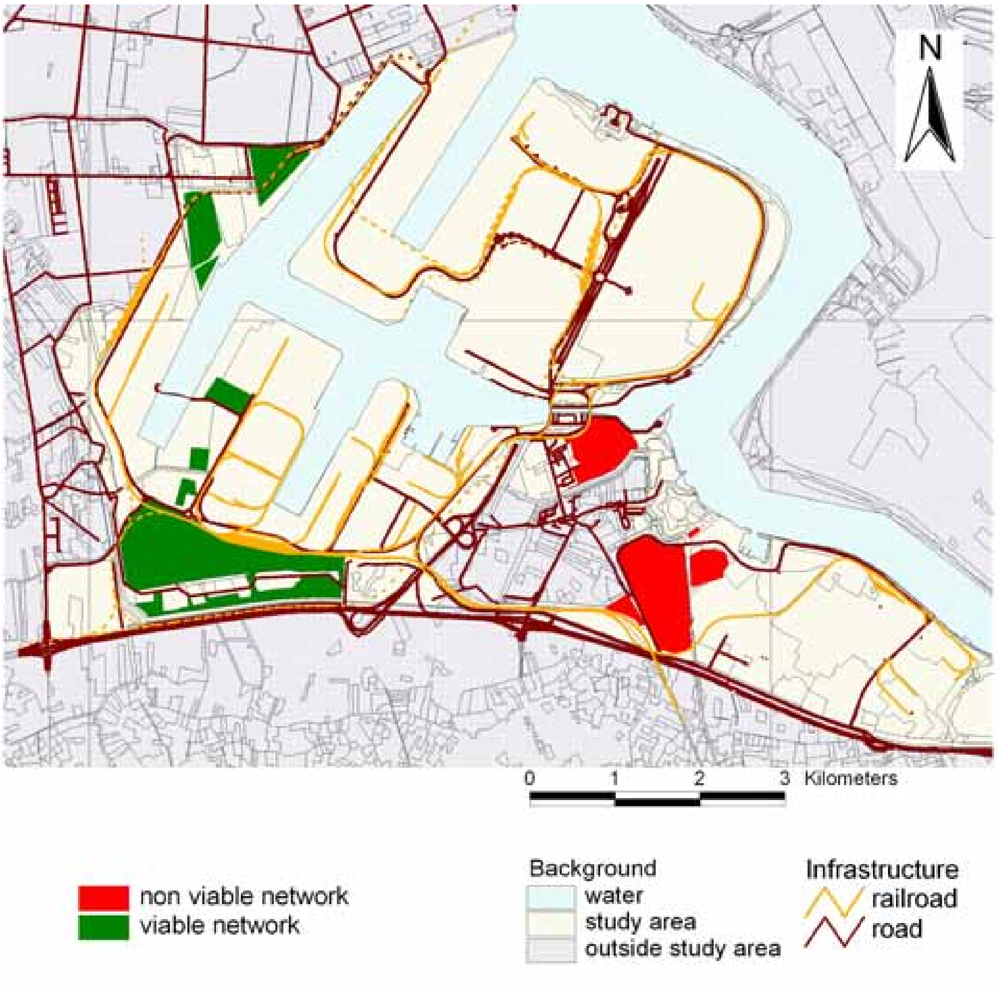

Figure 11. Viability of ecological networks of the natterjack toad in the expected future situation. Network 2 is in this figure already viewed as viable, assuming that the conservation measures described in section 5.4 and detailed in section 5.5 for network 2 should be implemented.

Important Remark: the areas colored as "viable network" are the outcome of the LARCH-analysis. These areas are based on monitoring data of 2005. They are shown on the map as a reference to this situation. Some parts of the 2005 viable networks will disappear in the future (as mentioned in 6.3) and will as a consequence not be part of the backbone structure.

5.4 Alternative solution options for the natterjack toad 'backbone' on the left bank

Keeping in mind the plans for the port area in the future and the potential of specific areas where no port expansion is planned to be sustainably fitted as habitat areas for natterjack toads, Alterra made a first attempt to define possible alternatives for preserving a viable population in and around the Port of Antwerp area (figure 12). The workshop held 17 October 2005 with the Research Institute for Nature and Forest, *Natuurpunt* and the Antwerp Port Authority resulted in the choice of establishing a 'backbone' **in** the southern part of the port area on the left bank of the Scheldt, because this area offers the best opportunities for the conservation of natterjack toad in the long term. On one hand, this is because it will remain (partially) free of port development and on the other hand, because it offers the best prospects for creating new habitable areas.

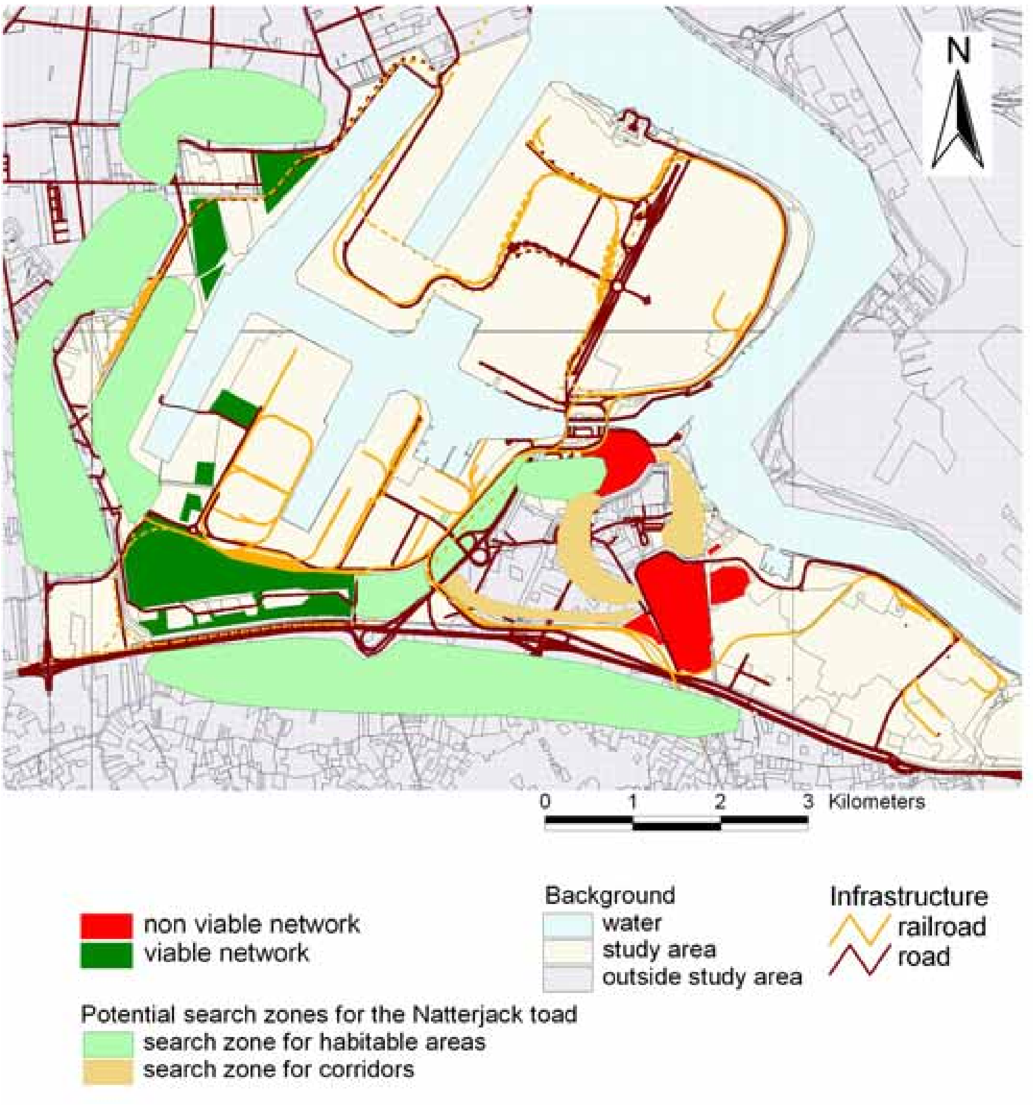

Figure 12. Alternative options for the natterjack toad on the left bank.

Network 1
Because of its non-viable nature and the lack of options for creating new habitable areas, network 1 is entirely abandoned and not incorporated into the 'backbone' structure. In total this involves 320 natterjack toads and 162 ha of habitable area that in part has already disappeared (natterjack toads that were captured and removed to make way for the expansion of industry) or which will disappear in the future in this area of the left bank of the Scheldt.

Network 2
Despite the loss of the key area to the west of Doel Dock and the disappearance of other partial populations, network 2 is included in establishment of the 'backbone' structure. This is because numerous opportunities are available to cushion the reduction of habitable areas in the southern part of the port area. For instance, plans have been drawn up for the establishment of new and improved living areas for the natterjack toad in Haasop. There is also an opportunity in the Steenlandpolder area to create new living areas for the species. In addition, along the western periphery of the port area, a sand-raised MIDA and the filled-in part of the Doel Dock offer prospects for temporary living areas for the coming 10 to 20 years[19].

Network 3
Network 3 is incorporated into the 'backbone' structure despite the fact that it is currently non-viable. This is because there are opportunities to make up for the loss of the key area in the direct vicinity (Vlakte van Zwijndrecht). For instance, the establishment of new and improved living areas for the natterjack toad on the Groot Rietveld is already under way, with parts already completed. This includes 1.8 hectares of breeding water established in the form of pools. The sand-raised lands to the north of Lisdodde-Melkader are also suitable for creating new and improved living areas.

Photo 7. 'Het Groot Rietveld' where possible new habitat for the natterjack toad can be found on the boarders of this site.

[19] In the framework of the NEW!Delta project – theme 3 Creation and restoration of coastal and estuarine habitats, action 3.3 Demonstration project in the port of Antwerp – the Port of Antwerp makes investments in the port of Antwerp that will contribute to the sustainable conservation of the natterjack toad population of the left bank area of the port of Antwerp.

5.5 Detailing the natterjack toad 'backbone'

At the expert meeting held 19 December 2005 in Antwerp, local specialists provided supplementary information for use in developing detailed plans for the 'backbone' structure.

Efforts to establish a persistent population, with which to safeguard the presence of the natterjack toad on the left bank in the longer term, will have to be focused in the southern segment of the port, because this is the zone that is spared the most from future port development and which offers the most opportunities for creating new or improved living areas. Here, various scenarios are possible. The most important is that the main four key areas – 1) Haasop, 2) Steenlandpolder,[20] 3) the sand-raised lands to the north of Lisdodde-Melkader and 4) Groot Rietveld, see figure 3 – be linked with one another (figure 13). Indeed, without such connectivity the metapopulation is not viable. Options for establishing a cohesive whole are indicated with search zones for living areas as well as corridors for enabling the species to cross the existing (infrastructure) barriers. Within these four key areas and de E.I. Steenlandpolder it is possible to establish more key patches[21] for the natterjack toad. Figure 13 and 14 show possible locations for these key patches. The employment of key areas according to the rule of thumb in section 4.5 can be seen as an instrument with which fluctuating numbers of natterjack toads can be maintained in a viable status.

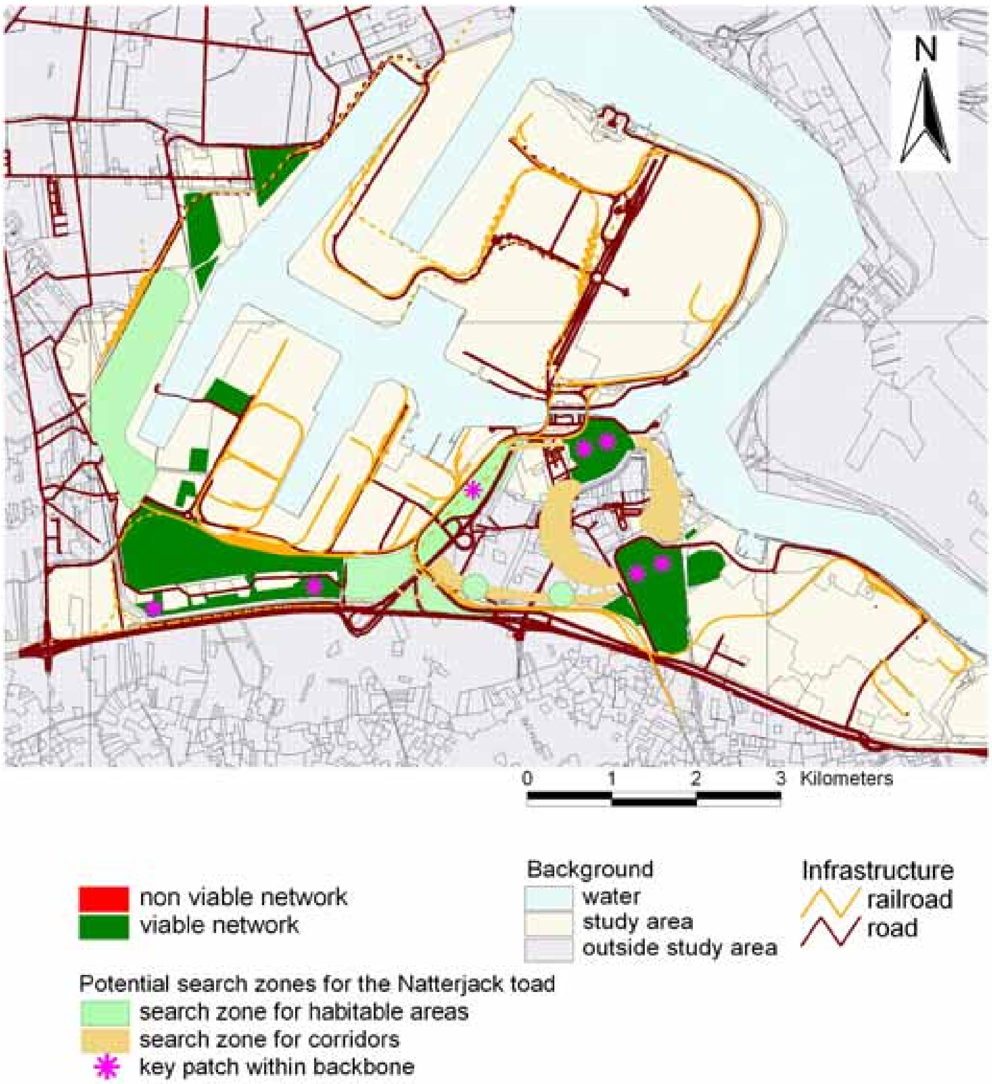

Figure 13. 'Backbone' and temporary habitable areas.

20 Steenlandpolder is not planned as one of the permanent living areas, but rather, is viewed as permanent Ecological Infrastructure (E.I.), where it is possible to establish a key area for the natterjack toad.
21 Key areas/patches within the backbone will be constructed according to the rule of thumb in section 4.5.

There are a number of possible options for linking the four key areas. Figure 14 zooms in on these alternatives. Because each of these linkages requires tailored design, the maps now show buildings and infrastructure. It is beyond the scope of this study to investigate which alternatives are most feasible; this then will be looked into further by the Antwerp Port Authority and local actors.

In addition, the sand-raised MIDA's and the filled-in part of the Doel Dock offer opportunities for temporary habitable areas for the coming 10 to 20 years. However, it is crucial that these temporary areas be linked with the metapopulation in the southern part of the port. Investigating the means by which this connectivity can best be established is, again, beyond of the scope of this study.

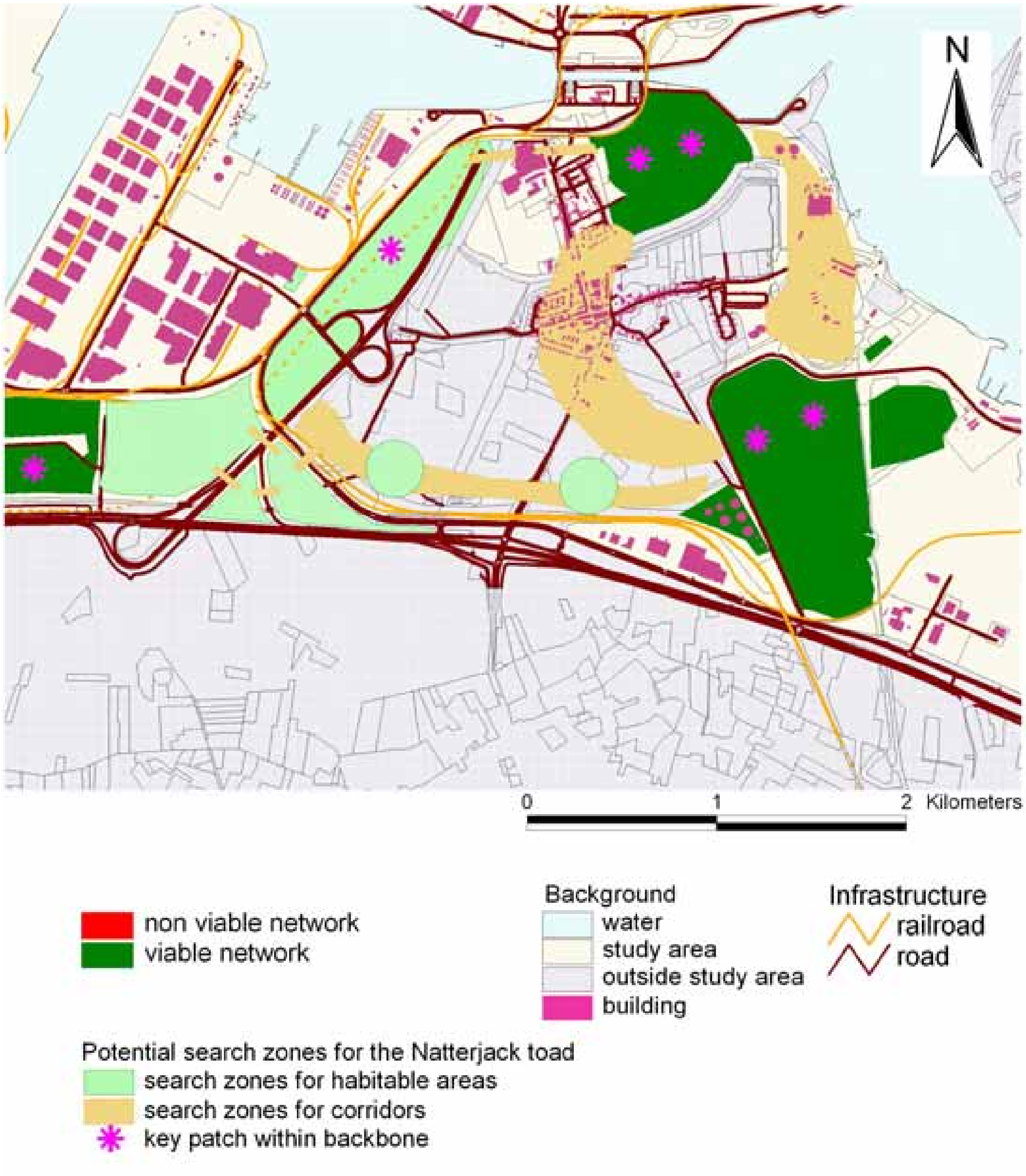

Figure 14. Different options for the 'backbone' structure.

6 Conclusions

In 2003 and 2004 a natterjack toad population of 1250 calling males was counted on a total area of 555 ha of Antwerp Port Authority grounds on the left bank of the Scheldt.

The current population occurs in three different networks. Of these, only the network located in the west (Haasop and vicinity) is viable in the current situation.

It is possible to establish a viable metapopulation structure for the natterjack toad alongside the economic activities taking place in the port area.

Because of economic developments in the vicinity of North Waasland Port, the centrally located network is not viable in the longer term. The 320 natterjack toads found on the 162 ha can, to some extent, be accommodated in the southern and western periphery of the port area, in the so-called 'backbone'. The fact that North Waasland Port is not incorporated in the 'backbone' does not mean that no natterjack toads can occur there. What it does mean is that the chance of persistent occurrence is slight.

Among the alternatives for the 'backbone' and temporary areas, the choice was made to target the conservation of a viable population initially within the boundaries of the port area.

For conservation in the shorter term (for the coming 10 to 20 years) on the temporary MIDA (Maritime Industrial Development Area) lands and the filled-in part of the Doel Dock, a corridor with existing and new habitable areas will be established with Haasop. This corridor is best created due west of Doel Dock; in areas where natterjack toads currently already occur.

Various alternatives are possible for the establishment of fixed viable key areas. For the permanent areas, or the 'backbone', the choice was made to establish these in the southern part of the port area. The authors suggest that four large core areas be established here, altogether encompassing about 200 ha and connected to one another by means of mitigating measures, stepping stones and corridors.

In each permanent living area and in one area with a permanent Ecological Infrastructure, a minimum of one key area (population) for the natterjack toad is anticipated, conform the rule of thumb.

One key area (population) is viable within a network, but it is also sensitive to catastrophes. If the aim is to preserve the number of natterjack toads, taking as starting point figure 5 (with the key area) and figure 8 (1250 natterjack toad calling males on about 555 ha), then a number of key areas (populations) must be conserved that are connected with one another. We call this a population network. This structure contributes to spread the risk and reduces the chance of extinction.

The authors suggest that the following numbers of key areas[22] be projected in the three permanent living areas:

1. Haasop, 2 key patches;
2. Lisdodde-Melkader, 2 key patches;
3. Groot Rietveld, 2 key patches.

Additionally, 1 key patch should be developed in Steenlandpolder, an area with a permanent Ecological Infrastructure (E.I.). Steenlandpolder can be considered as the fourth key area. See figure 13 and 14 for the locations of the key areas.

This total picture ensures a cohesive network in which 1400 natterjack toads could potentially be accommodated. For the minimal option of one key patch per permanent habitable area and in the Steenlandpolder Ecological Infrastructure, the potential number of natterjack toads is 800. Thus, the natterjack toad could sustainably co-inhabit the left bank alongside port activities. The measures and actions needed to bring this about could be worked out in more detail by the Antwerp Port Authority

[22] The employment of key areas according to the rule of thumb in section 4.5 can be seen as an instrument with which **fluctuating** numbers of natterjack toads can be maintained in a viable status.

together with the Region of Flanders and local actors (e.g. in the form of areas reserved for nature development on private business properties).
This process is already in execution. In two permanent habitable areas, the Groot Rietveld and on the Haasop, measures and actions have been taken by the Antwerp Port Authority and the Region of Flanders that will contribute to the establishment of a key patch (population).

Photo 8. The golf course and the available space between and around oil reservoirs are examples of private business were potential lies for the natterjack toad. For example creating of reproduction waters or suitable landhabitat.

The choice of establishing a ‘backbone’ in the southern area must necessarily lead to investments in mitigating measures (e.g. screens and tunnels) to eliminate the infrastructure obstacles, especially Highway R2 and the half-interchange near Kallo.

7 Recommendations

Beyond assessing ecological aspects related to the natterjack toad, this study made no attempt to prioritize other bottlenecks. It is nonetheless advisable to take stock of these (Van der Grift 2003). Important factors are: existing nature policy, species policy, location-specific approach, costs, legal liabilities, (possibly) multifunctional use of fauna facilities, support in the region and the like.

Further, there are also opportunities outside the ‘backbone’ to facilitate habitat for the natterjack toad. The Antwerp Port Authority, together with private landowners or users, should be able to take various other measures to the benefit of the natterjack toad (for example, in the form of temporary ecological infrastructure or habitats).

Terrains can be designed in a ‘natterjack toad-friendly’ way, for instance, with the establishment of one or more breeding waters or the creation of an appropriate land habitat. The lands located between the oil storage tanks come to mind here, or the golf course located near Lisdodde, see figure 3. East Waasland Port offers many opportunities in this regard. Such temporary facilities could make a significant contribution to sustainable conservation, in this example, mainly in relation to intermittent exchanges of young migrating animals.

The positioning of the ‘backbone’ is indicated in figure 13 (‘Backbone’ and temporary habitable areas) and figure 14 (Different options for the ‘backbone’ structure). To arrive at practical implementation, however, it is recommended that an action plan be drawn up. In broad lines, this plan would need to encompass the following:

1. Positioning of key (core) areas (Haasop, sand-raised terrains to the north of Melkader-Lisdodde and Groot Rietveld);
2. Positioning of the locations where mitigating measures, such as tunnels and screens, are to be implemented (linking Haasop with Steenlandpolder and Haasop with the area to the southwest of Kallo; link between Steenlandpolder and Melkader-Lisdodde);
3. The positioning of the corridors (with two stepping stones between Haasop and Groot Rietveld; the eastern and western variant between Melkader-Lisdodde and Groot Rietveld; the corridor with stepping stones between Haasop and temporary living areas);
4. Guidelines for implementation, such as having work done only outside of the breeding season.

Photo 9. Different types of corridors as pipes, ditches rail- and waysides lies in the Port of Antwerp. These corridors can, and sometimes already are, be useful for the movement of natterjack toads from one to the other site.

In addition to the plan of action for implementation, it is also strongly recommended that a management plan be drawn up for the natterjack toad. This management plan could be part of a species conservation plan for the port in its entirety. In this plan, maintenance work could be scheduled for the mitigating measures, such as the pools, toad tunnels and toad screens established.

To remain abreast of the local state of conservation of the natterjack toad on the left bank of the Scheldt, monitoring is recommended in future. For this we suggest following the ‘state of conservation determination method’ for the habitat types. Four aspects are of importance here: 1) distribution, 2) population, 3) habitable area and 4) future outlook. For that last, LARCH could ultimately be of service, for both the effects of management and for design variants. For this, it is recommended that adequate mapping be done of the vegetation types (type of ground cover map) on the various (nature) areas, as well as of the current and future infrastructure obstacles in the port area.

Of course, conservation of the natterjack toad in the Port of Antwerp is complementary to the conservation of the species in the whole of Flanders. There are in fact various opportunities for managing this species better, outside of the port area as well as within it. One possible additional search zone located outside of the port area is in the vicinity of Blokkers Dike and encompasses the nature areas to be developed around the Oosterweel complex. This zone could become extremely important if along the road a link could be established to the existing populations farther upriver along the Scheldt. This would also resolve the isolated status of the port population. The extent to which this is feasible will have to be worked out further, but there will certainly be potential habitat for the species in this zone.

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Appendix 1: List of terms[23]

Backbone
By 'backbone' structure we mean the living areas permanently established for the natterjack toad, where the species is safeguarded for the future in the Port of Antwerp area.

Carrying capacity
Every population has a theoretical maximum in a living area. That maximum can be thought of as a ceiling population magnitude. The 'carrying capacity' is a commonly used way of conveying this idea. For birds, the carrying capacity is often easily expressed in numbers of territories.

Core areas
Habitable areas in which a key population can occur. A concrete place, that can be spatially delineated and fulfills the survival and reproduction requirements of a species.

Corridor
Linear landscape element that is part of a linkage. From a functional perspective, a strip of land or water designed so that plants and animals prefer to travel within this strip instead of outside of it. The chance of survival is therefore greater, with the result that longer distances are traveled.

Dispersal
The non-specific movement of an organism towards a (possible) habitat patch (living area).

Dispersal flow
The number of individuals or seeds in dispersal per unit of time, for example, at a certain point in the landscape, from a habitat patch or for landscapes as a whole.

Ecological network
A collection of habitat patches where one metapopulation of a species can function. This implies that all patches are accessible to individuals of the species, irregardless of whether a portion of them are in fact vacant.

Fragmentation
The breaking up of a plant or animal species' living environment into smaller units (snippets or fragments) separated by obstacles or terrain that is unsuitable as habitat (Opdam & Hengeveld 1990).

Habitat (location)
The collection of values related to the living requirements of a species which fulfill the physiologically determined needs of that species for reproduction and survival. These requirements can thus relate to edaphic or climatic factors as well as to biotic factors (parasites or fungi).

Habitat patch
A spatially defined area where habitat for a species has been established. An ecotope can coincide with the habitat patch, but this latter might also be set apart from the ecotope, or perhaps coincide with a mosaic of ecotopes.

Home range
The area in which an animal forages and spends most of its time. The size depends on the size of the animal in question and its style of gathering food.

Key population (key patch / key area)
Relatively large population that is viable on the condition that there is one immigrant per generation (Verboom *et al.* 2001). There is usually a net dispersal flow towards the other parts of the ecological network.

Local population

[23] For a more detailed description refer to Pouwels *et al.* 2002.

A spatially delineated population in which 'random mating' takes place.

Metapopulation
Spatially structured population, divided into local populations that occur in habitat patches, which together via dispersal form an ecological network.

Minimum Viable Population (MVP)
Habitat area or population of such a magnitude that its extinction probability is less than 5% in 100 years. The habitat area or population is then just viable or persistent.

Network population
Synonym for metapopulation.

Obstacle
An element that relatively strongly or entirely blocks the dispersal flow.

Persistent
An ecological network or landscape is persistent if the survival chance is larger than 95% in 100 years. A (meta)population is persistent. The persistence can be calculated using various norms. An ecological network can exceed or fall below the persistence boundary. In the former, the landscape configuration is good, in the latter something is wrong with the situation and it can be looked into how improvements could be made.

Reproductive unit (RU)
The minimum number of animals needed to reproduce is called a reproductive unit; in many cases this is a male and a female (a pair), in a limited number of cases, it is a small social group (RU = Reproductive Unit).

Stepping stones
Stepping stones are small habitat patches that, because they are not located too far from one another, function in the same way as a corridor.

Viable population
Isolated population of such a magnitude that the chance of its dying out is very small.

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