

# Designing Artificial Habitats for Local Fauna Species in the Province of Zeeland, The Netherlands

**Commissioner:** P.C. Traas, Chairman of Traas

**Coach:** Jenny Kieskamp

**Expert:** Bastiaan Meerburg

**Team 869:** Sustainable pest control by using fauna towers

**Team members:**

Imke Kuiper

Djoeke Langeloo

Sunil Pariyar

Julia Samson

Jeltje Stam

Carmen Vazquez Martín

October, 2011



Pictures of the cover page:

Bat tower. Traas Nature Care

Typical Zeeland Landscape. Jeltje Stam.

This report is produced by students of Wageningen University as part of their MSc-programme. It is not an official publication of Wageningen University or Wageningen UR and the content herein does not represent any formal position or representation by Wageningen University.

Copyright © 2011 All rights reserved. No part of this publication may be reproduced or distributed in any form of by any means, without the prior consent of the authors.

Dit rapport is gemaakt door studenten van Wageningen Universiteit als onderdeel van hun MSc-opleiding.

Het is géén officiële publicatie van Wageningen Universiteit of Wageningen UR. Wageningen Universiteit neemt middels dit rapport geen formele positie in, noch representeert het haar visie of mening in deze.

Copyright © 2011 Alle rechten voorbehouden. Niets uit deze publicatie mag worden verveelvoudigd of openbaar gemaakt worden, in enige vorm of op enige wijze, zonder voorafgaande schriftelijke toestemming van de auteurs.

## **Preface**

Working on this project for almost eight weeks has been a very interesting experience for all the members of the team. Although we do not have the same backgrounds (cultural and educational) and often had differing opinions about the project, we managed to make a report that fits our ideas and thoughts. The time spent together was full of good laughs and some harder moments but we went through all of these as a team and are proud to present this report as the result of our work.

## **Acknowledgements**

Several people participated with us to this project and we would like to thank them for their knowledge, help and support. First we would like to thank our coach Jenny Kieskamp and our expert from the WUR Bastiaan Meerburg. Many thanks to Hein Vermin for the good contact and help and to Merijn Buitelaar and Peter Traas. We would also like to thank the experts who helped us with the content of the project: André Hannewijk, Jan Heersche, Nanning-Jan Honingh, Erik Korsten and Björn van Loon.



## **Abstract**

Habitat destruction and biodiversity loss are the key issue of today's world. In Netherlands over the past century biodiversity has been declining steadily but large decrement in bat and bird species of international significance. Habitat fragmentation due to intensive agriculture is the prime reason for animal loss in Netherlands. Regarding these issues habitat compensation and restoration is essential along with other conservation measures. To address these issues, this paper provides concepts of building habitat for local fauna in Netherlands, especially in Zeeland. The initial idea of fauna tower (Traas) to provide artificial habitat for several local species in Zeeland is not realistic and viable because of territorial behaviour, predator prey relation, inter- and intra-species competition for resources etc. In addition to this, the concept of fauna tower is not appropriate to accommodate species without providing foraging habitat and other behavioural need. Hence, the idea of fauna tower seems doubtful because of its expensiveness and functional restrictions. Thus, we concluded after analysing, it is better to go for a bat tower and several other alternatives. We propose a bat tower and hibernacula (for winter) with inside and outside design mainly focused on two local bat species of Zeeland. Next to this we propose several alternatives which are innovative, exclusive, flexible, creative, affordable and realistic. Functional fauna art, Garden and roof ornaments, artificial tree, bird wall, bird box cams and other fauna housing are the main alternatives for fauna tower. Further research on species habitat requirement and their behaviour is very essential for implementation of proposed design schemes.

*Keywords: Habitat, Fauna Tower, Zeeland, Bat, Alternatives.*



## Contents

1	Introduction .....	9
1.1	Fauna loss/decline .....	9
1.2	Problem, goal, RQs .....	10
2	Relevant information.....	13
2.1	Legislation.....	13
2.2	Landscape .....	14
2.3	Education.....	16
2.4	Potential clients.....	17
PART I: BAT TOWER.....		19
3	Background.....	21
3.1	Decline of bat species .....	21
3.2	Target species .....	22
3.3	Legislation.....	26
3.4	Existing bat towers or (artificial) roost places .....	26
3.5	Pest control and compensation measures .....	27
4	Design of the bat tower.....	29
4.1	Tower.....	29
4.2	Hibernacula.....	34
5	Conclusions .....	37
PART II: FAUNA HOUSING .....		39_Toc306901927
6	Background.....	41
6.1	Decline of fauna species .....	41
6.2	Target species .....	42
7	Fauna tower.....	47
8	Other fauna housing .....	51
8.1	Functional fauna art.....	52
8.2	Bird wall .....	54
8.3	Nest boxes with web cams .....	56
8.4	Garden and roof ornaments .....	57
8.5	Artificial trees .....	60
8.6	Other ideas .....	61
9	Conclusions and Recommendations .....	63
GENERAL CONCLUSIONS .....		65
10	Conclusions .....	67
APPENDICES.....		69
I.	References .....	71
II.	List of relevant Legislation .....	77
III.	List of fauna in Zeeland (Dutch, English and Latin name) .....	79
IV.	Expert interviews .....	81
	Björn van Loon, Education expert.....	81
	Jan Heersche, Landscape expert .....	83
	Erik Korsten, Bat expert .....	85
	Nanning-Jan Honingh, Zeeland Expert.....	88
	André Hannewijk, Mammal expert.....	90
V.	Dutch Summary (Nederlandse samenvatting ) .....	93



# 1 Introduction

## 1.1 Fauna loss/decline

Habitat destruction is amongst one of the main causes of fauna species loss in today's world (Fahrig, 2003). Human settlements and development are intricately related to habitat destruction. Habitat loss is an important risk not only for the fauna species dependent on said habitat, but it also can be a nuisance for human health (Loguidice *et al.*, 2003).

Elrich and Pringle (2008) have underlined the importance of increasing human population and its effect on nature, and have developed several steps to decrease the devastating effect of human populations on the environment. One of the most important steps is the adaptation of human-dominated landscapes to biodiversity, as well as the return of extirpated species to their natural habitats.

As humans take over the landscape, the connectivity between communities of species declines, their dispersal blocked by roads, streets, railways, etc. (Forman and Alexander, 1998). As an example, Fernandez-Juricic and Jokimaki (2001) studied the connectivity between bird communities in cities. Habitat fragmentation can be an important problem in cities, and bird communities can become more isolated when living in cities than when living in patches of wood separated by agricultural lands. Providing habitat connections between isolated populations through wooded avenues and streets can help connect communities living in city parks for example, but this is often not enough. Creating a suitable habitat for city-dwelling species is important and may help improve the connectivity between habitats (Fernandez-Juricic and Jokimaki, 2001).

Bats are declining in the Netherlands due to habitat destruction and all 21 bat species present in the Netherlands are listed as protected species (Johan *et al.*, 2009). In some managed forests, bats suffer from habitat loss, as many old hollow trees (their preferred habitat in those areas) are often removed (Ciechanowski, 2005). Although some measures have been taken to improve the situation, the use of bat boxes is not always sufficient, as its effectiveness depends strongly on the location of said box (Ciechanowski, 2005) and although the maintenance of old trees within managed areas is now within managing plans, trees have not reached the age stage appropriate to suit the bats' requirements (Erik Korsten, pers. comm.). In large agricultural landscapes, heterogeneous urban structures may represent important habitats for some bat species (Gehrt and Chelsvig, 2004). Bat Towers located around agricultural lands may represent important stepping stones for these bat populations.

A balanced ecosystem can highly benefit humans. Recent studies in the USA and Spain, have shown the impact of insectivorous bats on pests around agricultural fields. The presence of bats can not only decrease the amount of money spent on pest control, but can completely eradicate the need for pesticides (Boyles *et al.*, 2011; Flaquer *et al.*, 2011).

Bats are just an example of how important species loss can be. Insectivorous birds can provide similar services as bats, and suffer from habitat loss and fragmentation in a similar fashion (Martin *et al.*, 2010). Although the Dutch Government is working to create an ecological network that connects all protected areas (MNP, 2006), the connection of isolated populations cannot be achieved merely through connecting protected areas and the idea that species should be packed into conservation areas rather than being (when possible) integrated into our landscapes, strongly disagrees with the ideal of sustainability and green living.

Buildings suitable for fauna species threatened by human population growth and expansion have the potential to increase connectivity between animal communities and reintroduce species that have been pushed away or are susceptible of being pushed away from their natural habitat. For animals with a smaller territory, towers might be too isolated to work as stepping stones, but human landscapes can otherwise adapt to suit biodiversity, including smaller elements that, spread throughout the landscape can be used as stepping stones.

## 1.2 Problem, goal, RQs

Our goal is to provide artificial habitats for local fauna in the Dutch province of Zeeland. The main problem however, is that fauna towers are a relatively new concept which needs further development and study. The innovative nature of fauna towers represents an important obstacle for Traas in the development and implementation of this new project. We aim to fill this knowledge gap regarding the species that fauna towers might be able to accommodate, determine the viability of the project, and develop other ideas to provide habitat for local fauna.

In order to contribute to the overall goal of providing habitat for local fauna in the province of Zeeland, we will work on designing artificial fauna houses in general and a bat tower in specific. Fauna species can use these buildings for nesting, feeding, roosting or even hibernating. The purpose of this project is to develop a bat tower and fauna housing that provide suitable habitats for local fauna in the province of Zeeland, which are attractive for Traas and their potential clients.

We will make a list of the possible target fauna species and give insight into which species can coexist and share breeding grounds. The proper habitat for each species has to be studied and designed, this includes its position in the tower and its characteristics inside. The outside design of the tower should be attractive to fauna while maintaining the architectural standards of the area of interest. Besides, Traas is interesting in ways to give the towers an educative character, especially focused on children. Lastly, the design of the fauna housings should meet the requirements set by Traas and on the same time be interesting for its potential clients.

The main research question related to our purpose is: how should bat towers and fauna housing be designed in order to provide suitable habitats for local fauna in the province of Zeeland, while being attractive for Traas and their potential clients?

To answer this main research question, several sub questions need to be answered, all related to the design and development of a bat tower and fauna housing.

- Which local species in Zeeland should be provided with artificial nesting / feeding habitats and how do their natural habitats look like?
- Which fauna species can be combined in one tower?
- What is the best design of a bat tower and fauna tower?
- What are design criteria required by Traas and their potential clients?
- What are relevant restrictions occasioned by legislation and which licenses are needed for implementation of the towers?
- How should the towers be designed in order to fit in the landscape of Zeeland?
- How to give the towers an educative character?
- Who are potential clients of Traas interesting in a bat tower or fauna housing?

For contributing to our final goal, we will develop and design a bat tower (Part I) and develop ideas for fauna housing (Part II). Part I about the bat tower will start with background

information about bat species (Ch. 3). After target bat species are determined and their natural habitats are described, design criteria will be formulated. For the bat tower these design criteria are used to design a bat tower in detail (Ch. 4). Part II, which is about fauna housing, will also start with background information about fauna species in Zeeland (Ch. 5). Chapter 6 will be dedicated to give advice on the first idea of a fauna tower developed by Traas. We will continue with presenting several ideas of fauna housing (Ch. 7). Conclusions of both parts can be found in chapter 8. But first we will start with chapter 2 in which we discuss topics that are relevant both for the bat tower and the fauna housing, namely relevant legislations, fitting in the landscape, education and potential clients.



## 2 Relevant information

### 2.1 Legislation

The relevant laws, decrees and directives used in this section can be found in appendix X.

#### **Nature conservation**

Nowadays, almost all threatened native animals and plants are protected in the Flora and fauna law ('Flora- en faunawet') of 1998. Everybody has the duty of taking care of these organisms. This also means that, by this Flora and fauna law, disturbing or killing endangered animals or removing plants from their growing places is not allowed. This is important in the process of building, for example, a tower. If such an action cannot be avoided, a dispensation should be requested. If permission is not given, one can ask for an environmental license ('omgevingsvergunning') to make sure the tower can be built. In the case of a protected area, the proceedings should be mentioned at least one month, but no longer than a year, in advance according to the Flora en fauna law.

The European Union can also protect areas and animals by the use of the Habitats Directive ('Habitatrichtlijn') (1992) and the Birds Directive ('Vogelrichtlijn') (1979). These directives shortly mention important species that should be protected by the European member states. From those directives, the idea of 'Natura 2000 areas' emerged; these areas form a linked network of nature areas throughout Europe, their main goal being to stimulate biodiversity (Regiebureau Natura 2000, 2011). In March 2010, these areas covered almost 18% of the European Union grounds (Europese Unie, 2011). In The Netherlands, the appointment of 'Natura 2000 areas' is legally arranged in the Nature conservation law ('Natuurbeschermingswet') of 1998 (Bekker *et al.*, 2010). This law includes not only species protected by the European Union (by the above mentioned directives), but also species characteristic for a specific region.

According to the Nature conservation law, the nature policy plan ('natuurbeleidsplan') and the land use plan of nature and landscape ('structuurvisie Natuur en Landschap') mention the natural and environmental values of an area, the animals that will get special attention, and which natural monuments ('natuurmonumenten') are appointed as protected. A permit is needed in order to carry out activities which may be disrupting or harmful to the environment in or close to these protected areas. The Nature conservation law ('Natuurbeschermingswet') also allows for the panorama ('landschapsgezicht') to become protected; this is mentioned in the zoning ('bestemmingsplan'). All actions that change such a protected panorama should be avoided; if this is not possible, a permit is needed. The applicant has to make sure that they mention their own interests clearly in the request and that permission is asked for all the proceedings; these proceedings should meet the criteria mentioned in Article 46, of the Nature conservation law (1998).

Before building a tower, the zoning should be checked and when the tower is planned in or close to a protected natural monument or panorama, the named permits should be requested.

According to the Environmental law ('Wet milieubeheer') (1979, changed 2004), the Provincial Council ('Provinciale Staten') formulates a by-law to protect the environment, including conditions about groundwater protection and noise pollution prevention. The Provincial Council also establishes the environmental policy plan ('Milieubeleidsplan') every four years. This plan includes guidelines about environmental protection that municipalities can include in their

yearly environmental programme ('milieuprogramma'). In its environmental programme, the municipality should mention how it will protect the environment. If the planned proceedings to build a tower might damage the environment, the building commissioner has to make sure an Environmental Impact Assessment ('milieueffectrapportage') is made in advance. This Environmental Impact assessment includes a description of the proceedings and alternatives for the building of the tower.

A new law, Nature law ('Wet natuur') may be appointed in 2012. This law aims to combine the Forest law ('Boswet') (1961), the Nature conservation law (1998) and the Flora and fauna law (1998). This combination is needed in order to make the legislation less complex. In the draft version of this law, there are less protected species than in the previous legislation, so building a tower may become easier, as less species will be taken into account. Furthermore it will be easier to get building permits (Rijksoverheid, 2011).

### **Building a tower**

To build a tower, the building plan should fit in the municipality's zoning, which is renewed at least every 10 years (Wet ruimtelijke ordening, 2006). This plan also has to fit in the land use plan made by the municipality, Provincial Council, or the minister of infrastructure and environment (Planning act, 2006). Because of the zoning, it may be prohibited to change the use of a building or ground or to destroy buildings without an environmental license. Deviating from the zoning without a permit can lead to prosecution. Municipalities can change the plan before the 10 years have passed, so a builder could ask the municipality to make the plan suitable for building the tower. Besides that, the afore mentioned minister and Provincial Council can make an integration plan ('inpassingsplan') that can overrule the authority of the municipalities. Subsidies are provided to projects that meet the new functions of an area, so if nature development or nature conservation is a new function in a certain area, it may be possible to receive some subsidies for building, for example, a bat tower.

If it is necessary to make fundamentals for the tower, the soil Protection Act ('Wet bodembescherming') of 1987 becomes important. To protect the soil, ground and foundation works are restricted. One has to take measures to protect the soil from being polluted. If the soil is being polluted or infracted by one's proceedings and the polluted volume is bigger than 1000m<sup>3</sup>, it should be reported to the Provincial Executive ('Gedeputeerde Staten'). All conditions a building should meet are mentioned in the Buildings Decree ('Bouwbesluit') of 2003. This is a quite complex decree which will change soon. The new one will probably be published at the start of 2012, so we recommend to have a look on the new decisions by then.

Besides the previously mentioned laws, it is important to take the Working Conditions Decree ('Arbeidsomstandighedenbesluit') (1997) into account when building a tower, since people have to work in the tower for cleaning. This decree mentions some requirements a building should fulfil, like the height of doors to make sure it is possible to work in the building in good conditions.

## **2.2 Landscape**

The landscape in which this project is set, the landscape of Zuid-Beveland (Figure 1) with the municipality of Borsele in specific, is characterized by several elements: polders, dikes and water bodies like creeks ('kreken') and pools ('wielen') (Overbeek *et al.*, 2008), see Figure 2. All these elements remind the observer of the on-going war between land and sea. Water is omnipresent

in the landscape of Zeeland. In Zuid-Beveland, the polders are mostly small (a few tens of hectares) and made up of narrow parcels of land as a result of the land allotment ('oudlandverkaveling') (Bureau Lantschap, 2009; Bosch and Slabbers, 1995). The dikes can be divided into two groups: the big sea dikes that still have the function of stopping the sea from entering the land, and the small polder dikes (Bureau Lantschap, 2009). Almost all dikes in the municipality of Borsele are surrounded by trees or other vegetation (Bosch and Slabbers, 1995); some of them are the so-called flower dikes ('bloemdijken') which are characteristic for Borsele and are often grazed by the herds of sheep from Zeeland (Overbeek *et al.*, 2008).



**Figure 1. Region of study: Zuid-Beveland.** (Source: JouvZeeland)



**Figure 2. Typical landscape of Zuid-Beveland with dikes, creeks and hedgerows afar** (Picture: Mieras, 2010)

The landscape in Zeeland is strongly linked to the history of the region; every dike and polder has a rich history of fighting against the sea and providing enough usable ground for food production after times of hunger. Associations like the Zeeland Landscape Foundation ('Stichting het Zeeuwse Landschap') work on keeping the cultural elements of the landscape alive by using local volunteers to take care of nature in a certain region (André Hannewijk, pers. comm.). As stated in the Landscape policy ('Landschapsbeleidsplan') for Borsele (Bosch and Slabbers, 1995), the area of Zuid-Beveland is a special cultural landscape: one can read the history of the region in its landscape and it is thus important to approach the management of this landscape with a historical and cultural point of view. Besides the cultural and historical value, Zuid-Beveland is an area on which Zeeland and its inhabitants are very keen (NCRV, 2007) and so any changes brought to this area should be researched with the greatest care first.

In the municipality of Borsele, 84% of the land is used for agricultural purposes and only 3% is used for nature and recreation (Overbeek *et al.*, 2008). The touristic activities mentioned by the inhabitants of Zeeland are walking, biking and resting (NCRV, 2007). It is thus clear that the main attraction in Zeeland is the region itself and the nature it has to offer; any changes in the landscape should use this information in order to create more nature and touristic opportunities where possible.

The quality of a landscape can be divided into three categories referred to as "the 3 E's" (Bosch and Slabbers, 1995). These categories are the Esthetical quality, the Ecological quality and the Economical quality. The Esthetical quality criterion states that observers have to be able to experience the history of the landscape and gain a sense of beauty when looking at the landscape. The Ecological quality criterion states that the ecological possibilities of the landscape should be fully used and that ecosystems should get the opportunity to develop in a sustainable way. Lastly, the economical criterion states that the landscape should provide the

economical basis for different types of ground use like recreation, agriculture, etc. These different functions should get enough space to develop.

Creating artificial habitats for local fauna in Zeeland fits the quality requirements as stated by the Landscape policy ('Landschapsbeleidsplan') by Bosch and Slabbers (1995). The habitats should fit in the landscape or have an aesthetic value of their own (Jan Heersche, pers. comm.) and play a role in the economy of Zeeland by creating more nature and secondarily attracting tourists to visit it.

These artificial habitats aim to fulfil the ecological quality of the landscape.. When working on this project, one should take into account the history and culture linked to the landscape of Zeeland and in particular of Zuid-Beveland; throughout our whole research, we have tried to meet that criterion and have asked experts in different domains to assist us toward that aim

## 2.3 Education

Traas showed interest in giving the bat tower or fauna housing an educational character. Their main reason for that is to show children that nature conservation is not straightforward. Strife (2010) found that in general one of the main reasons for environmental education is to motivate human engagement and action to contribute to possible solutions.

We think that there are definitely possibilities to give the bat tower or fauna housing an educational character. Besides, it has been proven that environmental education can be an asset to the classroom and to children's development. It has been shown that children educated in environmental studies tend to get higher grades in subjects such as mathematics, reading or writing. Environmental education has been shown to increase cooperative learning and civic responsibility. Nature and environmental experiences can increase a child's language and communication skills, and this can lead to better social skills (Strife, 2010). So according to Strife (2010), education about bat towers or fauna housing might have more gains than only raising awareness about nature conservation.

Another approach that empowers people and makes them feel like they are part of the solution seems to be taking over. The "green movement" reaches out to people and offers a way for everyone to be involved in the problem solving process (Strife, 2010). This is in line with the teaching strategy that involves first a preliminary approach to the subject at hand; and second building / creating. People are much more likely to remember and accept given information when they are involved in a project related to said subject (Björn van Loon, pers. comm.). Applied to the fauna housing this will mean that first the topic of fauna housing can be introduced, possibly combined with information about nature conservation in general. When children are actively involved in the subject, for example by crafting, it will be more likely that the subject will be remembered by the children.

Also applicable to adults, it is important to bring the message on a positive way and stimulate involvement. In contrast, acquisition of environmental facts and data or the negative messages filled with fear and guilt, might actually lead to environmental apathy (Strife, 2010). Emotional affinity towards nature is likely to result in nature-protective behaviours more than a rational-cognitive approach. Other important predictors of nature-protective behaviours are indignation and interest for nature (Kals *et al.*, 1999). Artificial habitats can be an important way to put humans in the centre of nature conservation to increase the sense of collaboration and involvement. It is also a precious chance to teach the population about sustainability and animal habitats.

Education has already proved successful in protecting bat species in the Netherlands, where bats are easily associated with the rabies virus, and educational campaigns decreased the number of disturbed roosting sites (Hutston *et al.* 2001).

## 2.4 Potential clients

The “green movement”, the idea that we must change our everyday attitudes to decrease our ecological footprint, is gaining momentum. Companies, government agencies and private persons are increasingly demanding green products in the hopes of becoming more sustainable (Strife, 2010). Sustainable green products can therefore be interesting for companies and governments who want a “greener” look, and for the average private person, who wants to contribute to a more sustainable way of living.

Interconnecting fragmented communities is a matter of public interest. Smaller products developed for the private person (such as bird or bat boxes), or larger products that could interest governmental agencies or companies (such as bat towers, bird walls or artificial trees), have the potential to open a new market for sustainable fauna integration.

In addition to this, recent studies have shown the impact of insectivorous bat species on agriculture and pest control (Boyles *et al.*, 2011; Flaquer *et al.*, 2011). Increasing the number of said bats in agricultural lands can be very interesting for farmers, as pesticide use could decrease, which in turn may lead to a lower expense in pest control and the possibility to sell eco-products. Besides, bird boxes providing habitat in fruit orchards might lead to an increase in insect eating birds. Mols and Visser (2002) showed that blue tits in orchards reduced caterpillar damage in apples. Therefore artificial fauna habitats, like bat towers and fauna housing might be interesting for farmers and owners of orchards as well.



# PART I: BAT TOWER



*Myotis dasycneme*, picture made by Biopix: JC Schou



## 3 Background

### 3.1 Decline of bat species

All bat species that occur in the Netherlands are protected by law. Several species are very common and are listed by the IUCN as "least concern" (e.g. the Daubenton's Myotis; *Myotis daubentonii*), others are threatened or already considered extinct in the Netherlands (e.g. the *Rhinolophus* species; IUCN 2011).

Several reasons exist for the decline of bat species. In some countries bat numbers have declined dramatically, although it is often difficult to ascribe the exact causes for the decline. Known reasons for the decline or even extinction of bats in Europe are directly related to the increasing human population and their influence on land use, and/or the destruction or disturbance of habitat and roost sites, such as the removal of linear elements (e.g., trees and hedgerows) (Hutson *et al.*, 2001). Besides, changes in agriculture in the past centuries and the intensification of agriculture, including the use of pesticides, artificial fertilizers and monoculture crops, have had detrimental effects on various bat species (Hutson *et al.*, 2001). Mentioned reasons will be discussed in the next sections.

#### **Disturbance of habitats and roost sites**

One example in which the cause is clear, is the decline of *Rhinolophus* species in Europe, which are currently extinct in the Netherlands (IUCN 2011). *R. ferrumequinum* (greater horseshoe bat) declined over 90% in the past 100 years (Stebbings, 1988) and the lesser horseshoe bat (*R. hipposideros*) is thought to be extinct in the Netherlands, as it has not been seen since 1983 (Stebbings, 1988; Hutson *et al.*, 2001; IUCN 2011). The main cause why it is threatened or extinct in at least parts of its range, is the disturbance of caves, as these species rely on undisturbed caves for winter hibernation (Hutson *et al.*, 2001).

#### **Landscape changes**

The destruction of forests, including old hollow trees on which several bat species are reliant, has caused an important decline in bat population (Ciechanowski, 2005). Next to that, changes in more open landscapes in which several elements are important to bats were detrimental for bats. Research carried out in the Netherlands showed that linear elements, such as hedgerows and straight canals, are used by the Daubenton's bat (*Myotis daubentonii*). When such elements are absent, bats lose a network which is key to both, moving from one place to another, and hunting for insects and other prey (Hutson *et al.*, 2001).

#### **Chemicals**

Pesticides could negatively affect bats, both because insecticides decrease food availability and through accumulation of chemicals in the food chain, even when the pesticides are not used anymore for years. Since 1989 the use of the pesticides pentachlorophenol and Lindane is forbidden (Stebbings;1988; Mitchell-Jones *et al.*, 1989). Several other chemicals, such as organochlorides (DDT and DDT-like pesticides) were found in lethal concentrations in the southern bent-wing bat (*Miniopterus schreibersh bassanii*) in Australia (Allinson *et al.*, 2006; Mispagel *et al.*, 2004). The insecticide chlordane, which was already forbidden in 1970, still accumulates through the food chain and might also affect bats (Stansley *et al.*, 2001). Although most of these chemicals are not being used for 30 years or more in Europe, now forbidden pesticides (such as DDT) may still have an implication on bat populations in USA. Similarly, in

the Netherlands it was shown that pesticide residues may have affected the decline in pond bats (*Myotis dasycneme*; Hutson *et al.*, 2001).

Next to pesticide use in agriculture, bats might also be sensitive to several chemicals that are used for example to treat wood against insects or rot (IUCN, 2011). As bats often roost in close contact to timber in houses, they might also come in contact with pesticides that are used to treat the wood against rot or wood-boring insects. The pipistrelle bat (*Pipistrellus pipistrellus*) was found to be very sensitive to the chemical Dieldrin, which is taken up in the body of the bats (Shore *et al.*, 1999). It was suggested that several less-toxic or organic compounds, such as pyrethroid insecticides should be used, as they are supposed to be less toxic (Stebbing, 1988; Mitchell-Jones *et al.*, 1989).

### **Water quality**

In the west of Flanders, Belgium, many water ways occur which form a potential habitat for the pond bat (*Myotis dasycneme*), but many of those water ways are (more or less) polluted (Van de Sijpe *et al.*, 2004). The main food of the Pond bat are non-biting midges, Chironomidae. This midge occurs both in polluted and non-polluted water, but still the Pond bat showed a higher hunting activity above less polluted water bodies than over heavily polluted ones. In contrast, the Daubenton's bat (*Myotis daubentonii*) was found hunting over both less and heavily polluted water bodies (Van de Sijpe *et al.*, 2004). This shows that, although some bat species might be affected by water quality, this does not necessarily apply for other species. Another theory is that the pollution or eutrophication is actually beneficial for Daubenton's bat, because it increased the number of Chironomidae, their main food source (Hutson *et al.*, 2001). However, Hutson *et al.* (2001) stress that in general water pollution is detrimental to bats.

From these mentioned reasons for bat decline, the development of a bat tower will focus on partly compensating the decline of roosting habitats and disturbance by humans. On this way, bat towers can contribute to bat conservation. However, one should keep in mind that this will not be a comprehensive way of bat conservation, since no improvements will be made on other negative effects like destruction of foraging habitats, chemical use and water quality.

## **3.2 Target species**

In the Netherlands, 21 bat species occur (or occurred; IUCN, 2011). However, not all of them are suitable to inhabit an artificial roosting area or winter hibernacula. To properly design a bat tower, we decided to choose target bat species through the use of specific criteria. The final design of the bat tower will be based on these target species (Chapter 4). The area used for the criteria is Zeeland, with special focus on Zuid-Beveland and the municipality of Borsele, as this is the most likely place where the (pilot version of the) bat tower will be placed.

The criteria to determine target bat species were:

Based on different types of roosting preferences. The bats that occur in the Netherlands, either prefer roosting in hollows, such as hollow trees; crevices, such as cracks in rocks but also narrow spaces in buildings; or they prefer larger open spaces, such as caves or attics of buildings. Hollow-roosting bats prefer woods with old trees or rocks, whereas attic-roosting bats prefer larger open spaces and wooden buildings. The latter often roosts in small number per surface area, possible a bat tower could then hold at most ten bats. In contrast, crevice-roosting bats can

roost with much larger numbers together in a smaller area, up to 100-150 in the bat tower. When implementing a bat tower for pest control purposes, it is much more effective to aim for the latter group. (Erik Korsten, pers. comm.).

The bat species should be able to use the Zeeland landscape. E.g. When they need specifically old hollow trees or swamps, they are not suitable, because such landscape elements are not present in Zeeland.

The species should not be too common. Selecting design criteria for bats with very general habitat requirements is difficult, as opportunistic and common species might use the tower anyway.

The bat species should also not be too rare: it is not worth focussing on species that are very rare in the area of Zeeland (or the whole of the Netherlands) or are only migrating species that will visit the area only for a short time. The investment in the design will not compensate the chances that it will actually be used by the specific species.

The target bat species should be able to live together; both in the bat tower itself, as in the surrounding landscape which provides food and other resources. For example, pond bats and Daubenton's bats hunt both above water for species of Chironomidae (non-biting midges), so there could be resource and habitat competition between the two bat species. They have been shown to hunt in the same area (Van de Sijpe *et al.*, 2004), although not in similar numbers. In contrast, the Nathusius' pipistrelle (*Pipistrellus nathusii*) is relatively tolerant to other bat species regarding roosting sites. It was found to share colonies with the pond myotis (Mickeyeviene *et al.* 1999). They are therefore suitable to be included as target species for the bat tower design.

It should be possible to copy the natural roosting or hibernation habitat in a bat tower. The Daubenton's bat, for example, is not included in the target species list, because it needs very moist roosting conditions (e.g. under bridges), and is therefore less suitable to live in a tower-like design alongside other bat species (Erik Korsten, pers. comm.).

Two bat species in particular fit the criteria as mentioned above (Table 1), based on Jansen and Schaminée (2008), and Bekker *et al.* (2010): the pond myotis (*Myotis dasycneme*) and the Nathusius' pipistrelle (*Pipistrellus nathusii*). The design criteria for the bat tower will be based on the habitat requirements of these specific species.

**Table 1. Target bat species.** Bat species that fit the criteria as mentioned in the text; they will be used as starting point for the tower inner design. IUCN status (worldwide) shown between brackets; LC = Least Concern; NT = Near Threatened (IUCN, 2011).

Scientific name	English name	Dutch name	Specifics
<i>Myotis dasycneme</i>	Pond bat or pond myotis	Meervleermuis	Hunts over larger water bodies and uses linear landscape elements; eats mainly (water) insects (e.g. mosquitoes, flies, moths); roosts in crevices of buildings (NT)
<i>Pipistrellus nathusii</i>	Nathusius' pipistrelle	Ruige dwergvleermuis	Hunts in half-open landscape, mainly Empididae ('dansvliegen'), roosts in crevices of buildings (LC)

In addition to the selected bat species, the following bat species (Table 2) might use the bat tower as well, but no special design criteria are aimed for these species. This is mainly because these species are very common in the region (Janssen and Schaminée, 2008) and it is likely that they will use a bat tower that is designed for other bat species anyway.

**Table 2 Common bat species.** These bat species might use the tower as well; most are very common in the area and are therefore not used to base the design criteria on. IUCN status (worldwide) shown between brackets; LC = Least Concern; NT = Near Threatened (IUCN, 2011).

Scientific name	English name	Dutch name	Specifics
<i>Myotis daubentonii</i>	Daubenton's bat or Daubenton's myotis	Watervleermuis	Hunts above smaller water bodies; needs very moist hibernacula, mostly in hollows (e.g. old trees) (LC)
<i>Eptesicus serotinus</i>	Serotine bat	Laatvlieger	Very common in the area and the rest of the Netherlands; eats larger insect species; roosts in crevices (LC)
<i>Pipistrellus pipistrellus</i>	Common pipistrelle	Gewone dwergvleermuis	Very common in the area and the rest of the Netherlands; eats small insect species; relatively opportunistic in roost sites (including crevices of buildings) (LC)
<i>Plecotus auritus</i>	Brown big-eared bat	Gewone grootoorvleermuis	Very common in the area and the rest of the Netherlands, hunts in various landscapes and various insects and are opportunistic towards roosting sites (LC)

The following species (Table 3) will probably not make use of a bat tower, mostly because they are (too) rare in either the Netherlands or more specifically the province of Zeeland (Janssen and Schaminée, 2008; IUCN, 2011). In other cases, the bats have special requirements that are difficult to meet in a tower-like design, or the bats are only migratory in the Netherlands (Janssen and Schaminée, 2008), and therefore an artificial roosting or hibernation place is unlikely to be profitable for the specific species.

**Table 3 Rare bat species.** These bat species are unlikely to use a bat tower, as they are rare (in the province of Zeeland) or have very specific roosting requirements. IUCN status (worldwide) shown between brackets; LC = Least Concern; NT = Near Threatened (IUCN, 2011).

Scientific name	English name	Dutch name	Specifics
<i>Plecotus austriacus</i>	Gray big-eared bat	Grijze grotoorvleermuis	Very rare in the area; mainly roosts in high (church) attics (LC)
<i>Myotis mystacinus</i>	Whiskered myotis	Gewone baardvleermuis	Rare in the area and needs wooded areas that are not present in Zeeland; eats mosquitoes (so possible interesting for pest control) (LC)
<i>Myotis nattereri</i>	Natterer's bat	Franjestaart	Rare in Zeeland; uses woodland that is not present in the area (LC)
<i>Nyctalus noctula</i>	Noctule bat	Rosse vleermuis	Quite rare in Zeeland, roosts in old hollow trees that are not present in the area (LC)
<i>Eptesicus nilssonii</i>	Northern bat	Noordse vleermuis	Very rare in the Netherlands; roosts in tree holes and crevices (LC)
<i>Vespertilio murinus</i>	Particoloured bat	Tweekleurige vleermuis	Very rare in Zeeland, mostly migratory bat along the coast (LC)
<i>Myotis brandtii</i>	Brandt's bat	Brandts vleermuis	Very rare, does not occur in Zeeland; roosts in attics and building crevices (LC)
<i>Myotis emarginatus</i>	Geoffroy's bat	Ingekorven vleermuis	Very rare, does not occur in Zeeland; roosts in attics and caves in Limburg (LC)
<i>Myotis myotis</i>	Greater mouse-eared bat	Vale vleermuis	Very rare, does not occur in Zeeland. Roosts in large open attics or caves (LC)
<i>Nyctalus leisleri</i>	Lesser noctule or Leisler's bat	Bosvleermuis	Very rare, does not occur in Zeeland; hunt for small to medium sized insects (LC)
<i>Barbastella barbastellus</i>	Western barbastelle	Mopsvleermuis	Very rare in the Netherlands and in Zeeland (NT)
<i>Myotis bechsteinii</i>	Bechstein's myotis	Bechsteins vleermuis	Rare in the Netherlands, not in Zeeland (mostly Limburg and Eastern Netherlands); needs mature forest (NT)
<i>Rhinolophus ferrumequinum</i>	Greater horseshoe bat	Grote hoefijzerneus	Now extinct in the Netherlands (LC)
<i>Rhinolophus hipposideros</i>	Lesser horseshoe bat	Kleine hoefijzerneus	Not seen in the Netherlands since 1983, is considered extinct (LC)

### 3.3 Legislation

Nationwide bat species are protected by law, although the exact regulations differ per country. The “Bern convention” of 1982 regulates conservation of European Wildlife, and the “Bonn convention” law of 1979 states that migratory species must be protected (Stebbing, 1988; Hutson *et al.*, 2001). In the first, all bats occurring in the Netherlands (all microchiropteran bats), except for *Pipistrellus pipistrellus*, are included in the list of “strictly protected animals”. *P. pipistrellus* was placed “protected species” (Stebbing, 1988). Under the Bern convention, the “Agreement of Conservation of Bats in Europe” especially aims for the protection of bats by agreements on monitoring and habitat management (Stebbing, 1988).

Nationwide, three Dutch laws apply to bats, the Flora and Fauna law (‘Flora- en faunawet, 1998’), the Nature protection law (‘Natuurbeschermingswet’, 1998) and the Forest law (‘Boswet’, 1961) (the latter is not applicable within urban areas; Zoogdierverseniging, 2009A ?). These laws need to be taken into account when building, and especially when monitoring bats. As soon as bats roost in a building, the building itself is also protected by the Flora and Fauna law, and roosting bats cannot be disturbed (unless a permit is given, for example for monitoring purposes). In chapter 2.1 relevant legislation is discussed in more detail.

### 3.4 Existing bat towers or (artificial) roost places

In 1929 a first large bat tower was constructed by C. Perky (and thus called Perky’s bat house or Perky’s bat tower) in Sugarloaf Key, Florida, US (Figure 3a). His intention was to control the mosquitoes in the area and consequently introduced bats (*Molossus molossus tropidorhynchus*) collected from Cuba. However, the bat tower never worked; the introduced bats flew away and apparently never re-used the tower (Frank, 1997). The reasons for this are not clear, it is possible the bat house was not well-designed and lacked crevices (Erik Korsten, pers. comm.).

Basing a design on Perky’s bat tower in the Netherlands is not preferable, as most common bat species in the Netherlands are more crevice-like species who prefer stone roosts over wooden roosts.

After this initial attempt, several other bat towers or artificial bat roosting sites were designed, with mixed success. Some had the purpose of creating awareness on bat decline and were more artistically designed, while others had the main purpose of housing large bat colonies to enhance local bat population. An example of the latter is the Bat Condo (Figure 3b), practically a small wooden house on poles, with wooden panels inside for the bats to roost in (Bat Conservation and Management, Inc., 2011). These Bat Condos are said to be able to house thousands of bats, but it is unknown whether any research has confirmed the use of the Bat Condos by bats. However, this design is unlikely to work in the Netherlands, as bats preferably roost near stone, and these condos are designed for wood roosting species (Erik Korsten, pers. comm.).

Several constructions for artificial bat roosts exist in the Netherlands. For example, old World-War II bunkers are often used by bats, and in the Hoekschevaard a bat tower was added to one of these bunkers (HSWL-bunker Strijen in the Mariapolder, the Netherlands) to provide a winter hibernaculum (Figure 3c), especially for the brown big-eared bat (*Plectoris auritus*; Geerts and Meerburg, 2010).



**Figure 1. Other bat tower designs.** From left to right: a) Perkey's Bat Tower, located at Sugarloaf Key, Florida, US, originally designed by C. Perkey (Photo taken by Marc Averette); b) Bat condo, outside view; bat condo and inside view with wooden panels (Pictures from: John Chengler; Bat Conservation and Management, Inc.); c) "Towerbunker" in the Mariapolder, the Netherlands, to provide winter roosts for bats (Picture: Rob Geerts, taken from: Geerts and Meerburg, 2010)

As an exceptional measure, it was decided in fall 2009 to build a bat tower as a compensatory measure for the demolishing of old military buildings in which bats roosted (Erik Korsten, pers. comm.; Zoogdierverseniging, 2009A; Dienst Landelijk Gebied, 2011). This old military terrain in the South of the Netherlands housed several bat species. Because no other alternatives were present to protect and house the bats, the artificial bat tower was build nearby, and planned to be monitored for at least 5 years. The final results of this monitoring project are not yet available, and no guarantee was given that the bat tower would fully compensate the demolition of the buildings. (On the contrary, preliminary results suggest that the bats may have been disturbed by the demolition before the bat tower was completed.)

### 3.5 Pest control and compensation measures

Boyles *et al.* (2011) have attempted to estimate the value of insectivorous bats for agriculture in the US. The bat disease White Nose Syndrome (WNS) affects cave-dwelling bats in Northern America, and is causing important declines in bat population. These declines are increasing awareness of the ecological and economic impact bats have on agriculture. It was estimated that bats contribute to US agriculture, mainly as insect pest controllers, for an amount between 3.7 and 53 billion US dollar per year. This estimate includes the decreased insecticide-use, but not other impacts that pesticide use might have on ecosystems. This amount shows the value bats may have as pest controllers (Boyles *et al.*, 2011).

In a Spanish study, it was shown that a local population of pygmy bats (*Pipistrellus pygmaeus*) were successful in controlling the pest insect *Chilo suppressalis* in rice plantations. Proper roosts were a limiting factor for the bat, and by providing artificial roosts, the bat population was enhanced and could control the crop pest to such an extent that the use of pesticides could be minimized or even completely stopped (Flaquer *et al.*, 2011).

Researches as mentioned above show the (potential) value of bats in the use of natural pest control.

In the Netherlands the contribution of bats and birds to "Functional AgroBiodiversity" was assessed in the Hoekschevaard (just North of Zeeland; Geerts and Meerburg, 2010). The bats

present in the area (mainly *Pipistrellus pipistrellus* and *Pipistrellus nathusii*) have a large contribution to the control of insects in the area, although the exact numbers are not known. To maintain and enhance this value, it is advised to provide both the specific habitat requirements and suitable roosting places (Geerts and Meerburg, 2010).

However, using bat towers as compensation measures for, as an example, the demolition of a part of nature (e.g. when building a road) or the demolition of a building where bats are known to roost, is not realistic. Compensation often exist of a set of different measures, that focus on the replacement of all elements that are destroyed or made inaccessible (Erik Kosten, pers. comm.). A bat tower only (potentially) provides roosting space for a limited number of bats and bat species. A bat tower does not take food sources and other landscape elements into account. Only in the (rare) case when only a building containing bat roosting spaces is demolished but all surrounding landscape remains intact or is enhanced, a bat tower might be a possible solution. And even in this case, the tower needs to be properly designed, placed near the former building and the use by bats should be very likely.

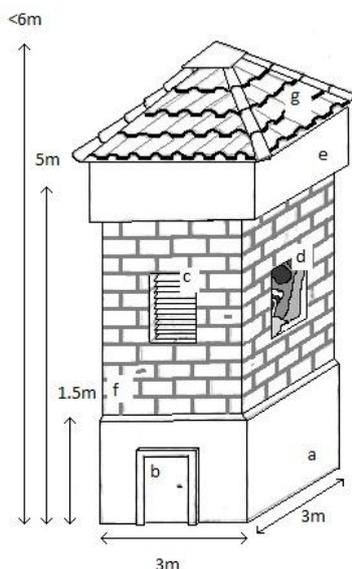
## 4 Design of the bat tower

Bats have different requirements for summer and winter. During the summer, bats are active. They hunt, reproduce, and mothers form colonies during pregnancy and lactation periods. All summer long, bats accumulate reserves for winter hibernation. For the purpose of pest control, summer habitat should better be provided, as it is in the summer that bats hunt insects, and it is in the summer, that insects may become a nuisance to humans. To increase the number of bats in the Netherlands, hibernation grounds should be improved, protected and provided if none is present. Some bats will hibernate in the same area in which they roost. Hence we provide two different guidelines. One for a female summer roost (that may be used by some species as hibernaculum, section 4.1) and another for a hibernaculum (section 4.2). These two buildings can be combined at one location, but it is not necessary that they stand close to each other or be provided at the same time.

As this project has never before been successfully undertaken, we would like to highlight the importance of carrying out a pilot study first and commercializing the product only when it has been proved that the tower can sustain a healthy bat population. Monitoring of the pilot tower every summer for a period of 5 to 10 years is vital for achieving a sustainable bat tower concept. Every tower should be placed in areas surrounded by hedges and with linear landscape connections to feeding areas as well as to already existing roosts. The tower might not be occupied in the first years, as it may take a while for the animals to find the tower for the whole colony to move, but this does not mean that the tower is not suitable for bats.

### 4.1 Tower

The recommendations for this design are based, amongst others, on roosting requirements for the target species, on guidelines on the use of bat boxes and bat bricks formulated by several conservation groups (such as the Norfolk Bat Group), on the interviewed bat expert, Erik Korsten and on previous bat tower and bat house designs. Projects such as Perky's bat house have given insight on the importance of choosing the right location, species, and the understanding of the specific needs of said species (Frank, 1997). Other design ideas come from the bat tower designed by Hwang (2010) which now houses bats in New York; the publication of Baranauskas (2009) on choice of bat boxes by mothers of *Nathusius' pipistrelle* when offered different bat box designs;



**Figure 4. Example of tower.** Where: a) Metallic / smooth material sheet surrounding tower to avoid predation; b) Inspection hatch; c) Wooden shutters with a windowsill; d) Alternative to shutters; e) Panel hiding 2 entrance holes; f) Shallow brick; and g) Partly raised roof tile. Drawing not up to scale.

#### Outside design

Bats roost at variable heights, and there is no specific upper limit to the height of a roost entrance (Erik Korsten, pers. comm.). The height of the entrance is often dependent on the height of the surrounding landscape features (Boonman, 1999). However, due to building restrictions and licences that affect tall buildings, it is suggested to maintain the height of the tower under 6 m (Bouwbesluit, 2003).

All entrances to living spaces should be placed above 3.5 m. Although entrances to maternity roosts can be found at lower levels in nature (Boonman, 1999), this height should prevent vandalism and other types of human disturbance.

To avoid having to adjust the tower to proper living conditions as mentioned in the Working decision (Arbeidsomstandighedenbesluit, 1997), we recommend that the entrance to the tower should not be a door but an inspection hatch of smaller dimensions than a door but that still allows for a human to enter the tower when needed.

The tower should be built with rough material that allows grip for the bats. Ceramic bricks are best at maintaining warmth and should be favoured for the external and internal walls. Cement blocks are worse at maintaining heat. They can overheat during the day and get too cold at night, so they should not be used in direct contact with the outside.

Small bats are susceptible to predation by for example rats. We suggest to make the lower part of the tower very smooth, for example by attaching metallic sheets, to prevent the latter from climbing the tower (Figure 4).

Although Figure 4 provides an example of the outside design of a tower, it is important to state that this design is just a mere example. The tower could take many shapes, as long as the crucial elements that are described in this chapter are included. The outside of the tower could take a round shape, or a cubic form, or the bricks could be covered by rough lime. Also the building does not necessarily need to fit the 'tower' idea (although height requirements should be taken into account). For example, local artist can be instructed about the obligated elements and subsequently get the freedom to develop a creative design (Jan Heersche, pers. comm.).

### **Outside elements**

There are certain elements that, if incorporated into the outside of any building, will provide a suitable living and resting space for solitary bats that, although not the main target of the tower, can benefit. Some of these might be wooden shutters, shallow bricks or partly raised roof tiles. They are additional measures and options to add to the tower.

#### *Wooden shutters*

The shutters should be placed in the wall, so that they are protected from wind and rain. They could be placed facing any direction, although direct exposure to wind should be avoided to facilitate landing and take-off. A windowsill should be provided to allow space for landing (Figure 4).

There should be a small space between the shutters and the wall (around 3 cm) to allow for bats to use the shutters as a night refuge. The shutters should prevent sun from hitting the wall during the day. The distance between the wooden bars constituting the shutters should not exceed 2 cm. The size of shutters can be varied.

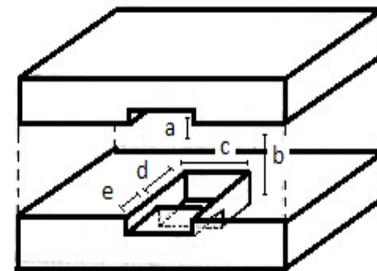
An alternative to the shutters can be seen in the Berkeley Bat House, which has incorporated a creative design with layers of different thicknesses and separation, providing numerous hiding spots, and an entrance to an indoor wall suitable for roosting (Figure 5).



**Figure 5. Bekerley Bat House.** Designed by Jorgen Tandberg and Yo Murata (source: Treehugger).

### *Hollow bricks*

To make the tower suitable for solitary males, we propose to introduce hollow bricks. These bricks should emulate crevices in the wall. This way we propose an entrance of 2 cm tall, 5-10 cm wide. The bat can then crawl to a space within the brick of the same width, but around 3.5 cm tall (Figure 6). The whole tower should not have more than 5 or 6 of these bricks, as not many solitary males share the same territory. Other alternatives to this brick already exist in the market (e.g. IBSTOCK, Norfolk brick).



**Figure 6. Overview of a hollow brick.** Appropriate measures are: a) 2cm; b) 3.5cm; c) 5cm; d) 3cm; and e) 2cm

Be aware that these bricks can disrupt the structural stability of the tower, so a building expert should be consulted.

### *Partly raised roof tiles*

Solitary bats use roof tiles as cover. When possible, a couple of roof tiles can be slightly separated from the ceiling, to allow for bats to crawl into the space. A dark, ceramic roof is preferred, as it will keep warmth better.

### **Inside Design**

We propose to build a double brick wall (ceramic bricks with a rough exterior on both sides to allow for grip). The outside wall will be separated from the inner wall by a wooden panel (around 2 cm thick). The distance between the outer wall and the inner wall should be less than 4 cm as wasps might be attracted to this space, but leaving enough space for the bats not to touch the outside wall that could become too cold or too hot. The distance should be 3.5 cm. The wooden panel will be separated from the inner wall by 3 cm. This way we offer the bats two different spaces that differ in temperature, so they can change spaces at different times of the day (figure 7).

The wooden panel separating the two walls should be of a rough material and be provided with slits or a plastic mesh thicker than a mosquito net (Erik Korsten, pers. comm.) glued to the wooden panel to add more grip. Non-toxic wood preservatives can be applied, but should be applied before bats are present (Reiter and Zahn, 2006).

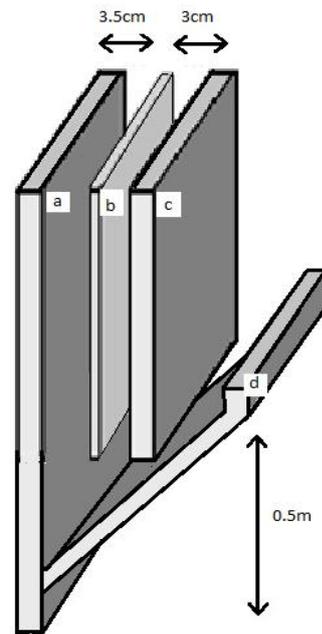
The roof should also be double. Although not all selected species roost in roof spaces, it is important to provide multiple microclimates to suit the bats' temperature and humidity needs. Some roosts of serotine bats have been known to fluctuate from 17°C to 35°C, but the average temperature should stay between 20°C to 25°C (Reiter and Zahn, 2006).

All roosting spaces should be accessible to all bats. This is why we propose two entrances to the inside of the tower that will lead to a common space from which all other spaces can be accessed (Figure 8).

It is important to include temperature and relative humidity data loggers around the roosting spaces to assess the effectiveness of the tower. This could be useful for future design changes if needed. Inspection hatches should be available inside the tower. They should be placed outside of the reach of people as to avoid vandalism or theft. Inspection crew should provide their own ladder.

To avoid predation from rodents such as the black rat (*Rattus rattus*) we suggest to install a metallic sheet (Figure 7) similar to that one described for the outside of the tower. The inside of the metallic panel should be covered with a plastic or mosquito net, or be provided with hooks to allow for bats to climb out of it. The part of the metallic sheet facing the inside of the tower should be smooth to prevent possible predators from accessing the roost.

The tower should be cleaned once a year to extract bat droppings. Bat guano is a very effective fertilizer. To facilitate cleaning, we propose to cover the floor with a biodegradable plastic sheet that is easy to remove and replace.



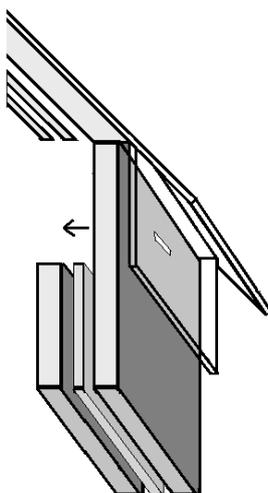
**Figure 7. Wall structure.** Where: a) Outer brick wall; b) Wooden panel; c) Inner brick wall; and d) Metallic sheet underneath wall to prevent predation with a rough side (facing the wall) and a smooth side facing the inside of the construction.

### Entrances

There should be two entrances placed between 4 and 5.5 m from the ground. The entrance holes should be no more than 2 cm tall and 5 – 10 cm wide. The entrances should be placed avoiding the direction of the wind. The entrance hole should be covered by a rough panel, separated from the outer wall by no more than 2 cm. Wider separation may lead to birds nesting in the entrance and this may drive bats away. Bats like to crawl into their entrance instead of directly flying into it (Figure 8).

### Educational character

Bats are often regarded as a nuisance, not only because of their relation to the rabies virus but also due to everyday concerns such as smell, noise or accumulation of droppings. Education has proven to be quite effective in the Netherlands, where after education campaigns, bat roosts, even those infected by rabies virus, have been left to rest (Hutson *et al.*, 2001).



**Figure 8. Entrance.** Note the double roof and double walls. The entrance hall is protected by a thin panel.

It is important that children be educated in importance of bats and other animals in ecosystem functioning and balance. We propose excursions to the tower to learn more about the habitat requirements of these animals. These excursions should be coupled with a workshop, given earlier on the week of the excursion as to introduce the children to the theme and create enthusiasm about it (Björn van Loon, pers. comm.). These workshops could be done in school (in which case the local schools would have to be contacted to propose this excursion and workshop) or Traas could organize these workshops on a weekend, as an activity for parents and children. In the case of Traas giving the workshop, further insight into the teaching and children care taking requirements should be made (such as proper licenses number of kids allowed per supervising adult, etc.). The advantage of Traas carrying out these workshops is that it may increase the popularity of the company and the bat tower as a product (Björn van Loon, pers. comm.).

The workshops should have a very short theoretical introduction, made fun and light by images, sounds and interesting facts about bats, their effects on our daily lives, how we affect theirs, and how that may change. If during the lecture one wants to show animals that have been stuffed, these animals should have been stuffed with a proper permit or by someone who can officially stuff animals (Flora- en faunawet, 1998). The workshops should be coupled to the age of the children and could compose anything from arts and crafts (build your own bat ears, bat wings, bat mobile or, for the older kids, build your own bat box) to games and activities built to understand the requirements of a bat (e.g. a small treasure hunt in which the teams must collect the as many insects as they can, winning team gets to survive hibernation). When dealing with small children (up to around ten years) it is a good idea to give them a badge or certificate they can be proud of and show their parents (such as a bat expert certificate, or a bat shaped badge).

It is not only children that need education in the subject, adults take a decisive role in the future of these animals as pest control, and as a balancing element in the ecosystem. Involving the parents in the workshop can be a good idea.

For those adults with no children, the tower could be equipped with a web cam, especially the entrances, as in these spots, the bats will be the easiest to spot. This webcam could have feed to local cafes, or to a webpage, accessible to everyone. It is important to only give access to this webcam once the presence of the bats has been confirmed. Day excursions to introduce people to nature in Zeeland could be organized and should include a visit to the tower during dawn or dusk. If the intention is for the group to remember the tower, it should be mentioned and talked about all throughout the excursion and be seen as a last point to the excursion (as a final important element to nature; Björn van Loon, pers. comm.). However, promotional talk should be avoided (Björn van Loon, pers. comm.).

For these excursions both the webcam and a bat detector might add to the impression that the target group receives. A bat detector can be included in the tower to detect the different species present in the tower. However, this means that the tower should have access to electricity, therefore this option might not always be desirable. The bat detector might be accompanied with pictures and information on those species, as people should not come too close to the tower and they must not enter the tower. These nature walks might already exist, and it would be interesting to add the tower to the existing routes. For this we suggest further contact with Natuurmonumenten once the tower is inhabited by bats.

## 4.2 Hibernacula

The design of the hibernacula is based on the guidelines given by Twisk and Alberts (no date), the research works of Voûte and Lina (1986), the recommendations given by Erik Korsten (pers. comm.), and guidelines from enthusiast groups and businesses (the Norfolk Bat Group and IBSTOCK).

Bats need a stable climate (0 – 10 °C) and high relative humidity (between 80 – 100%) during hibernation. Buildings below ground, such as bunkers and fundaments, often fulfil these requirements. Bats that are awoken in the middle of hibernation are likely to die of starvation. Temperature stability that prevents both freezing and spring temperatures is vital to the success of the bat's hibernation. To insure the stability of the hibernacula, a layer of dirt or sand should cover the hibernacula (at least one metre thick). Also for the stability of the hibernacula, we recommend that the inspection hatch and entrance for the bats be placed in such a way that they lead to a hall rather than the actual hibernaculum, as this way, drafts can be better avoided. A layer of water on the bottom of the hibernacula ensures the high humidity. A plastic mesh or a net should be placed over the water so that the bats do not drown. It is also possible to use troughs or buckets filled with water and covered with a mesh or net to increase humidity, but only the first solution provides an anti-vandalism measure.

The air temperature within the hibernacula will gradually change from colder when close to the entrance to warmer deep inside. Higher ceilings have warmer temperatures. It is important to spread hibernation areas along the temperature gradients within the hibernacula to suit all different species requirements. It may also be interesting to create different height ceilings or a height gradient along the hibernaculum.

Different bat species have different hibernation requirements. Some prefer to hang from the ceiling while others prefer to find cracks and crevices in walls which are safer from sudden drafts and temperature changes.

We recommend to place several hollow bricks or bat bricks (e.g. see the Norfolk Bat Group or IBSTOCK). These bricks consists of several (up to 6) small holes of different sizes to fit different species. These could be placed on their own (5 or 6), or give access to a resting area (5 or 6). In the first case, when placed alone, up to three bats per brick have been seen hibernating together. They can also be placed as an opening to an artificial crack in the wall (5 cm deep, 3 cm wide, 6 cm tall).

Another option is to provide spaces in the ceiling (20 x 20 cm, with 3 cm of depth) protected by metal bars, which should be separated from each other by 1.5 – 2 cm. Bats are known to occupy ventilation shafts as they are protected from drafts. We recommend the hibernacula be given 4 - 8 of such spaces. The area of these spaces can be varied, as long as de depth is maintained.

The entrance to the hibernacula should be 50 cm long and about 12 cm high. It should be placed away from the hibernation area to avoid direct draft.

Hibernation areas should be placed 1.80 m above the ground to avoid predation, but there is not a limit to the maximum height of the hibernaculum.

The number of bats that hibernate together is difficult to estimate. Therefore providing an exact number of hibernation elements is a difficult task, the numbers provided above are estimations.

Bats should not be disturbed during hibernation, so, in this period, it is important that the animals remain undisturbed. An expert could enter the hibernacula for research purposes. Other educational purposes are difficult to include. A camera might not be useful, as bats hide in crevices and holes, and a camera on the entrance will only be interesting two times a year, when they fly in, and out. If workshops related to the bat tower are given, they could include information on the hibernacula and hibernation requirements of bats.



## 5 Conclusions

- One of the threats to bats are the disturbance and destruction of their roosting places. A bat tower might enhance the local bat population which might in turn stimulate natural pest control.
- A high number of bats will have a higher impact on the pest population. We therefore aim for crevice-roosting bats.
- Landscape elements (e.g. dikes, hedges, trees), food resources and the presence of nearby bat colonies are vital for the success of artificial bat housing.
- Even when artificial bat housing is successful, it should not become a compensatory measure. Proof that a new provided habitat properly replaces its destroyed counterpart is almost impossible to gather (Erik Korsten, pers. comm.).
- The tower should have rough surfaces to provide grip for the bats.
- Apply non-toxic wood preservatives (e.g. against insect pests and wood rot).
- Avoid vandalism by making the site unattractive to enter and for example make the inside inspection hatch inaccessible except with a ladder.
- Avoid predation by including smooth metal plates so the tower and the bat roosting places are inaccessible for rats, mice etc. Also take into account the avoidance of birds and wasps nesting in the tower, by constructing small spaces.
- Pilot tower should be monitored for at least 5 years (e.g. bat species present, number of species, temperature oscillations, humidity, etc.), and its design should be adjusted if temperature and humidity requirements are not met.
- The absence of bats (especially in the first few years) does not necessarily imply a failure, if the microclimates (e.g. temperature, relative humidity) are sufficient. Perhaps local bats have not found the tower yet and it is a question of time and patience.
- Add education programs (with active involvement) to the tower to raise public awareness of the ecological value and protection of bats.



# PART II: FAUNA

## HOUSING



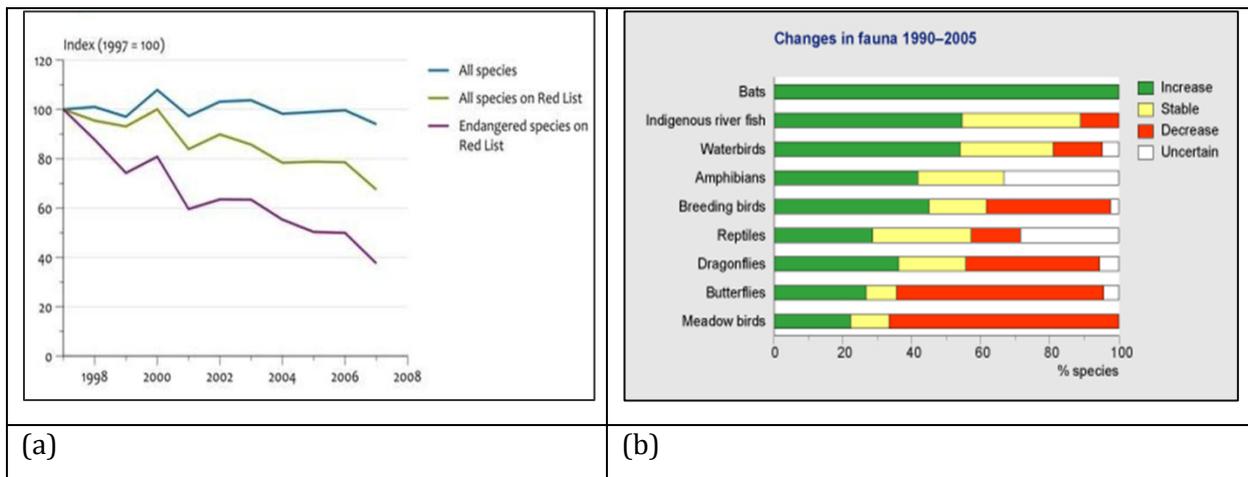
*Erinaceus europaeus* (hedgehog). Source: Totemtier: de Egel



## 6 Background

### 6.1 Decline of fauna species

Over the past century biodiversity in the Netherlands has been steadily decreasing (Martin *et al.*, 2010). In most areas, the number of species has declined and, especially for birds there has been a large decrease in size of both, population and distribution (Figure 9a and 9b). Many animal species that occur in the Netherlands, are of international significance, primarily the birds, alongside some mammals, fish, reptiles, amphibians and higher plants (Nieukerken, 1995). According to Martin *et al.* (2010), about 8 % of Dutch breeding birds, mammals, reptiles, amphibians and butterflies have become extinct, and about 40 % of current species are listed on the Dutch Red Lists as vulnerable, endangered or critically endangered.



**Figure 9. Trends in diversity loss.** (a) Status of faunas in Netherlands from 1997 to 2008 (Source: PBL 2009) (b) changes in fauna 1990 to 2005 (source: MNP 2006)

### Habitat destruction and species extinction

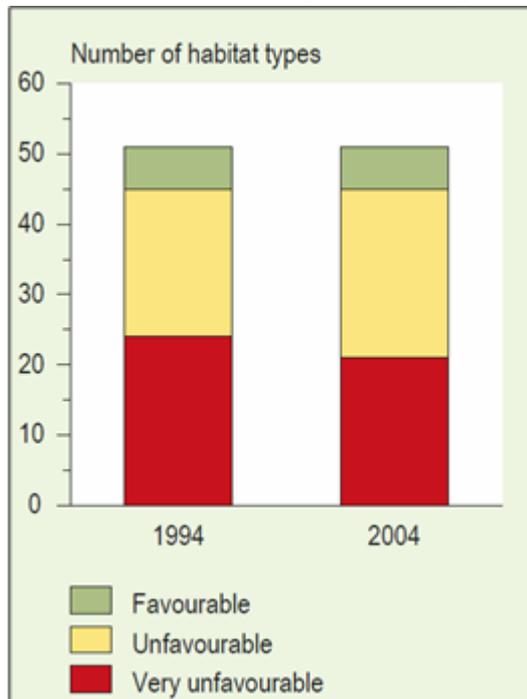
Habitat destruction due to intensive agriculture is the main cause of wild animal loss in the Netherlands (Martin *et al.*, 2010). To counteract this problem, the Dutch Government established, in 1990, a 'National Ecological Network' to protect and expand natural habitats and to mitigate habitat fragmentation (PBL, 2009). The outcome was decreased environmental pressure on natural areas, although target levels still need to be met (PBL, 2009). Recent studies suggested that, around 51 Dutch 'Habitats of Regional Importance' that are protected by the 'Habitats Directive' have an unfavorable conservation status and have barely improved in the last decade (Notenboom *et al.*, 2006) (Figure 10). About two thirds of the species that are protected by the 'Habitats directive' are declining, mainly birds protected under the Birds Directive (Notenboom *et al.*, 2006). These declines can be attributed to significant habitat deterioration.

Habitat loss and fragmentation impact the spatial conditions of a large number of species. By 1990, the spatial requirements for an estimate of 50% of the fauna species were not met (MNP, 2006). Though the 'National Ecological Network' is expected to counteract habitat fragmentation, spatial habitat requirements are not met for 15 -45% of all species (Notenboom *et al.*, 2006).

The main causes of habitat fragmentation in Netherlands are road construction and residential or industrial development. Roads form barriers and traffic causes road kill. Habitat

fragmentation creates small areas that are isolated to a greater or lesser degree and in which certain species have difficulty surviving. As an example, fragmentation by roads poses a serious threat to the badger (*Meles meles*) and the sedge warbler (*Acrocephalus schoenobaenus*) populations in the Netherlands.

It is clear that protecting species is all about protecting their habitat. In those cases in which their habitat has already been lost, providing them new (or artificial) habitat could represent a



**Figure 10. Conservation status regarding habitat types in the Netherlands** (source: Netherlands Environmental assessment Agency, 2006).

solution (Ministry of Agriculture, Nature and Food Quality, 2005). In the last two decades protection measures implemented in the Netherlands have decreased the rate of loss of natural areas. The 'National Ecological Network' is working to develop nature on former agricultural lands to connect natural areas that are currently isolated. But the fact is despite the execution of such nature policies, saving biodiversity is not likely to be achievable without a change in policy (MNP, 2006) or without involving the people in the process of nature connection (Elrich and Pringle, 2008). Hence connection of fragmented habitats along with the creation of new habitat for species with declining population can be the key conservation policy for future. In this regard, the proposition of creating artificial habitat for fauna of Zeeland may commence a step towards sustainable biodiversity conservation and management.

As we believe connectivity between isolated populations, and integration of biodiversity onto the

human landscape to be very important elements to aid nature conservation, we will explore the possibility of designing a tower that can be inhabited by different species and act as a stepping stone, a point that unites populations and a point from which animals can disperse. More dispersed living grounds, spread out throughout the landscape may also provide connectivity between habitats. We will further explore the idea of smaller, spread out habitats. Although all animal species should be protected and a way to include them into human habitats should be studied, there are practical concerns that prevent us from exploring all species. We will therefore start by selecting relevant animal species.

## 6.2 Target species

To select the target fauna for our study, we will focus on their spatial occurrence in the Zeeland area, as well as some other selection criteria. For the tower, we chose common species that occur all throughout Zeeland, as a tower might be easier to implement in different locations when aimed for common species. We left out red list species, as manipulating these species is forbidden by the Flora and Fauna law ('Flora- en faunawet'), and if any were to nest in the tower, it could no longer be accessed. Rodents are very common pest in Zeeland so we selected birds of prey which are well known for preying on rodents (natural enemies) to conserve birds meanwhile regulating the population of rodents. For small birds we selected mostly insectivores

and the species which can be easily tempted to the nest boxes and can decrease the number of insects.

Main emphasis will be given to bird species because declining bird population is one of the major threats to the biodiversity in the Netherlands (Figure 9). We selected 15 different species of birds including three birds of prey and 4 mammal species (Table 4).

**Table 4: List of selected fauna species.** A more detailed fauna species

Species	Physical description	Habitat	Food habits	Natural predators	Behaviour	Reference
<b>Barn swallow</b> <i>(Hirundo rustica)</i>	Size: 14.6 – 19.9 cm Weight: 17-20g	Open areas like agricultural field, grassland also in forests	Insectivores	Hawks, owls, gulls, common grackles, rats, squirrels, domestic cats, snakes	Migratory Colony breeders Territorial with territory size of 4-8 m <sup>2</sup> Breeding season: May – August	Dewey and Roth (2002)
<b>Winter wren</b> <i>(Troglodytes troglodytes)</i>	Size: 8-12cm Weight: 8-12g	Wide range of habitat mainly deciduous forest. also pastures, farms, scrub forests and villages. Home range: 1 to 7 acres.	Insectivores	Domestic cat is the major predator. Nests are targeted by crows, jays and weasels.	Migratory or sedentary Sedentary are territorial with size of 8 -12 km <sup>2</sup> area Half-hole breeders.	Baillie and Crick (2007)
<b>White wagtail</b> <i>(Motacilla alba)</i>	Size: 14-21 cm Weight: 12-50g	Prefer habitats close to water bodies. Also found in farmland, moorland, gardens, sewage farms, and reservoirs.	Insectivores	Falcon, hawks and owls are major predators Eggs are mainly eaten by weasels, squirrels, mice and house cats.	Colony breeders (April to August) Clutch size 4 to 7 Territorial during breeding season Clutch size 2-3.	Camfiel (2004)
<b>Common swift</b> <i>(Apus apus)</i>	Size: 16-17cm Weight: 44.09g (average)	Mainly found in temperate region Prefer areas with trees for nesting and open space for flying Home range: 48-61km.	Insectivores	Eurasian hobbies, sparrow hawks, and buzzards are main enemies of swift.	Migratory Colony breeders Breeding season: April – May	Thompson and Fraser (2006)
<b>Spotted flycatcher</b> <i>(Muscicapa striata)</i>	Size: 14cm Weight: 17g	Mainly found in woodland and places with mature trees, gardens Breeds in mature open woodlands, parks and gardens.	Insectivores	Grey squirrel is the main predator of spotted flycatcher.	Large distance migratory bird Half-hole migrant breeder Breeding season: May - August Clutch size: 4-5	Robinson (2005)

<b>Barn owl</b> <b>(<i>Tyto alba</i>)</b>	Size: 32-40cm Weight: 430-620g	Low altitude open habitat (agricultural field, grasslands, deserts, marshes) Home range 7.12km <sup>2</sup> ..	Small mammals such as voles, mice, rats, muskrats, rabbits and small birds.	Stoats, snakes, golden eagles, falcons, great horned owls etc.	Hole breeders Breeding season (any time of year) Clutch size: 2 to 18.	Bachynski& Harris (2002)
<b>Little owl</b> <b>(<i>Athene noctua</i>)</b>	Size: 22cm (average) Weight: 98-350g	Dry climates Open country side, farmland Nests in tree holes and burrows of other animals. Home range: 1.8-95ha.	Small mammals (mice, voles, shrews) Small birds and fish Insects like earthworm, snails and slugs.	Owls, eagle, falcons, common buzzards, cats, fox, domestic dogs.	Hole breeders Breeding season (February to may) Clutch size: 1-12 Territorial (0.151 k <sup>2</sup> territory size).	Hunt (2011)
<b>Common kestrel</b> <b>(<i>Falco tinnunculus</i>)</b>	Size: 30-36cm Weight: 150-190g	Open grass fields and farmlands Sometime in forest and marshlands Home range: depending on food availability and perching sites.	Small mammals (voles and mice) Insects especially beetles and grasshopper Small birds.	Goshawks, falcons, sparrow hawks, eagle owls.	Hole breeders Breeding season (April – may) Clutch size: 3-7 Territorial: territory size 2-10km <sup>2</sup> Non breeding birds migrate short distance during summer	Nelson and Fraser (2006)
<b>Common house martin</b> <b>(<i>Delichon urbicum</i>)</b>	Size: 13cm (average) Weight: 18.3g (average)	Open country with low vegetation (pasture, meadows and farmlands) Near water bodies.	Insectivores Mainly flies, aphids, ants.	Hobby is the main predator of house martin.	Migrant colony breeder Colony size of 10 nests.	Robinson (2005)
<b>Common red star</b> <b>(<i>Phoenicurus phoenicurus</i>)</b>	Size: 13-14.5 cm Weight: 11-23g	Open birch and oak woodland Old trees with holes for nest.	Insectivores Butterfly, beetles, spiders.	Sparrow hawk is the main predator of common red star.	Migratory (August – November) Half-hole breeders Breeding season: spring Clutch size: 6-7.	Robinson (2005)
<b>Stock dove</b> <b>(<i>Columba oenas</i>)</b>	Size: 28-32cm Weight: 300g	Open woods, parks, farmland Nest in holes in trees or buildings.	Seeds, buds, berries and grain Occasionally invertebrates.	Falcons, sparrow hawks, owls, eagles and kestrels.	Residence bird but some extent migratory (April to May) Hole breeders Breeding season: March Clutch size: 2.	Robinson (2005)
<b>Ermine</b> <b>(<i>Mustela</i>)</b>	Size: 170-330mm Weight: 25-116g	Woodlands, marshes and	Small warm blooded	Larger carnivores like fox, martens,	Can move easily above	Loso (1999)

<b>ermine)</b>		open areas near the forest or shrub. Hollow logs, stone walls, rodent burrows are use as dens. Home range 10ha.	mammals (rabbit), birds, eggs, frogs, fish and insects.	fishers, badgers, raptors and domestic cats.	ground and through burrows for hunting. Territorial: territory size: 0.1-0.2km <sup>2</sup> . Breeding season: late spring or early summer	
<b>European polecat (<i>Mustela putorius</i>)</b>	Size: 350-460mm Weight: 205-1710g)	Nearby fresh water bodies, wetlands, edge of forests or grassland.	Carnivores Rodents and rabbits Insects and fruit.	Red foxes, wild and domestic cats.	Solitary and sedentary nocturnal Territorial: males have larger territories than females during. Breeding season (winter)	Lundrigan and Conley (2001)
<b>Least weasel (<i>Mustela nivalis</i>)</b>	Size: 165-205cm Weight: 30-55g	Open forest, farmlands, meadows, prairies, steppe and semi-desert.	Small mammals mainly rodents. Bird's eggs and nestlings Insects and lizards.	Snakes and birds of prey (owls and hawks).	Male female live apart except during breeding. Breeding season: spring and late summer.	Newell (1999)
<b>Western European hedgehog (<i>Erinaceus europaeus</i>)</b>	Size: 135-165mm Weight: 800-1200g	Woodland, farmland, suburban areas. Home range: more than 100 acres.	Insectivores Beetles, ants, butterflies, bees, lizards, snakes, rodents, grasshoppers, snails etc.	Foxes, wild dogs, snakes, large owls and badgers.	Nocturnal, solitary Male female meets only during mating season (April to September) Territorial: territory size of 0.048-0.04 km <sup>2</sup> .	Roberts (2011)
<b>Note: all the above tabulated species are listed as least concerned (LC) in IUCN Appendix.</b>						



## 7 Fauna tower



**Figure 11. Fauna Tower.** Source: Traas Nature Care.

The initial idea of the fauna tower, created by Traas Nature Care, was to provide a habitat for several local fauna species in Zeeland to contribute to local nature conservation. The first drawing of the tower (Figure 11) showed a building which provides habitats for birds of prey like the barn owl (*Tyto alba*) and the kestrel (*Falco tinnunculus*); birds like barn swallows (*Hirundo rustica*), blackbirds (*Turdus merula*), great tits (*Parus major*) and sparrows (*Passer spp.*); mammals such as bats (order Chiroptera) , weasels (*Mustela nivalis*) and hedgehogs (*Erinaceus europaeus*); and insects like bees (*Apis mellifera*) and butterflies (order Lepidoptera). The drawing looks promising and suggests that it can be possible to combine many different fauna species in one tower.

However, while developing this idea in more detail, several practical difficulties or even impossibilities emerged. Basically, fauna species require two important things in their habitat: (1) possibility to raise their offspring in a suitable and safe place and (2) availability of sufficient food in all weather conditions (SOVON and Vogelbescherming Nederland, 2011). Regarding these basic requirements, we concluded that this initial idea of the fauna tower is not a realistic and viable way to conserve nature. The reasons behind this conclusion are explained in this chapter.

First of all, the drawing appeals to one's imagination, all species live peaceful alongside each other. Such a concentration of species, especially combinations of predators and preys, will

never be found in nature. A barn owl, for example, hunts mainly little mammals like mice, but also birds and large beetles (Soortenbank). The presence of a large bird of prey in the fauna tower will cause such a threat for its preys, that they will look for a habitat elsewhere, where it is more safe. This natural way to chase away other birds with a bird of prey, is gratefully used in for example fruit orchards and cities in which specific birds cause nuisance. Birds of prey trained by special falconries are brought into action in such specific situations (Roofvogelboerderij, 2010). Due to this natural territory and threat, it is not likely that prey will live in the same tower as their predator. This implies that when a bird of prey inhabit the fauna tower, probably no other birds will nest in the tower. There are examples of nesting barn owls in a barn that caused all barn swallows to leave the area (André Hannewijk, pers. comm.).

Next to this, the strong territorial behaviour of the bird of prey makes it unlikely that two birds of prey will inhabit the fauna tower, even when they are of different species. They will compete for their own habitat. The only situation in which two birds of prey will inhabit the tower, is when a couple will nest and raise their chicks in the tower.

Another combination of fauna species which is not very probable is the combination of mustelids, like the weasel, the ermine (*Mustela erminea*) or the polecat (*Mustela putorius*), together with small birds like swallows and tits. Besides rodents, amphibians and insects, birds and bird eggs are also a tasty meal for mustelids. If the mustelids have the opportunity, they will climb up the fauna tower and plunder the bird nests. However, this can be prevented by making (part of) the outside of the tower smooth. Also the opening of the nest box in the tower can be adjusted, for example by making a tube opening, to prevent mustelids to strike (Vogelbescherming Nederland<sup>A</sup>, 2011). Although there are some options to protect the bird boxes against mustelids, there are still some doubts whether a bird would nest in the tower knowing that a mustelid have its hole 2 meters below its nest. Birds will only make a nest on a location where they feel safe (requirement 1) (Vogelbescherming Nederland<sup>B</sup>, 2011).

Similar to the birds of prey, mustelids are solitary and their territory can range up to 50 ha. This indicates that when a weasel inhabits the tower, it will protect its territory and will never allow another mustelid in their vicinity (Bekker *et al.*, 2010).

Birds also compete for a nesting place. Birds can be divided into colony breeders and solitary breeders. For the solitary breeders, like tits, it is important to take into account that the nest boxes for birds of the same specie should be 10 m apart, due to their territorial behaviour (Vogelbescherming Nederland<sup>B</sup>, 2011). This implies that only one bird (couple) of one species can live in one tower. Birds from different species tolerate each other better, the nest boxes of for example a great tit and a blue tit should be 'only' 3 m apart (Vogelbescherming Nederland<sup>B</sup>, 2011). Having taken this distance into account, it is only possible to combine maximal 3 or 4 couples of different bird species in one tower.

Above mentioned distances are not applicable to colony breeders like sparrows and swallows. Nest boxes for those birds can be placed in groups, with a little distance between the boxes. In order to accommodate as many birds as possible in one tower, it is wise to aim to accommodate colony breeders. The risk is however that when a colony lives in the tower, no other bird species will inhabit the tower, so the fauna tower will only be occupied by one species of colony breeders. Barn swallows are for example easily disturbed by sparrows (SOVON and Vogelbescherming Nederland, 2011), while both are colony breeders.

Besides, we also think that the initial design is not practical and efficient with space, because the openings of the nest boxes and butterfly and insect hotels cannot be placed randomly in the tower. Butterflies and insects have a preference for warm and sunlit sites, so they should be placed on the south side of the tower (Natuurmonumenten). Conversely, nest boxes of birds should not be placed on the south side, because the sun can raise the temperature in the boxes till an uncomfortable, or even fatal level for the chicks. For the opening direction of nest boxes it is also important to take into account the wind direction. Since the wind direction in Zeeland is mainly south west, openings should point to north east (Vogelbescherming Nederland<sup>B</sup>, 2011). These guidelines imply that not every side of the tower can be used to provide habitat, which is a pity for all the space available on those sides.

The next concern we have about the fauna tower is related to nature conservation. The main purpose of the fauna tower is to provide a suitable nesting / feeding habitat for several fauna species. With this purpose the fauna tower can fulfil one of the two basic requirements of some specific fauna species. However, the fauna tower does not contribute at all to the aforementioned second requirement: providing a foraging habitat. One should remember that nature conservation is not only about providing a suitable and safe habitat in the tower, but the surroundings of the tower should provide a suitable foraging habitat as well. Knowing this, the fauna tower can only accommodate species which are common and are already doing well in the Zeeland landscape, requirement 2 should be fulfilled naturally. For areas that lack suitable natural cavities, artificial hollows / nest boxes might enhance the bird population. Newton (1994) found that nest box provision can clearly have a positive effect on the breeding density of birds. He concluded that nest boxes can contribute to nature conservation when suitable nesting places are a limiting factor.

To give an example about comprehensive nature conservation: stoats are declining in number in the province of Zeeland by several reasons: introduction of the fox in the seventies (predator), traffic, parasites, decline in habitat, landscapes become more large-scaled, decline of water rat number (food), and impoverishment of the landscape. To contribute to the conservation of stoats, measures should focus on several of these causes. Only providing a nesting place for stoats by building a fauna tower will not enhance the stoat. What is needed is a set of measures, consisting of creating a messy landscape (hedgerows, heaps from branches, clutter spots) with linear elements, improving food availability by countering rat and mice poisoning, planting berry and nut bearing plants, etc. (Zoogdierenvereniging, 2009).

Summarizing, the main concerns are: (1) only a restricted amount of fauna species can be accommodated in one tower, (2) a part of the tower cannot be used, because of the unsuitable direction regarding wind and sun and (3) the contribution to nature conservation is minimal. Because of all these concerns we doubt whether it is worth it to build such an expensive tower (estimated costs €23,000). We expect that the economic viability of the tower is limited. If prices for the potential clients are too high, the amount of fauna towers sold will be limited. Basically, one can see the fauna tower as a collection of existing nest boxes for birds, sheds for mammals, boxes for bats and insect hotels. To compare: in an optimistic situation suppose that a fauna tower can accommodate the following:

- 1 kestrel	1 nest box of €100.-	€ 100.-
- 3 different bird species:	3 nest boxes of €30.-	€ 90.-
- 1 colony of common swift:	15 nest boxes of €70.-	€ 1050.-
- 1 colony of bats:	15 nest boxes of €20.-	€ 300.-
- 1 hedgehog:	1 shed of €50.-	€ 50.-
- 1 mustelid	1 hole of €60.-	€ 60.-
- Several insects:	different hotels,	€ 200.-
		€1850.-

The estimated total costs of this collection of single parts are €1850-. With this amount the same goal of providing a nesting habitat for several species can be reached, similar to the goal of the fauna tower which costs €23,000 instead.

With this simple calculation we want to make clear that building a fauna tower is a huge investment, while there are several existing alternatives which are much cheaper and have the same purpose of providing a nesting/feeding habitat for different animals. Although we think that a fauna tower is an innovative, creative and new concept, we think that that potential clients who aim for providing nesting/feeding habitats are interested in the fauna tower, but are not willing to pay such a huge amount while other cheaper, and effective alternatives are available. A municipality which can spend €23,000.- on nature conservation can either choose to buy one fauna tower, or can buy the single nesting/feeding habitats (like the list described above) and have €21,150.- left to invest in other nature conservation measures.

## 8 Other fauna housing

In the previous chapter we advised not to continue with developing the initial idea of the fauna tower, because of several reasons. In this chapter, we would like to give other ideas for fauna housing that, very probably, would be more successful. By selecting these ideas, several design criteria were used (Box I). The first selection criterion was that it should be innovative. For example, we will not advise to offer all different kind of single fauna boxes, because those are already available in every garden centre and via several web shops. If Traas wants to distinguish themselves, new products should be innovative and creative.

We also think that products are more interesting for potential clients when they have an exclusive character. A municipality does not want to have exactly the same object as the neighbouring municipality. In order to be exclusive, the products should be flexible. Only small adjustments can already make the object look different.

Another selection criterion is creativity. This criterion is also related to criteria like new, innovative and exclusive. When a new fauna housing is developed, it can be an idea to ask an artist to think along. The product does not necessarily have to be only functional, but may be artistic as well.

One of the problems of the fauna tower was that the price did not bear a proper proportion to the possible achievements. We think that it is important to develop an affordable product, focused on the target clients.

Beside the selection criteria of being exclusive, creative, etc., the product should be realistic. The main purpose of the object should still be to create a nesting/feeding habitat for fauna species. This needs to be the starting point and one should make sure that, for every product, the likelihood of the target species using the provided nesting and feeding habitats is high. This implies that there should be attention paid to possible combinations of fauna species and to the requirements they have for their nesting/feeding habitats. When choosing bird species, one should create nesting habitats for birds that naturally nest in holes ('holenbroeders'). Only those species can be invited to nest in an artificial nest box (Vogelbescherming Nederland, 2010). To make the product a Walhalla of birds flying in and out, it is wise to focus on colony breeders. Those birds nest with many individuals concentrated on one spot, so it will create a lively image.

It will not be realistic to focus on Red List species or on other endangered or rare fauna species. Creating a suitable nesting/feeding habitat will probably not attract those species to the landscape if they are not already there. This will only be successful when the nesting/feeding habitats are part of a larger set of measures to conserve those species. To have the highest chance of success, the target species of the products should be species that are common in the landscape of Zeeland.

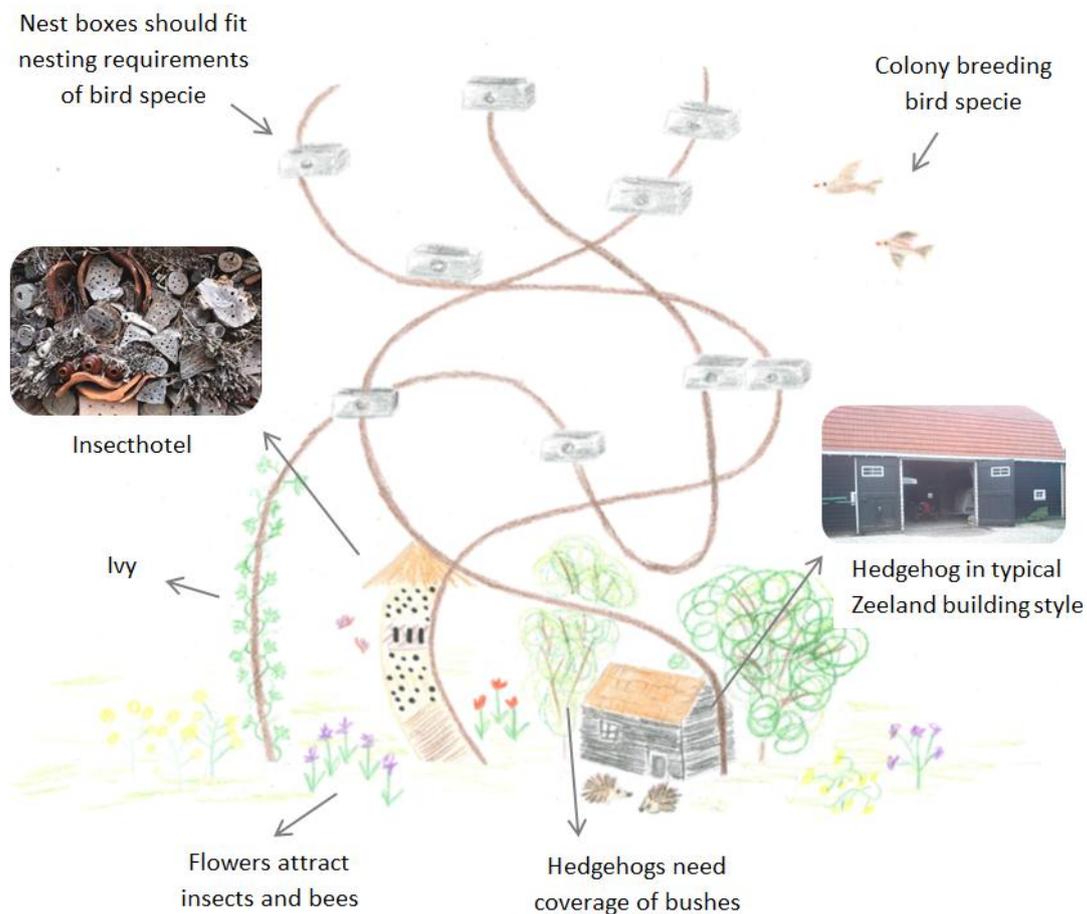
In the following paragraphs, several fauna housing ideas, as alternatives to the original fauna tower idea, will be worked out in more detail according to the criteria mentioned above. Next, we will provide several other suggestions that could be explored in more detail by Traas Nature Care.

### Box I: Selection criteria for new products

- New and innovative
- Exclusive
- Flexible
- Creative
- Affordable
- Realistic
- Create nesting/feeding habitat for fauna

## 8.1 Functional fauna art

One of the Fauna housing ideas focuses on the combination of functionality and creativity, therefore it is called Functional Fauna Art (Figure 12). The idea exist of three bars of iron in a natural twisted shape. These curved bars depict the dikes that are typical for the Zuid-Beveland landscape and also refer to the waves of the sea. This makes the art symbolizing the continuous fight between the inhabitants of Zeeland and the sea. The “dikes” have caught several bird houses that were brought by the sea. These now hang proudly on top of the sculpture and can accommodate a colony of birds raising their offspring. The optional hedgehog shelter is inspired by a typical Zeeland building style with black wooden walls and a roof covered with orange tiles. One of the bars can be covered with ivy ('klimop'), which is a typical plant in Zeeland (Halfwerk, 1996). The flowers below brighten the sculpture and make it attractive for different kinds of insects. The Functional Fauna Art will take care of these small creatures and provide a habitat made from wood and bamboo sticks. The whole image should be simple, modest and in harmony, exactly those characteristics which the inhabitants of Zeeland are known for.



**Figure 12. First drawing of Functional Fauna Art.**

The Functional Fauna Art will be at least 4m high and 4m width. Because of this size, the potential clients are municipalities, companies and associations. A location can be for example the centre of a roundabout or a park. But in that case placing a hedgehog shelter, a roundabout is not a desirable placement. Even for the other species, the roundabout should not be very crowded with traffic. Besides that, the environment of the depicted area should be suitable as

well. The habitat around the art sculpture should match the required habitat of the target species. A suitable foraging area needs to be close by, to make sure that the birds will survive.

The area of the functional fauna tower will be brightened with flowers, which provide a feeding habitat for several kind of insects like butterflies, bees, flies, wasps and beetles. However, it is expected that these insect will remain low in number if the bird boxes on top of the sculpture are occupied with (insect eating) birds.

The target species of the Functional Fauna Art is a colony breeding bird species, which is also a hole breeder, like tree sparrow (*Passer montanus*), house sparrow (*Passer domesticus*), house martin (*Delichon urbicum*), barn swallow and common swift. However, the barn swallow will only nest inside a shed, barn or stable, so this species will not live in this Functional Fauna Art. Besides, barn swallows are difficult to tempt to nest in an artificial nest boxes. They even dare to build their own nest right next to an artificial nest (Gierzwaluwbescherming Nederland, 2011). Therefore the sculpture should focus on the other bird species, one species per sculpture. Because the art should be functional, much attention should be paid to practical issues, like the placement and size of the nest boxes. General requirements of nest boxes are:

- Thickness of (wood) walls > 15 mm to prevent temperature fluctuations. Choose for example Red Cedar, this is a sustainable material and does not need to be treated.
- Never treat or paint the inside of a nest box.
- The flying route towards the nest box should be free of obstacles like trees, lampposts, etc.
- No sunshine on the nest box from 11.00 till 18.00h.
- Related to the wind direction, the nest box openings should point north-northwest or northeast.

Specific nest box requirements of earlier mentioned species are presented in table 5. However, this overview of requirements is not complete. When a target specie is chosen for the Functional Fauna Art, it is important to search for more specific nest requirements of that species. This information is easy to find on for example websites of the Bird Protection association (Vogelbescherming.nl) and Natuurpunt.nl.

**Table 5: Requirements of nest boxes of different colony breeding birds.**

Species	Size (LxWxH) (cm)	Opening (cm)	Hanging height	Comments
<b>Tree sparrow</b>	12 x 12 x 26	4.0	2 – 3 m	
<b>House sparrow</b>	12 x 11 x 21	3.5	> 2 m	
<b>House martin</b>	Bowl with diameter of 12.5	5.0 x 2.7		
<b>Barn swallow</b>	12 x 9.5 x 6.5 (half bowl)	-	> 2 m	Inside a barn only
<b>Common swift</b>	30 x 17 x 16	6.5 x 3	> 3 m	

Be aware that for some birds species it might take years before the birds will find the location. Sometimes it may help to play the sound of the bird to attract the target birds to the nest boxes (Gierzwaluwbescherming Nederland, 2011). Besides, one should remember that only during spring and summer the bird boxes are occupied by birds. During fall and winter some bird species might migrate (swallows), others will look for another habitat if there is no sufficient amount of feed available (sparrow).

The nest boxes should be cleaned in fall by emptying the boxes and pour it over with boiled water to kill possible parasites that are trying to survive in the nest boxes during winter (Vogelbescherming Nederland, 2010).

## 8.2 Bird wall

The concept of bird wall is to build a wall or use the wall of old houses to provide habitat for birds by adapting attractive nest boxes. The current design of the bird wall targets bird species commonly found in Zeeland (Table 4). As mentioned before, the house martin, common swift and barn swallow are colony breeders and it is therefore possible to provide them with multiple nest. If non colony breeders are targeted, we must remember that the nest must be from 3 (different species) to 10 (different species) metres apart. The combination of different species of colony breeders should be avoided (see chapter 6).

The essential part of constructing a bird wall is adjusting the height of the nest from the ground, as different birds make their nest at different heights (Chris, 2005; Figure 13), so it is very important to adjust the height when a combination of different birds on a single wall is aimed for.

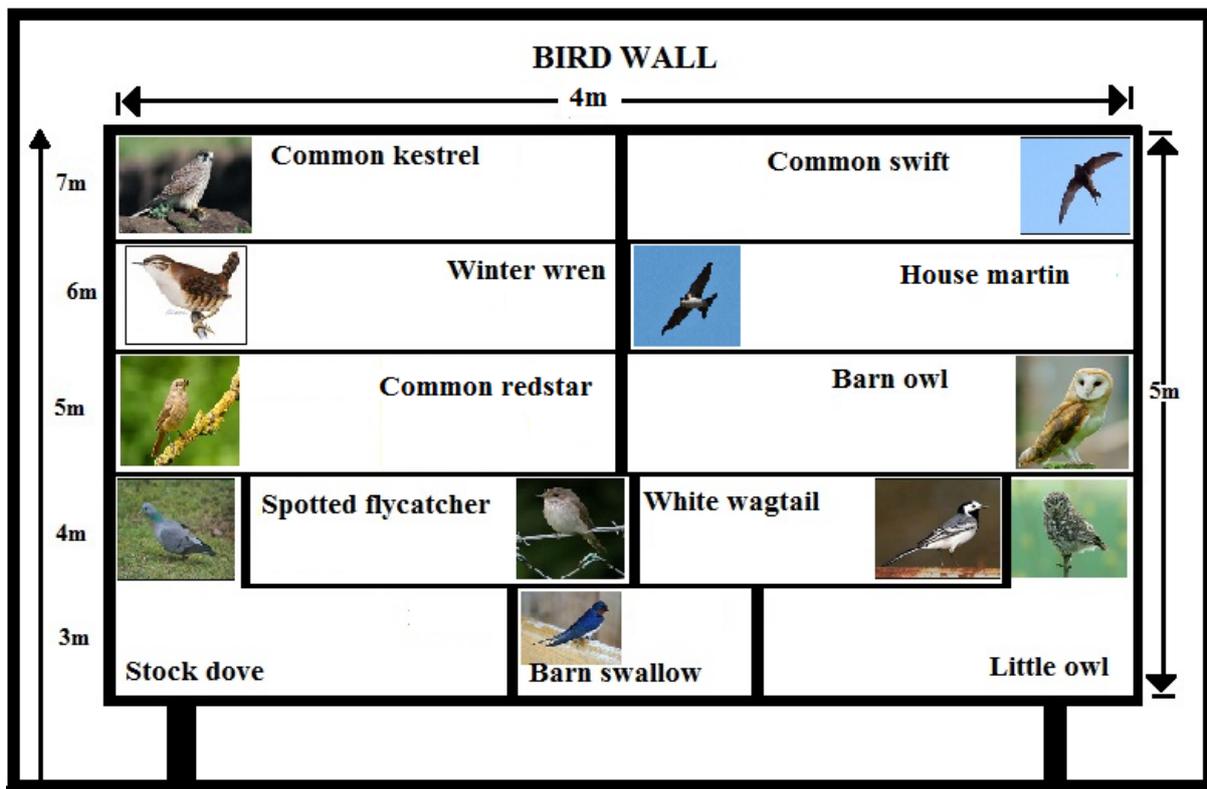
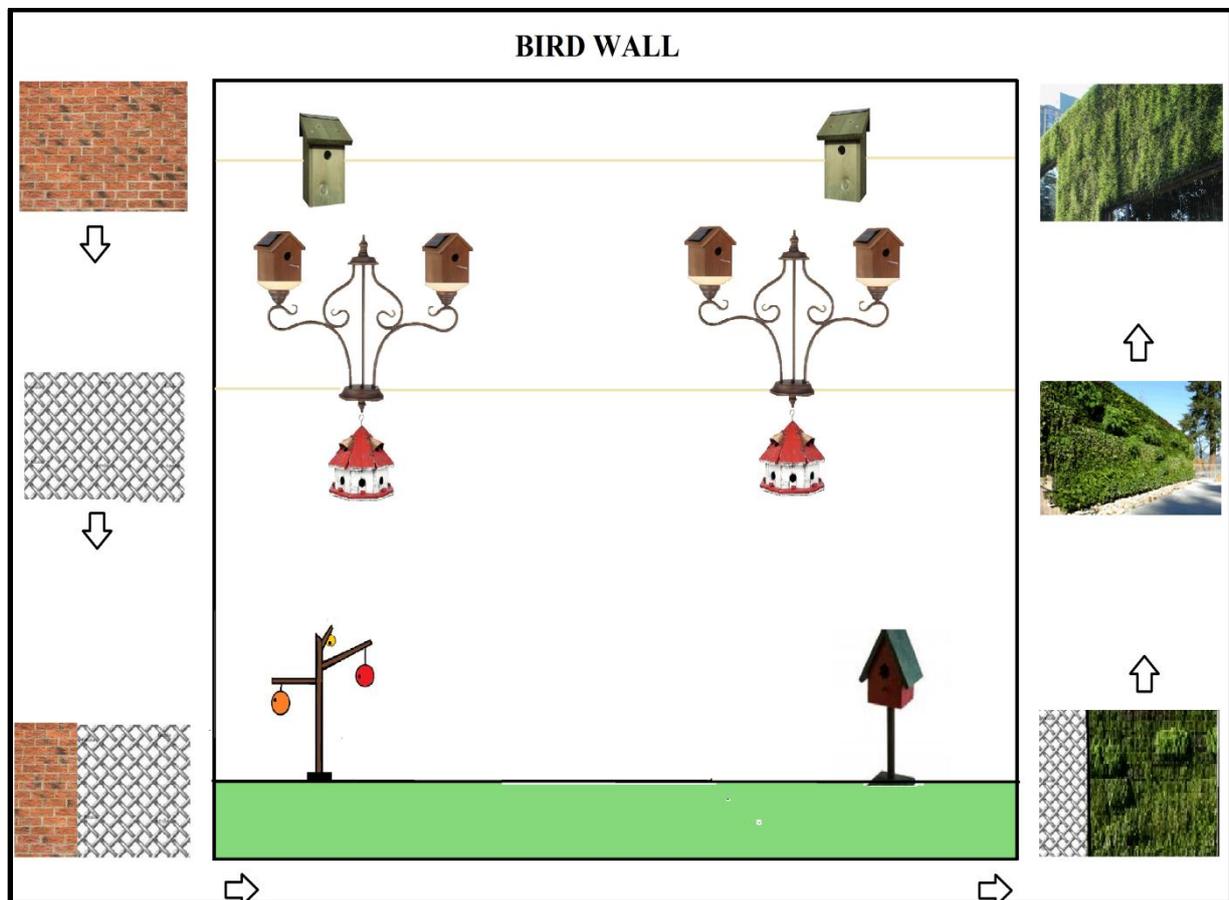


Figure 13: Nesting heights for different species placed in the wall. Note that all of these species cannot be combined in the same wall.

### *Design and Dimension*

Construction of a new wall can be more expensive, so using wall of old buildings might be more economic.. People who love birds around their homes and gardens can benefit from constructing bird wall in their home. Building a bird wall with decorative nest boxes and plants at the back side of the house can improves the aesthetic beauty of the house as well as its recreational value.

The dimensions of the bird wall are mainly determined by type of species but, in general, a wall of 4m x 3m will be enough for most of the birds. For a proper location of the bird nests (e.g. not directly in the wind or sunshine to prevent direct draft or overheating), the wall should preferably be orientated north-west or north-east. The wall will be covered with metallic netting to provide climbing and anchoring support for plants. This metallic netting could resemble that given to rose bushes to climb up the wall, and could be shaped differently (netting, swirls, etc.) depending on the client's wishes. Climbing plants like vines which are locally found can be a good option for such bird wall. For the Netherlands, clematis (*Clematis spp.*) can be a good choice because it is a perennial climbing flower which blooms all summer, providing scenic beauty for the house owner. Different nest boxes of different decorative design can be placed on the wall in order to attract the birds of interest (Figure 14). For colony breeders it is possible to place several nest boxes in a single wall but for territorial and hole breeders it is better to place single nest box (see chapter 6). The dimensions of nest boxes, with placement heights are given in the table 6. The wall could also be provided with pots to add flowers and plants which will add to the aesthetic value of the product.



**Figure 14. Design of bird wall.** Metal netting can be placed on the wall to allow for grip (left), so plants can partly overgrow the wall (right). Several decorative designs of bird boxes can then be placed on the wall (middle).

### **Materials**

Construction material is required for building new walls and also in case of recovering walls of old buildings and houses. If it has to be built into an already existing house then only a metal net of 4m x 3m and bird nests of the target bird is required. Plant species of common occurrence or interest can be included in order to increase aesthetic beauty and make the wall more attractive for the birds. To build bird nests, wooden materials are the best choice because they are cheap

and preferred by most of the birds, because it provides good microclimates. However, the wood should never be painted or treated from the inside. A webcam could be added to the nest box to observe the bird and its behaviour inside the box for extra fun and education (see chapter 7.3 for more information on web cam).

**Table 6: List of bird species with nest box information.** Source: Chris (2005) and U.S Fish and Wildlife Services

Bird	Nest Dimension (cm)	Nest height from the ground (m)	Entrance dimension (cm)	Entrance Type	Breeding type
<b>Barn swallow</b>	15 x 15 x 15	2.5 – 3.5	5 x 5	Window	CB
<b>Barn owl</b>	25 x 45 x 38	3.5 – 5.5	15	Hole	HB
<b>Spotted flycatcher</b>	15 x 15 x 30	1.5 – 4.5	3.2	Hole	HHB
<b>Common kestrel</b>	20 x 20 x 30	3 - 9	7.5	Hole	HB
<b>Little owl</b>	19 x 21 x 52	2 – 3.5	11 x 12	Window	HB
<b>House martin</b>	15 x 15 x 15	2 - 6	5.5	Hole	CB
<b>Winter wren</b>	20 x 10 x 10	1.5 - 6	7	Hole	HHB
<b>White wagtail</b>	18 x 15 x 24	2 >	15 x 24	Window	HB
<b>Common swift</b>	27 x 30 x 16	7	5	Hole	CB
<b>Stock dove</b>	45 x 20 x 40	1.8	15 x 10	Window	HB
<b>Common red star</b>	28 x 15 x 15	1.5-5.5	14 x 14 x 16	Open fronted	HHB

**CB: Colony breeders, HB: Hole breeders; HHB: Half-hole breeders**

### ***Potential clients***

The targeted client of the proposed bird walls are mainly individual households, although companies and municipalities could also implement this product in walls or parks. People preferring birds in their garden can construct bird walls on the backside of their house, facing the garden with decorative bird nests and add flowering plants. We think that it will increase the value of garden and the house itself. The concept of the bird wall can also be useful for additional bird conservation, by providing artificial habitat, mainly in the urban areas.

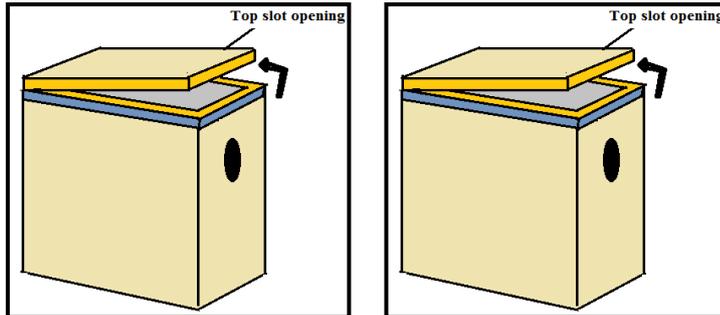
## **8.3 Nest boxes with web cams**

### ***Design of nest box***

Generally, bird cams are placed at the top of the nest box (Bird box cameras, 2010). But it's not always a good idea to place at the top, because it is not interesting to view the birds only from up top. People also want to get different view of the box interior and all possible bird activities. It is

not practical to place the webcam at the top when the bird house is very tall or the nest is high, or when birds get bigger, consequently it is not possible to see much inside. Therefore, designing a suitable bird house and placing the webcam in proper location is very essential. The, the best way to do so is to design or use a bird house which has opening slots on either side of the box (Figure 15) or at the top of the box, so that the position of the web cam can easily be changed as required by opening the bird house slots. It will be even more interesting to provide sun shield on the webcam to see the inside and outside view if needed.

The camera can be designed as small as 3cm x 2.5 cm x 2cm (e.g. SpycameraCctv; 2007), so it is easy to attach them to the wall or roof of the bird box. The power needed to run the camera, transmitter and infrared camera/light is about 12 volt (e.g. SpycameraCctv; 2007. It is possible



**Figure 15. Top slot opening nest box.** Camera can be placed within the slot.

to provide battery along with the power adapters. The webcam can be connected to a transmitter, after with the video images are received in displayed, either on a TV or computer (NatureCameras, 2011). A dual mode (colour and infrared) web cam are effective to get the continuous day/night pictures (BirdBoxCameras, 2010). An automatic dual mode design (such

as the one explained above), that can catch night and day images is likely to draw the attention of people and create new possibilities of producing bird box cams for different types of bird species.

It is also possible to install some tiny (micro) meteorological sensors to measure some essential parameters inside the box. It's is exciting to monitor the internal environmental condition because some bird species are temperature or moisture sensitive. It is even more interesting to know about the internal condition during breeding seasons. Hence, different meteorological sensors (mainly temperature and humidity) with data loggers (e.g. Sparkfun, 2010) can be placed inside the bird house to measure and record the internal meteorological condition.

The concept of providing bird boxes with sensors is expected to provide useful tools for those who are interested in researching behavioural ecology of birds or for those who are just interested in knowing which bird inhabits the bird box. If chicks are present, this could become an amazing opportunity for the younger kids to learn more about how birds behave. We think the concept of sensor mounted bird house may be helpful to study seasonal variation of environment condition and the behaviour response as well as the life cycle of different bird species. It can also be attractive to individual households if they want to know whether the internal environment for bird is appropriate or not. Hence it can be beneficial for different groups of people mainly individual household, researchers in universities, and nature care organizations.

## 8.4 Garden and roof ornaments

This idea for fauna houses focuses on new or adjusted (garden) ornaments that consumers may add to their garden or balcony. The ornaments are adjusted in such a way that various animal species might make use of it. First, a description of already existing ornaments will be given, to

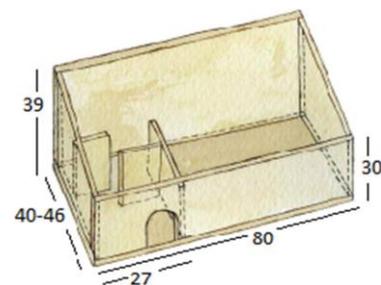
give ideas on the possibilities. Next, several suggestions for adapting these ornaments, or creating new ones, are given.

As an example, Waveka Home and Garden Decorations is an internet shop that sells different items to decorate the garden. On the one hand they have things purely to decorate gardens, like garden gnomes; on the other hand they sell products for animals in the garden. Pots, adapted for bat and bird use, homes for ladybirds and some food providing items (Waveka, 2011). Any garden ornament could be subject to adaptation, to house different fauna species.

Another big internet shop company is Vivara, which sells many bird nest boxes. Quite a lot of their boxes are checked by the bird protection services (Vogelbescherming), so the chance that a bird will use the nest boxes is somewhat larger than that of unchecked boxes. Furthermore they provide feeding and sleeping “houses” for hedgehogs, squirrels and bats. Most of them are developed based on recommendations of the protection associations (e.g. the ‘Zoogdierverseniging’).

People like to decorate their gardens with different objects. Sometimes these are just for decoration, sometimes they are meant to provide housing or food for animals. We suggest the possibility of combining decorations with animal houses or breeding places. All decorations that are meant to put on the ground can be made suitable for small mammals, reptiles, amphibians and maybe also insects.

Hedgehogs build their burrow below garden waste such as dried leaves and branches. They sometimes use hedgehog houses as provided by Vivara. The dimensions of the house should be around 60x40x36 cm (Figure 17) (Vivara, 2011 and Zoogdierverseniging, 2009). Those hedgehog houses consist of an inner and an outer part. The inner part is the sleeping box, which is just a cardboard box filled with dried leaves or paper. The inner part should never be filled with hay or straw, since this will remain stuck in the spines of the hedgehog (Zoogdierverseniging, 2009). The sleeping box is placed on some isolation material, the mammal society advises to use Styrofoam, although that is not very sustainable (Zoogdierverseniging, 2009). The outer part of the hedgehog house exists of ‘big room’ in which the sleeping box can be placed. There is a small corridor to this “big room”, to prevent predators going in and to prevent draft (Fig. 17). This corridor goes a bit upwards to prevent water going in. The entrance should be around 10-15 x 15 cm (Zoogdierverseniging, 2009). Furthermore there are some vents for ventilation in the “big room”, since the humidity is much higher in such a house than it will be in a natural nest.



**Figure 17. Hedgehog house.** Outer box of hedgehog house, inside the big hole, a cardboard box can be placed filled with dried leaves, to provide a nice sleeping environment (picture adjusted from Zoogdierverseniging, 2009).

A hedgehog house as described above can be implemented in some big plant holders, such as the ones people like to put on their terraces, or in the pedestal of a small statue. If it is implemented in such an ornament the same requirements as described above should be met. But in this case the ventilation is even more important, since it is then more surrounded by soil or stones. We therefore suggest to make small vents which allow enough ventilation. These holes may be made in such a way that it is possible to look inside. Therefore it is possible to see if the ornament is inhabited. To make it easy to clean or replace the sleeping box, the ornament should have a hatch implemented in it.

To make a fancier ornament, a webcam could be added to see what happens inside the hedgehog house (see chapter 7.2). If a webcam is added, the vents do not have to function as a window anymore, but they still should be there.

To enlarge the chance a hedgehog will use the housing, the ornament should be placed on a quiet



**Figure 18. Roof tile wall**, inspiration for open wall tiles in the garden (Picture: Djoeke Langeloo).

place in the garden, preferably close to a hedge or a wall. If possible the entrance should not be directed to the windy side, most of the time that is the north, or north east side. Therefore, when implemented in a statue, it should not be fixed on the pedestal, so it can be moved when necessary. Another option is to offer the statue pedestal combination in more than one version of the statue (with entrances facing different directions). Besides the correct direction and location of the housing, the environment is also an important

factor. If a natural environment is available in which the hedgehog can hide and in which it can forage, it is more likely the housing will be inhabited. Hedgehogs like slugs, so they are really useful as a pest control against slugs, but they will also eat cat food when provided (Zoogdiervereniging, 2009).

Small ceramic pots in which animals can hide can also be placed in your garden. These can be combined with flowers or small plants to give them a nice look. It is also a nice option to develop a wall of (roof)tiles that have many open spaces in which amphibians and insects can hide. Also this option can be combined with plants. If there is some water close to the wall, it might be used by amphibians and insects. This idea is based on Figure 18. This could be sold as a general idea, creating a net of roof tiles with different separations that can be half buried in the garden, with spaces in between to fit flowers or plants.

### Roof ornament

Throughout history, roofs and doors all over the country have been decorated with different items like facade signs. The facade signs are usually wooden ornaments that are added to the top of the roof as decoration. In the north of the Netherlands this decoration also covered the first part of the facade, to make sure the roof would not leak. These decorations are called 'Uilenborden', but have many dialect names as well (Figure 19). These 'Uilenborden' were the inspiration for another fauna house developed here. Since they are not really common in Zeeland they can be used as a new ornament for the roofs. In the triangle are holes, through which owls can enter the barn.



**Figure 19. "Uilenbord"**.  
Source: Riet Promotie

Nowadays, the 'Uilenborden' can be combined with nest boxes for owls. Screech owls (*Megascops spp.*) nest in boxes with an entrance opening of 6.5-7 cm. 15 cm behind the first entrance opening is a second entrance of the same size, which is not directly in line with the first opening. This is to make the second part dark (Landschapswerkgroep Abcoude, 2011). The second part should be at least 40 cm wide and 40 cm high. Other options are to implement the roof ornament to the roof of a shed, or to put other kinds of nest boxes behind it for other bird species.

For this latter option the original entrance should be ignored, but instead small boxes should be placed, in the example given, behind the curved necks of the swans. If it is planned to have more than one nest box in one roof ornament, the box should meet the requirements of colony breeders as described in chapter 6.

## 8.5 Artificial trees

In nature, hole breeding birds will look for hollow trees to nest in, these can mainly be found in old (dead) trees. Since nature management in the Netherlands is well organised, most trees are felled at a young age so that less suitable cavities are available in nature (Newton, 1994). Although new management options highlight the need to maintain old, dead trees to enhance



**Figure 20: Artificial tree hollow** . Source: Garden Glow.

biodiversity, not enough of these are available yet (Erik Korsten, pers. comm.). Nest boxes for birds can provide artificial nesting places and are widespread available in web-shops, garden centres, etc. We think that it will not be interesting for Traas to provide nest boxes as well, since nest boxes cannot fulfil the criteria for new products mentioned earlier. A more creative and innovative idea however, is the design of an artificial hollow tree.

The simplest execution of this idea is to place a trunk of a tree and make an artificial hollow in it, with a size that fits the target bird. An impression is given in figure 20.

Also for an artificial hollow tree it is possible to combine both art and functionality. An artist can design a tree for a specific location and include a hole in the tree that is suitable for a chosen target species. Again, a target species need to be a hole breeding bird and may be a colony breeding bird when the main goal is creating a nesting place for many birds around or in the tree. However, the target may also be bats, as forest dwelling species are dependent on tree whole and hollow dead trees (Ciechanowski, 2005). When the target species is not a colony breeding bird, one should realize that the tree will only be inhabited by only one (pair of) bird. To make it more impressive, we advise to focus on birds of prey like owls or kestrels. Be aware that for example the long-eared owl (*Asio otus*) is not a hole-breeder and therefore not suitable for an artificial hollow. The nest box requirements of the birds of prey are presented in table 7.

Due to the nesting requirements, we think that building an artificial tree for a little owl or a kestrel, or for tree hollow roosting bat species (such as Daubenton's bat) would be most successful. However, this idea needs to be worked out in more detail, to know more about the nest box requirements and preferred location of the birds, in order to have the highest change of success. Also some research is needed to find out to what extent the tree should look like a natural tree.

The costs will depend on the design of the artificial tree. A cheap version could be designed of a straight pole with on top an artificial hollow or nest box. A more extended version of a tree, including branches will obviously be more expensive.

Potential clients of these artificial hollow trees are municipalities, farmers, companies and owners of orchards. Besides it can be interesting for private persons with a large garden, close to the natural habitat of the target species or for managed forest which lack old hollow trees.

**Table 7. Nest box requirements of several birds of prey.** Source: Nestkastbouw.

Species	Size (LxWxH) (cm)	Opening (cm)	Placement height	Details
<b>Little Owl</b> (‘Steenuil’, <i>Athene noctua</i> )	75 x 30 x 23	7.0 Equipped with jackdaw lock that prevent entering of jackdaws.	2 – 4 m	The barn owl prefers a half open agricultural landscape. Place the nest box in an orchard, wooded bank or small group of trees at farm/house). Important are an unobstructed view and a quiet location.
<b>Barn Owl</b> (‘Kerkuil’, <i>Tyto alba</i> )	100 x 50 x 50 The box is divided in different compartments	12.5	3 – 20 m	Barn owls prefer to nest in old buildings, sheds, church towers and old trees. Nest boxes are often placed in attics of buildings.
<b>Kestrel</b> (‘Torenavalk’, <i>Falco tinnunculus</i> )	30 x 40 x 30	Half open nest box	> 6 m	Unobstructed view over pastures or fields.

## 8.6 Other ideas

In previous sections several ideas of habitat providing objects were worked out in detail. However, we thought of more creative ideas and we would like to mention them briefly in this section.

From an economical point of view, it is wise to provide a nesting / feeding place for birds and mammals on an existing location or building. A first idea is to place nest boxes of birds or bat boxes on or underneath power pylons (Figure 21). Also insect hotels or for example a hedgehog shelter can possibly be placed below the power pylon. Especially on agricultural fields, the squared areas below the power pylon are often not used, since it is not possible to drive with a tractor underneath. Only in pastures these squares are used by grazing cattle. We tried to contact Essent, an electricity providing company, to find out whether it is possible to build something underneath the electricity poles or to attach nest boxes on the poles. Unfortunately, Essent did not reply. Because this idea can only be worked out when there is permission, first more information is needed where this permission can be obtained. This might be Essent, another electricity providing company in Zeeland or TenneT, the administrator of the national electricity grid. Besides that, some research has to be done to know more about the risks birds are facing when nesting close to electricity wires.



**Figure 21: Power pylon with an unused patch below.** Source: Papendrecht.net, 2008.



**Figure 22 : Electricity house** (Picture: Jeltje Stam)

Large numbers of empty electricity houses can be found in Zeeland (Figure 22). These houses include a transformer, or are not in use anymore. It can be interesting to develop some ideas to adapt such electricity houses to provide a nesting / feeding habitat for birds or mammals. We think that these houses can be suitable for bats species. This idea can be developed using the knowledge provided in part I about bat housing. Further studies can focus on developing such bat houses or can look for possibilities to make these houses attractive for birds or even mammals. Similar to

the power pylon, permission is needed to make adaptation in those electricity houses.

Another idea is to develop housing for colony breeding birds, a bit like the functional fauna art, but with a single purpose of providing habitat for a colony of birds. Inspiration can be gained in figure 23 where two different designs are showed of a house martin nesting house. The house martin house in Elsendorp did not accommodate any birds yet, we think because of a wrong location of the house. Such habitats should be provided in cities or villages, where house martins



**Figure 23: House martin nesting house in Biddinghuizen** (Source: Dorpsbelangen Biddinghuizen) **and Elsendorp** (source: Vogelwerkgroep Gemert).

do have a foraging habitat, but where suitable nesting locations are rare. In Germany there are several house martin houses placed and successfully used (Vliegvlug Meppel, 2009). However, one should realize that this idea does not meet all new design criteria we have described before, because a similar design will not be new and innovative. However, this might also be an advantage, because practical experiences and knowledge is available, which can help to make the

housing successful. If Traas decide to continue with this idea, more information need to be found on the best location of this house martin house and the specific design criteria.

The final idea focuses on the combination of providing nesting habitats with pest control. An interesting study by Mols and Visser (2002) showed that placing of bird boxes for great tits in apple orchards, caused a reduction in caterpillar damage to apples from 13.8% to 11.2%. Besides, the yield of fruits increased significantly from 4.7 to 7.8 kg apples per tree. This study proved that great tits can certainly contribute to biological control in fruit orchards, although single great tits on their own cannot reduce caterpillar damage below the threshold. Only 2 nest boxes per ha already allowed great tits to breed in the orchard. More research is needed to find out more ways in which providing nest boxes can contribute to biological pest control.

## 9 Conclusions and Recommendations

### Conclusions

- Habitat destruction in Netherlands is mainly due to intensive agriculture in the past century. Significant improvement in fauna conservation observed in recent years because of effective compensation measures along with habitat restoration activities. is being implemented – still slight decrement in average population of all species.
- The initial idea of fauna tower (Traas) to provide artificial habitat for several local species in Zeeland is not realistic and viable because of territorial behaviour, predator prey relation, inter-species as well as intra species competition for resources.
- We proposed several alternatives rather than fauna tower to provide nesting/feeding habitat for different animals in Zeeland.
- The Functional Fauna Art is mainly focused on colony breeders and realistic for birds who naturally nest in holes (e.g. common swift, house sparrow, house martin, barn swallow).
- Bird wall, Garden and roof ornaments is the concept of conserving fauna with garden decoration meanwhile provide habitat for birds and other mammals.
- For hole breeding birds, making artificial hole in artificial trees of specific size is another alternative for fauna tower which should be focused mainly on birds of prey like owls or kestrels.
- Building nesting/feeding place for fauna on an existing buildings and towers is another economic alternative for fauna tower. Bird nest on an power pylon, use of empty electricity houses and developing housing for colony breeding birds are some realistic innovative concepts as an alternative to fauna tower.

### Recommendations

- Further research is needed to explore more about local birds and their habitat requirement in order to select appropriated site to build different towers.
- The design criteria for proposed alternatives can vary with the existing environment setting mainly the climate, so the local climate as well as weather should be keep in mind while designing the towers.
- The proposed alternative ideas can also implement for other species which are not listed in this report. So, more research on species found in Zeeland will create possibility of designing habitat for other species.
- While combining species, it is very important to look on their ecological function and territorial as well as competitive (intra species as well as inter species) behavioural with in ecosystem.



# GENERAL CONCLUSIONS



Picture by Jeltje Stam.



## 10 Conclusions

The goal of this project was to provide artificial habitats for local fauna in the Dutch province of Zeeland. In order to fulfill that goal, the concepts of the bat tower and artificial fauna housing were studied and were possible designed. The research question on which the project is based is: how should bat towers and fauna housing be designed in order to provide suitable habitats for local fauna in the province of Zeeland, while being attractive for Traas and their potential clients?

Throughout the whole project, two criteria showed to be of paramount importance for fauna housing in general to be successful: the functionality of the housing and the environment in which it is placed. The functional design of the artificial habitats has to be developed very carefully for each product; the habitat needs of the animals in question have to be thoroughly researched before deciding on how to design the interior of the habitats. The outside of the habitats is of less importance for the animals and is almost entirely related to human taste. The second important point to keep in mind while designing fauna housing is the location in which it has to fit. Even the best design will fail if it is not placed on a favourable location for the targeted species. Knowing which environment the species needs and if it is already present in the vicinity is an important clue to a successful fauna housing placement.

During the last seven weeks, we noticed that there definitely is a future for artificial habitats and that these could be successful products to sell to different target groups like individuals, municipalities, regions, associations etc. However, as was clear from the literature and the interviews with different experts, although it all may work in theory, having pilot tests and practical trials for each product is highly recommended. The idea of the bat tower for example is not new but very little is known about the success rate of previous and contemporary attempts to house bats in special buildings. With this research, we aimed at giving our commissioner all the clues available to build a successful bat tower in theory but this should be tested before bringing the product out on the market. This process of testing the habitats in practical situations should be used for all the habitats our commissioner wants to explore and eventually sell. For this, close collaboration with experts in different fields is recommended.

Finally, we encourage our commissioner to continue to come up with new ideas and explore this new branch of nature conservation. We think it is important for Traas to be innovative and leading in this domain and we believe that there will be a growing support and interest in products related to the field of nature conservation and enhancement in the coming years.



# APPENDICES



## I. References

- Allinson, G., Mispagel, C., Kajiwarra, N., Anan, Y., Hashimoto, J., Laurenson, L., Allinson, M., & Tanabe, S., 2006. "Organochlorine and trace metal residue's in adult southern bent-wing bat (*Miniopterus schreibersh bassanii*) in southeastern Australia", *Chemosphere*, Volume: 64 Issue: 9 Pages: 1464-1471.
- Bachynski, K., Harris, M., 2002. "*Tyto alba*" (On-line), Animal Diversity Web. Accessed October 17, 2011 at:  
[http://animaldiversity.ummz.umich.edu/site/accounts/information/Tyto\\_alba.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Tyto_alba.html).
- Baranauskas, K., 2009. "The use of bat boxes of two models by Nathusius' pipistrelle (*Pipistrellus nathusii*) in southeastern Lithuania," *Acta Zoologica Lituanica*, vol 19, issue 1, 3-9.
- Baranauskas, K., 2003. "The first data about the hibernation of Daubenton's bat (*Myotis Daubentonii*) in the Paneriai tunnel (Vilnius, Lithuania)", *Acta Zoologica Lituanica*, Vol 13, Numerus 4.
- Bat Conservation and Management, Inc. (1998-2006). Accessed October 16<sup>th</sup>, 2001at:  
<http://www.batmanagement.com/Ordering/condos/batcondo.html>
- Bekker, J.P., Buise, M., Calle, L., Dobbelaar, S., Fortuin, A., Hannewijk, A., Jacobusse, G., K. de Kraker, K. de., Vliet, J., Wieland, A., J & Willemsen J., 2010. "Zoogdieren in Zeeland". Fauna Zeelandica Deel 6, Zoogdierwerkgroep Zeeland & Het Zeeuwse Landschap, p 40-43.
- Bird Box Cameras, Copyright © 2010; d Box Cameras, Copyright © 2010; Accessed October 12<sup>th</sup>, 2011 at:  
[http://www.birdboxcameras.co.uk/productdetail\\_1.php?category\\_id2=201&product\\_id=101023](http://www.birdboxcameras.co.uk/productdetail_1.php?category_id2=201&product_id=101023)
- Biopix: JC Schou. Accessed October 16<sup>th</sup>, 2011  
at: <http://www.biopix.dk/photo.aspx?photoid=20358&photo=myotis-dasycneme>
- Boonman, M., 2000. "Roost selection by noctules (*Nyctalus noctula*) and Daubenton's bats (*Myotis daubentonii*)", *J. Zool.*, vol 251, 385-389.
- Bosch en Slabbers tuin- en landschapsarchitecten bv., 1995. *Landschapsbeleidsplan gemeente Borsele voor de periode 1995-2005*, Gapinge/Heinkenszand.
- Boyles, J. G., Cryan, P. M., McCracken, G. F., & Kunz, T. H., 2011. "Economic Importance of Bats in Agriculture" *Science* VOL 332 1 APRIL 2011.
- Camfield, A., 2004. "Motacillidae" (On-line), Animal Diversity Web. Accessed October 17<sup>th</sup>, 2011 at:  
<http://animaldiversity.ummz.umich.edu/site/accounts/information/Motacillidae.html>.
- CBS., 1997. "Biobase Register Biodiversiteit". CBS. Voorburg/Heerlen.
- Chris, D. F., 2005. "Nest Boxes". Extracts from British Trust for Ornithology Field Guide Number 23 with some additions and amendments. British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU.
- Ciechanowski, M., 2005. "Utilization of artificieral shelters by bats (Chiroptera) in three differenttypes of forest", *Folia Zool.*, vol 54, issue 1-2, 31-37.
- Clavero, M., Garcia-Berthou, E., 2005. "Invasive species are the leading cause of animal extinctions", *Trends in Ecology and Evolution*, vol 20, issue 3, 110.
- Dakota, A., 2009. "*Troglodytes troglodytes*" (On-line), Animal Diversity Web. Accessed October 17, 2011 at:  
[http://animaldiversity.ummz.umich.edu/site/accounts/information/Troglodytes\\_troglodytes.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Troglodytes_troglodytes.html)

- Dewey, T., Roth, C., 2002. "*Hirundo rustica*" (On-line), Animal Diversity Web. Accessed October 17, 2011 at:  
[http://animaldiversity.ummz.umich.edu/site/accounts/information/Hirundo\\_rustica.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Hirundo_rustica.html)
- Dienst Landelijk Gebied, Ministerie van Economische Zaken, Landbouw en Innovatie; Ontwikkeling Militaire terreinen. Accessed October 19<sup>th</sup> 2011 at:  
<http://www.ontwikkelingmilitaireterreinen.nl/pages/magazijnencomplex-baarle-nassau.aspx>, last retrieved on 19-10-2011.
- Elrich, P. R., Pringle R. M., 2008. "Where does biodiversity go from here? A grim business-as-usual forecast and a hopeful portfolio of partial solutions", *PNAS*, vol 105, supplement 1, 11579-11586.
- Europese Unie., 2011. "Natuurlijke habitats", *Natura 2000*, Accessed October 14<sup>th</sup>, 2011 at:  
[http://europa.eu/legislation\\_summaries/environment/nature\\_and\\_biodiversity/l28076\\_nl.htm](http://europa.eu/legislation_summaries/environment/nature_and_biodiversity/l28076_nl.htm).
- Fahrig, L., 2003. "The effects of habitat Fragmentation on Biodiversity", *Annual Review of Ecology, Evolution and Systematics*, vol 34, 487-515.
- Fernandez-Juricic, E., Jokimäki, J., 2001. "A habitat island approach to conserving birds in urban landscapes: case studies from southern and northern Europe", *Biodiversity and conservation*, vol 10, 2023-2043.
- Flaquer, C., Guerrieri, E., Monti, M., Rafols, R., Ferrer, X., Gisbert, D., Torre, I., Puig-Montserrat X., & Arrizabalaga A., 2011. "Bats and pest control in rice paddy landscapes of Southern Europe"; *XII European Bat Research Symposium*; August 22-26, 2011; Vilnius, Lithuania (Abstract).
- Forman, R. T. T., Alexander, L. E., 1998. "Roads and their major ecological effects", *Annual Review of Ecology and Systematics*, vol 29, issue 207, 31.
- Frank P. A., 1997. "First Record of *Molossus molossus tropidorhynchus* Gray (1839) from the United States", *Journal of Mammalogy*, vol 78, issue 1, 103-105.
- Garden Glow. *Habitat creation*. Accessed October 17<sup>th</sup>, 2011 at:  
<http://www.gardenglow.net.au/habitat-creation/>
- Geerts, R.H.E. M., Meerburg, B.G., 2010. "Vogels en Vleermuizen in de Hoeksche Waard en hun bijdrage aan Functionele AgroBiodiversiteit (FAB); Resultaten van een globale inventarisatie in 2009" *Plant Research International* B.V., Wageningen, the Netherlands.
- Gehrt, S.D., Chelsvig, J.E., 2004. "Species-specific patterns of bat activity in an urban landscape", *Ecological Applications*, vol 14, 625-635.
- Gierzwaluwbescherming Nederland. 2011. " Acceptatie van kunstnesten door de gierzwaluw in Berlijn," Accessed on October 16<sup>th</sup>, 2011 at:  
[http://www.gierzwaluwbescherming.nl/onderzoek\\_nestkast.html](http://www.gierzwaluwbescherming.nl/onderzoek_nestkast.html).
- Halfwerk, W., 1996. " Natuur in Zeeland" – *Tussen zee en zoom*. De Koperen Tuin, Goes.
- Hunt, K., 2011. "*Athene noctua*" (On-line), Animal Diversity Web. Accessed October 17<sup>th</sup>, 2011 at:  
[http://animaldiversity.ummz.umich.edu/site/accounts/information/Athene\\_noctua.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Athene_noctua.html)
- Hutson, A. M., Mickleburgh, S. O., & Racey, P. A., 2001. "Microchiropteran bats", IUCN, Gland, Switzerland and Cambridge, UK.
- IBSTOCK © IBSTOCK Building Industry, eco- products. Last visited on 05-10-2011 at:  
<http://www.ibstock.com/sustainability-ecozone.asp>

- IUCN, 2011. "IUCN Red List of Threatened Species", Version 2011.1. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 10 October, 2011.
- Jacobusse C., Hemminga, M. A., Karman, A. A., 2001. "Zeldzaam Zeeuws" – *Bijzondere planten en dieren in Zeeland*. Stichting Het Zeeuwse Landschap, Heinkenszand.
- Johan B.M., Thissen, D. B., Hans H. de I., van Strien. A. J., 2009. "The 2006 national Red List of mammals of the Netherlands and a IUCN Regional Red List", *Lutra*, vol 52, issue 1, 23-35.
- John, A. M., Janseen, J., Schaminée, H. J., 2008. "Europese Natuur in Nederland; Soorten van de Habitatrichtlijn", KNNV Uitgeverij, Zeist.
- Kals, E., Schumacher, D., Montada, L., 1999. "Emotional Affinity toward Nature as a Motivational Basis to Protect Nature", *Environment and Behaviour*, vol 31, 178-202.
- Landschapswerkgroep Abcoude, 2011. Accessed October 13<sup>th</sup>, 2011 at: <http://www.landschapswerkgroepabcoude.nl/files/PDF/Nestkasten/steenuilkast.pdf>.
- Landschap, B., 2009. "Ontgonnen verleden". *Regiobeschrijvingen provincie Zeeland*, rapport 2009/dk116-J, Directie Kennis/Ministerie van Landbouw, Natuur en Voedselkwaliteit; Ministerie van LNV, directie IFZ/Bedrijfsuitgeverij: Ede.
- Logiudice, K., Ostfeld, R., Schmidt, K. A., Keesing, F., 2003. "The ecology of infectious disease: Effects of host diversity and community composition on Lyme disease risk", *PNAS*, vol 100, issue 2, 567-571.
- Loso, H., 1999. "*Mustela erminea*" (On-line), Animal Diversity Web. Accessed October 17<sup>th</sup>, 2011 at: [http://animaldiversity.ummz.umich.edu/site/accounts/information/Mustela\\_erminea.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Mustela_erminea.html)
- Lundrigan, B., Conley, M., 2001. "*Mustela putorius*" (On-line), Animal Diversity Web. Accessed October 17, 2011 at: [http://animaldiversity.ummz.umich.edu/site/accounts/information/Mustela\\_putorius.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Mustela_putorius.html)
- Martin, J., Henrichs, T., Velkavrh, A. P., Volkery, A., Jarosinska, D., Csagoly, P., & Hoogeveen, Y., 2010. "The European environment," *State and outlook-synthesis report*, European Environment Agency, Copenhagen, Denmark.
- Masing, M., Baranauskas, K., Siivonen, Y., Wermundsen, & T., 2009. "Bats hibernating in Kaunas Fortress, Lithuania", *Estonian Journal of Ecology*, Volume 58, Issue 3, Pages 192-204.
- Mickevieiene, I., Mickevieius, E., Baranauskas, K., 1999. "Notes on Summer Distribution of Bats in Lithuania"; *Acta Zoologica Lituanica*, Volume 9 Issue 1 Pages 16-19.
- Ministry of Agriculture, Nature and Food Quality., 2005. "Nature Conservation in the Netherlands Contents". Department of Nature, The Hague, the Netherlands.
- Mispagel, C., Allinson, M., Allinson, G., Iseki, N., Grant, C., & Morita, M., 2004. "DDT and metabolites residues in the southern bent-wing bat (*Miniopterus schreibersii bassanii*) of south-eastern Australia," *Chemosphere*, Volume: 55 Issue: 7 Pages: 997-1003.
- Mitchell-Jones A. J., Cooke, A. S., Boyd I. L., & Stebbings, R. E., 1989. "Bats and remedial timber treatment chemicals; a review," *Mammal Review*, Volume 19, Issue 3, pages 93-110.
- MNP., 2006. "Nature Balance 2006". Milieu- en Natuurlandbureau (MNP), Bilthoven, The Netherlands.
- Mols, C.M., & Visser, M. E., 2002. "Great tits can reduce caterpillar damage in apple orchards," *Journal of applied Ecology* 39, 888 – 899.
- Nature Cameras Limited, © 2011; Accessed October 18<sup>th</sup>, 2011 at: <http://www.naturecameras.co.uk/boxwireless.php>
- Natuurmonumenten. *Insectenhotel*. Accessed October 10<sup>th</sup> 2011 at: <http://www.natuurmonumenten.nl/sites/default/files/Insectenhotel.pdf>.

- NCRV. 2007. "Aflevering 6: Zuidwest-Zeeland", *Nationale landschappen*, NCRV Natuurlijk. Accessed October 18<sup>th</sup>, 2011 at <http://nationalelandschappen.ncrv.nl/ncrvgemist/ncrv-natuurlijk-nationale-landschappen-26>
- Nelson, T., Fraser, A., 2006. "*Falco tinnunculus*" (On-line), Animal Diversity Web. Accessed October 17, 2011 at: [http://animaldiversity.ummz.umich.edu/site/accounts/information/Falco\\_tinnunculus.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Falco_tinnunculus.html)
- Nestkastbouw. *Specialist in het maken van nestkasten voor uilen, roofvogels en zoogdieren*. Accessed October 15<sup>th</sup>, 2011 at: <http://www.nestkastbouw.nl/>
- Newell, T., 1999. "*Mustela nivalis*" (On-line), Animal Diversity Web. Accessed October 17<sup>th</sup>, 2011 at: [http://animaldiversity.ummz.umich.edu/site/accounts/information/Mustela\\_nivalis.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Mustela_nivalis.html)
- Newton, I., 1994. "The role of nest sites in limiting the numbers of hole-nesting birds; a review," *Biological Conservation* 70, 265-276.
- Nieuwerkerken, E.J., Loon, V., 1995. "Biodiversiteit in Nederland," Nationaal Natuurhistorisch Museum. Leiden.
- NorfolkBatGroup © 2008. The Norfolk Bat Brick. Last visited on 05-10-2011 at: <http://www.norfolk-bat-group.org.uk/norf.html>
- Notenboom, J., Van Veen M., & Wesselink, L.G., 2006. "Halting the loss of biodiversity in the Netherlands," *MNP report*, 500094001. Netherlands Environmental Assessment Agency, Bilthoven.
- Overbeek, M.M.M., Somers, B.N., Vader, J., 2008. "Landschap en burgerparticipatie", *WOt-rapport* 65, Wettelijke Onderzoekstaken Natuur & Milieu: Wageningen.
- PBL, 2009. "State of the Nature 2009". *PBL publication*, 500402017, Planbureau voor de Leefomgeving, Bilthoven, the Netherlands. Accessed October 5<sup>th</sup>, 2011. Report at: <http://www.mnp.nl/bibliotheek/rapporten/500402017.pdf>. English summary at: [http://www.pbl.nl/images/Nature\\_Balance\\_2009\\_-\\_Summary\\_tcm61-44828.pdf](http://www.pbl.nl/images/Nature_Balance_2009_-_Summary_tcm61-44828.pdf)
- R. E. Stebbings, R. E., 1988. "Conservation of European bats," *Christopher Helm* (Publishers) Ltd, Imperial House, Brombley, Kent, UK.
- Regiebureau Natura 2000. 2011. "De natuur beleven, gebruiken en beschermen". Accessed October 14<sup>th</sup>, 2011 at: <http://www.natura2000.nl/>.
- Reiter, G., Zahn, A., 2006. "Bat roost in the alpine area: Guidelines for the renovation of buildings", *Living space network*, INTERREG IIIB.
- Rijksoverheid., 2011. Iedereen mag meepraten over nieuwe Natuurwet. Accessed October 16<sup>th</sup>, 2011 at: <http://www.rijksoverheid.nl/nieuws/2011/10/06/iedereen-mag-meepraten-over-nieuwe-natuurwet.html>.
- Roberts, C., 2011. "*Erinaceus europaeus*" (On-line), Animal Diversity Web. Accessed October 17, 2011 at: [http://animaldiversity.ummz.umich.edu/site/accounts/information/Erinaceus\\_europaeus.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Erinaceus_europaeus.html)
- Robinson, R. A., 2005. "Bird Facts: profiles of birds occurring in Britain & Ireland," *BTO Research Report* - 407, BTO, Thetford. Accessed October 5<sup>th</sup>, 2011 at <http://www.bto.org/birdfacts>
- Roofvogelboerderij. 2010. "Roofvogelshow". Visited on 2011-10-11 at: <http://www.roofvogelboerderij.nl/pagina/9/0/roofvogelshow>

- Shore, R. F., David, G., Myhill, Wright, J., 1999. "A comparison of the toxicity to laboratory mice and pipistrelle bats *Pipistrellus pipistrellus* of exposure to remedially-treated timber," *Environmental Toxicology and Pharmacology*, Volume 2, Issues 2-3, 15 October 1996, Pages 125-129.
- Soortenbank. Kerkuil (*Tyto alba*). Accessed October 5<sup>th</sup>, 2011 at: <http://www.soortenbank.nl/soorten.php?soortengroep=vogels&record=Tyto+alba>
- SOVON and Vogelbescherming Nederland, 2011. "Advieslijst boerenzwaluwvriendelijke maatregelen," Accessed October 11<sup>th</sup>, 2011at: [http://www.sovon.nl/pdf/Boerenzwaluw\\_Erfscan.pdf](http://www.sovon.nl/pdf/Boerenzwaluw_Erfscan.pdf).
- Sparkfun Electronics; © 2010 Humidity and Temperature Sensor - SHT15 Breakout. at: <http://www.sparkfun.com/products/8257> Accessed October 16<sup>th</sup>, 2011
- SpycameraCctv; © 2007 Open Twenty Four Seven Ltd. Spy Camera CCTV; Accessed October 19<sup>th</sup>, 2011 at: <http://www.spycameracctv.com/spycamera/wireless-birdbox-day-night-hidden-camera-receiver>;
- Stansley, W., Roscoe, D. E., Hawthorne, E., & Meyer, R., 2001. "Food chain aspects of chlordane poisoning in birds and bats," *Archives of Environmental Contamination and Toxicology*, Volume: 40 Issue: 2 Pages: 285-291.
- Strife, S., 2010. "Reflecting on Environmental Education: Where is out Place in the Green Movement?," *The Journal or environmental Education*, vol 41, issue 3, 179-191.
- Thompson, K., Fraser, A., 2006. "*Apus apus*" (On-line), Animal Diversity Web. Accessed October 17, 2011 at: [http://animaldiversity.ummz.umich.edu/site/accounts/information/Apus\\_apus.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Apus_apus.html)
- Totemdier: de Egel. Accessed on October 16<sup>th</sup>, 2011 at <http://www.sjamaanrudy.be/Egel.html>
- Treehugger. © 2009. Award-winning Architectural Bat House Opens for Batness. Accessed October 17, 2011 at: <http://www.treehugger.com/files/2009/09/award-winning-bat-house.php>.
- Peter Twisk, Fons Aelberts; "Winterslaapplaatsen van vleermuizen, Leidraad bij de bouw, de inrichting en het beheer van vleermuiswinterverblijven", Vleermuiswerkgroep Noord-Brabant (no date); viewed online at [Vleermuizeninfo.be](http://www.vleermuizeninfo.be); Accessed October 5<sup>th</sup>, 2011 at: <http://www.vleermuizeninfo.be/download/BouwVleermuiswinterverblijven.pdf>
- U.S Fish and Wildlife Services., 2011. Pamphlets. Accessed October 15<sup>th</sup>, 2011 at: <http://www.pueblo.gsa.gov/cictext/misc/forbirds/forbird.htm>
- Van De Sijpe, M., Vandendriessche, P Voet, P., Vandenberghe, J., Duyck, J., Naeyaert, E., Manhaeve, M., & Martens, E., 2004. "Summer distribution of the Pond bat *Myotis dasycneme* (Chiroptera, Vespertilionidae) in the west of Flanders (Belgium) with regard to water quality", *Mammalia*, Volume 68, Issue 4, Pages 377-386.
- Van Veen, M. P., Brink, B. J. E., Braat, L. C., & Melman, Th. C. P., 2008. "Halting Biodiversity Loss in the Netherlands". Evaluation of progress. Planbureau voor de Leefomgeving, Bilthoven, The Netherlands. Accessed October 13<sup>th</sup>, 2011 at: <http://www.rivm.nl/bibliotheek/digitaaldepot/HaltingBiodiversityLossInTheNetherlands.pdf>
- Vivara. Accessed October 5<sup>th</sup>, 2011at: [http://www.vivara.nl/product/id=1063/egelwoonhuis\\_groot.html](http://www.vivara.nl/product/id=1063/egelwoonhuis_groot.html)
- Vliegvlug Meppel., 2009. "Vliegvlug plaatst zwaluwentillen", Accessed October 5<sup>th</sup>, 2011 at: <http://www.vliegvlugmeppel.nl/vliegvlugmeppel1/pdf/Meppeler%20Courant%20180209.pdf>

- Voûte, A. M., Lina, P. H. C., 1986. "Management Effects on Bat Hibernacula in The Netherlands", *Biological Conservation*, vol 38, 163-177.
- Vogelbescherming Nederland., 2010. "Meer vogels in de tuin – tips voor het inrichten van een vogelvriendelijke tuin," Fifth edition, Roto Smeets, Utrecht.
- Vogelbescherming Nederland<sup>A</sup>., 2011. "Tips vogels in de tuin," Accessed October 17<sup>th</sup>, 2011 at: <http://www.vogelbescherming.nl/tuinvogel/tuinvogels/tips>.
- Vogelbescherming Nederland<sup>B</sup>., 2011. "Plaats nestkast," Accessed October 12<sup>th</sup>, 2011 at: <http://www.vogelbescherming.nl/tuinvogel/nestkasten/plaats>.
- Waweka. Accessed October 12<sup>th</sup>, 2011 at: [www.waveka.nl](http://www.waveka.nl)
- Weijden, V., Leewis, W. J. R., & Bol, P., 2007. "Indicatoren voor het invasieproces van exotische organismen in Nederland". *Report 53.6*, Statutory Research Tasks Unit for Nature and the Environment. Wageningen, the Netherlands.
- Zoogdierenvereniging. 2009. "De Hermelijn (*Mustela erminea*)," Accessed October 11<sup>th</sup>, 2011 at: <http://www.zoogdierenvereniging.nl/node/484>
- Zoogdierenvereniging, A., 2009. Accessed October 18<sup>th</sup>, 2011 at: <http://www.zoogdierenvereniging.nl/node/822>
- Zoogdierenvereniging, 2009. "Practische tips en wetenswaardigheden over egels ook in uw tuin". Accessed on October 15<sup>th</sup>, 2011 at: <http://www.zoogdierenvereniging.nl/sites/default/files/imce/nieuwewebsite/Zoogdiersoorten/Egel/downloads/Egels%20ook%20in%20uw%20tuin%20een%20uitgave%20van%20de%20Zoogdierenvereniging.pdf>

## II. List of relevant Legislation

- Flora- en faunawet, 1998  
(Art. 2.1,3,4,8,9,10,11,12,26,75,75b)
- Natuurbeschermingswet, 1998  
(Art. 5,7,9,10,16,26,41,46)
- Wet bodembescherming, 1987  
(Art. 8.2a,13,27,28.3)
- Wet milieubeheer 1979, changed 2004  
(Art. 1.2,4.9,4.20,7.2,7.7)
- Wet natuur, 2012
- Wet ruimtelijke ordening, 2006  
(Art. 2.1.1,2.2.1,2.3,3.1,3.3,3.7.5,3.26, 3.28,3.36b,6.10)
- Arbeidsomstandighedenbesluit, 1997  
(Art. 3.13)
- Bouwbesluit, 2003, changed 2012
- Habitatrichtlijn, 1992
- Natura 2000
- Vogelrichtlijn, 1979



### III. List of fauna in Zeeland (Dutch, English and Latin name)

Latin name	Scientific name	Dutch name
<b>Birds</b>		
<b>Little owl</b>	<i>Athene noctua</i>	Steenuil
<b>Barn Owl</b>	<i>Tyto alba</i>	Kerkuil
<b>Long eared owl</b>	<i>Asio otus</i>	Ransuil
<b>House Martins</b>	<i>Delichon urbicum</i>	Huiszwaluw
<b>Barn swallow</b>	<i>Hirundo rustica</i>	Boerenzwaluw
<b>Common kestrel</b>	<i>Falco tinnunculus</i>	Torenvalk
<b>Hobby</b>	<i>Falco subbuteo</i>	Boomvalk
<b>Winter wren</b>	<i>Troglodytes troglodytes</i>	Winterkoninkje
<b>White wagtail</b>	<i>Motacilla alba</i>	Witte kwikstaart
<b>Common swift</b>	<i>Apusapus</i>	Gierzwaluw
<b>Spotted flycatcher</b>	<i>Muscicapa striata</i>	Grauwevliegenvanger
<b>Stock Dove or stock pigeon</b>	<i>Columba oenas</i>	Holenduif
<b>Common redstar</b>	<i>Phoenicurus phoenicurus</i>	Gekraagderoodstaart
<b>Bats</b>		
<b>Pond bat</b>	<i>Myotis dasycneme</i>	Meervleermuis
<b>Nathusius' pipistrelle</b>	<i>Pipistrellus nathusii</i>	Ruige Dwergvleermuis
<b>Daubenton's bat or Daubenton's myotis</b>	<i>Myotis daubentonii</i>	Watervleermuis
<b>Serotine bat</b>	<i>Eptesicus serotinus</i>	Laatvlieger
<b>Common pipistrelle</b>	<i>Pipistrellus pipistrellus</i>	Gewone dwergvleermuis
<b>Brown-eared bat</b>	<i>Plecotus auritus</i>	Gewone grootoorvleermuis
<b>Grey big-eared bat</b>	<i>Plecotus austriacus</i>	Grijze grootoorvleermuis
<b>Whiskered myotis</b>	<i>Myotis mystacinus</i>	Gewone bardvleermuis
<b>Natterer's bat</b>	<i>Myotis nattereri</i>	Franjestaart
<b>Noctule bat</b>	<i>Nyctalus noctula</i>	Rosse vleermuis
<b>Northern bat</b>	<i>Eptesicus nilssonii</i>	Noordse vleermuis
<b>Particoloured bat</b>	<i>Verpestilius murinus</i>	Tweekleurige vleermuis
<b>Brandt's bat</b>	<i>Myotis brandtii</i>	Brandts vleermuis
<b>Geoffroy's bat</b>	<i>Myotis emarginatus</i>	Ingekorven vleermuis
<b>Great mouse-eared bat</b>	<i>Myotis myotis</i>	Vale vleermuis
<b>Lesser noctule or Leisler's bat</b>	<i>Nyctalus leisleri</i>	Bosvleermuis
<b>Western barbastelle</b>	<i>Barbastella barbastelus</i>	Mopsvleermuis
<b>Bechstein's myotis</b>	<i>Myotis bechsteinii</i>	Bechsteins vleermuis
<b>Greater horseshoe bat</b>	<i>Rhinolophus ferrumequinum</i>	Grote hoefijzerneus
<b>Lesser horseshoe bat</b>	<i>Rhinolophus hipposideros</i>	Kleine hoefijzerneus

**Other Fauna**

<b>Stout</b>	<i>Mustela ermine</i>	Hermelijn
<b>European polecat</b>	<i>Mustela putorius</i>	Bunzing
<b>Least weasel</b>	<i>Mustela nivalis</i>	Wezel
<b>Western European hedgehog</b>	<i>Erinaceus europaeus</i>	Egel

## IV. Expert interviews

All interviews will be typed in the language they took place in.

### Björn van Loon, Education expert

**Expert:** Björn van Loon, intern at the Science Center NEMO (Amsterdam).

**Present:** Carmen Vazquez Martín, Djoeke Langeloo, Imke Kuiper, Jeltje Stam, Julia Samson, Sunil Pariyar.

**Date:** October 7, 2011

Educating people about bats and other local fauna in Zeeland is a very important aspect of the project we are working on. It is important to Traas that people, and especially children, learn that conserving species is not something that just happens; it takes knowledge, skills and effort to conserve nature. In order to get some ideas about educating people and how to reach different audiences in the most effective way, we asked Björn van Loon, an MSc Biology student from Wageningen University, to help us. Björn has been involved in the education of university and high school students and of broader audiences and is currently working as an intern at the education department of the famous museum and Science Center NEMO in Amsterdam.

The first and most important thing when trying to educate people is that, in order for the learning to really take place, people (especially children) need to do something. It is not enough to just tell or show them something about the topic, they need to be busy with it and work on it themselves. Björn had a quote to describe this: "Tell me and I will forget. Show me and I might understand. Involve me and I will know (and like)". This is especially true for young children because, under the age of 12, they have problems reading and memorizing information and it can be very discouraging for them to expect them to read and learn.

A second very important thing is to make sure the information is repeated several times; people have to come into contact with the information more than once in order for it to stick. This should preferably not happen on the same day. For children, fitting everything in one day is also too long and their concentration drops really quickly; 1,5-2 hours are more than enough. When working with children, the format used by NEMO is to prepare the children for the activity; this usually happens at school through a workshop or a specially themed lesson, given by the teacher; this requires material offered to the teacher, in a module or a reader. Also, having a themed lesson or workshop beforehand allows children to get used to the new topic and (unconsciously) allows the topic to sink in their minds. Then, the second encounter with the information takes place at NEMO and the children are asked to do something (like build their own rocket) and put the knowledge and skills they got during the preparation into practice. Inverting the activities (first the big activity like visiting the bat tower and then doing something about it like reading or modelling a tower) does not work that well because everything gets less impressive. For the learning to happen, it is important that the climax activity is placed at the end. This climax will be the "experience" and experiences last in people's memories. Having a great experience also gets people talking about it with friends, family and colleagues.

For the bat tower, one may think about designing school projects that have more than two contact moments. The conclusion on educating children is that it is very important to make them enthusiastic because they will tell about their experiences to their parents; this is an effective way to get the information to adults.

Then, we discussed how to reach other groups of people, especially adults without children to sensitize to the tower. Björn warned us that it would be very difficult to reach adults and make them enthusiastic if we only propose a tower and an excursion to visit the tower. Another problem is that older people (over 60) don't really understand topics on ecology and animal conservation. Björn advised to try to reach people living in Zeeland, in the area of the bat tower, first. Later, the area in which educational activities about the tower are offered can be extended outside of Zeeland. Important aspects in educating these people and making them interested in the educative activities were: using small groups of people, adding a (bat) excursion with the tower at the end (for example have a walk through nature and ending at the tower at dusk so one can see the bats flying in and out of the tower). This kind of education program should be quite short (one afternoon or evening) but quite some time should be spent on the tower (talking about it, working on it, visiting it...). Doing this together with organizations like Natuurmonumenten could be very interesting because of the famous name of Natuurmonumenten, which can help to attract people who are most likely to be interested in these projects. Other associations like the VVV should also be contacted so the tower is mentioned on maps and leaflets distributed in the region; this would allow Traas to get to people passing by the tower (tourists, bikers...). This is important because it is one thing to have people talking about it, but once people would like to visit it, they have to have access to information on where to find this tower.

For the groups of people not involving children, it is important to connect knowledge in order to make the information stick in their minds; this means that one could talk about the nature in Zeeland or explain how an ecosystem works and then connect this knowledge to the functioning of the bat tower. One thing to avoid are promotional talks; Björn said that people stop learning and being interested when the guide or teacher starts trying to sell the product or names the company very explicitly. Somehow, people seem to become immune for commercial talks; people interested in the tower come to visit it, no to buy things. Eventually, some of them might buy the tower but that should not be the focus of the activities. Setting up educational programs that can be given regularly should be thoroughly planned for 5-10 years and start locally.

When it comes to sensitizing people to buy products, it is important to remember that people need time to get used to new things (this is where it is important to have several contact moments as mentioned above). People also want to see products before buying them so it would be nice if Traas could sponsor the first products: give them to organizations, municipalities, schools etc. so people can get acquainted with these products and see how they work.

During the interview, we brought up the idea of using cameras in the tower or other fauna housing products; Björn said that cameras are always a good thing to make products more interesting. He had the idea to connect a camera in the bat tower to the local cafeteria so that it would be visible to everyone that there is a tower and what is actually happening in it, even if the people sitting in the cafeteria are not directly interested in it. People tend to have short concentration peaks for new things but if they are sitting in a cafeteria anyway, they will surely see the webcam several times. One should not underestimate the power of unconscious uptake of information by people. Another idea is to span a curtain or piece of fabric and light it to attract insects; this could be done near the bat tower to see some bats hunting the insects. This could be part of an excursion in which the guide shows people how important bats are for the food webs of that region for example. Another idea to make people interested is to sell articles inspired by nature like a CD with bat noises (similar to CD's with natural sounds or whales "singing").

Making products more attractive for the buyers could involve the development of make-it-yourself kits. Björn said that some products can be very interesting and attractive but that it's really the name that makes or breaks these products. One can sell useless make-it-yourself kits if the name is attractive. Of course, people will be disappointed afterwards if the product is bad; but the first goal (selling a product) depends on its name.) Personalized kits, where the customers can chose between different colours or materials or styles (like Ikea furniture: chose one model and then the size and the colour) can be interesting to use because people feel like they buy something unique and this adds to the attractiveness of a product.

We also discussed how to bring information to people in general, outside organized excursions or activities. Björn stressed the fact that making information leaflets does not work anymore and that leaflets nowadays can be used to announce an excursion or an activity but not to convey information. Giving information can best be done through the internet. We thought about making a website where people can play games to combine animals or develop apps for phones: to recognize species by the noise they make (like it is possible to look for a song just by having it play a few seconds to the phone), games to make fauna combinations, barcodes that can be scanned by phones and provide access to information...

As a conclusion, Björn emphasized that it is important that we trigger our commissioner to keep dreaming and find new ideas; even if they are not all realistic, some of them will eventually work out to be successful. So, it is best to start on a smaller scale, but keep your dreams as goals for the future.

### Jan Heersche, Landscape expert

**Expert:** Jan Heersche, landscape architect.

**Present:** Imke Kuiper and Julia Samson

**Date:** October 10<sup>th</sup>, 2011

Op 10 oktober 2011 hebben Imke en Julia een afspraak gehad met Jan Heersche. Jan Heersche is landschapsarchitect en werkt voor de Dienst Landelijk Gebied regio West / regio Oost. We bezochten hem met een paar vragen over het uiterlijk van de vleermuistoren en hoe deze wel of niet in het landschap (met name van Zeeland) ingepast kan worden.

Na een korte inleiding op ons project begon Jan meteen met de noodzaak voor ons om ons te richten op het beschrijven van de losse elementen waaruit de toren moet bestaan: de stenen, de openingen etc. Met deze beschrijvingen van de basiselementen voor een vleermuistoren geven we Traas de mogelijkheid flexibel te zijn in het ontwerpen van een dergelijke toren; we moeten ons niet vastpinnen aan een ontwerp.

Het idee waar we mee kwamen was om de vleermuistoren het uiterlijk van een molen te geven; het idee hierachter was dat dit goed in het landschap zou passen en ook per regio aangepast kon worden (verschillende stijlen molens voor verschillende regio's). De toren was geschat op vijf meter hoogte. Jan zei meten dat dat niet vergelijkbaar is met een molen (ongeveer 15 meter hoog); daarbij zouden er geen wieken aan de toren komen en zou het algehele beeld van de vleermuistoren dus tegenvallen (een hele kleine, niet eens complete namaak-molen). De toren op een windmolen laten lijken geeft het ook geen extra functie en heeft geen nut op zich; bovendien is er geen duidelijk verband tussen een molen en vleermuizen, dus er is geen reden om deze twee dingen te combineren.

Jan vroeg of de winter- en zomerverblijven bij elkaar gebouwd moeten worden. Is dit een vereiste vanuit de ecologie van de vleermuizen of kunnen de twee verblijven apart van elkaar staan? Een idee was ook dat als men een toren bouwt, men het fundament als kelder of winterverblijf kan gebruiken. Ook zou het mogelijk moeten zijn om een zomerverblijf boven op een geschikt winterverblijf (bunker bijvoorbeeld) te bouwen, mits het winterverblijf ook goed geïsoleerd wordt als dat nodig is. Jan opperde ook om een zomerverblijf en winterverblijf te combineren in een ruimte. Een goede isolatie zou dit wellicht mogelijk kunnen maken.

Een belangrijk punt gedurende de hele afspraak is dat we ons niet aan een tekening of ontwerp moeten binden (vooral wat het uiterlijk van de toren betreft). Voor een toren van vijf meter hoog maakt het niet uit of het in de Zeeuwse stijl gebouwd wordt of niet. Zeker wanneer de toren bij bomen of langs een heggenrij wordt geplaatst, zal de toren nauwelijks zichtbaar zijn en zeker niet boven de begroeiing uitsteken. Jan benadrukte dat we mogen pronken met de vleermuistoren op zichzelf en dat er geen noodzaak is de vleermuizen onopvallend weg te stoppen. Het ontwerp mag creatief en vernieuwend zijn met als enige doel het aanbieden van een habitat voor vleermuizen. Men zou bijvoorbeeld een (lokale) artiest kunnen vragen de buitenkant van de toren te ontwerpen of per stad of regio een verschillend ontwerp maken. Hierbij zou men de basiselementen, die niet veranderd mogen worden (hoogte, grootte openingen, indeling binnenruimte...), aan de ontwerpers geven en ze daarin de vrijheid geven die ze nodig hebben. Zo zouden de torens hun functionaliteit behouden en toch aangepast kunnen worden aan de smaak van het publiek. Smaken verschillen dus het is belangrijk een flexibele toren aan te bieden. Jan benadrukte ook dat niet alles altijd hoeft te passen; een toren hoeft niet perse bij de rest van de omgeving passen en mag best de aandacht trekken.

Een volgend idee waar Jan over begon was het aanpassen van bestaande gebouwen: fabrieksschoorstenen bijvoorbeeld, maar ook voersilo's op boerenerven. Hierbij zei hij dat je een voersilo niet middenin een veld kan plaatsen dus een van de hoofdvragen bij het bouwen van een vleermuistoren is: waar zet je welk ontwerp neer? Een aantal plekken die naar boven kwamen waren parken, boerenerven, bunkers, rotondes (Rijkswaterstaat heeft rotondes op N-wegen in beheer) en richtingsborden boven wegen (waar een vleermuiskast achter zou passen). Ondergrondse winterverblijven zouden bijvoorbeeld naast bunkers ook in dijken gebouwd kunnen worden. Een vraag van Jan aan ons was of het plaatsen van torens alleen zomerverblijven zou genereren en of dat een probleem zou zijn. Hij vertelde ook over een vleermuiskelder in Wielrevelt (Haarzuilens).

Tot slot vroeg Jan hoe het was met vleermuizen in de randstad. Hierover wisten we niet veel omdat we ons voor dit project op Zeeland concentreren. Jans vraag was gericht op de behoefte van een toren in de randstad: gaat het dan om een daadwerkelijke behoefte omdat vleermuizen te weinig ruimte hebben of is het alleen een mooi idee zonder echte problematiek of noodzaak? We hebben het interview afgesloten met het idee een keuzeboom te maken om onder andere de volgende vragen aan bod te laten komen bij het ontwerp van een toren: waar moet de toren staan? Hoe moet het eruit zien? Moet het in het landschap passen of moet het aandacht trekken? Wordt het in de buurt van een boerenbedrijf geplaatst of in een open veld of in het bos? Is er mogelijkheid om de toren met al bestaande gebouwen te combineren of moet het op zichzelf staan?

Uiteindelijk zijn we met een nieuwe blik terug naar Wageningen gegaan. Het is duidelijk dat men zich niet moet blindstaren op een bepaald ontwerp of idee. Daarnaast moet de functionaliteit

van het gebouw altijd bovenop staan en ook de enige reden zijn om zo'n vleermuistoren te bouwen.

### **Erik Korsten, Bat expert**

**Expert:** Erik Korsten, former member of the Mammal Society ('Zoogdiervereniging').

**Present:** Carmen Vazquez Martín and Jeltje Stam.

**Date:** October 12<sup>th</sup>, 2011

### **General information**

It is a good idea to find a sustainable solution to provide habitats for animals such as bats, swifts and sparrows in cities. However, when possible, it is better to adapt buildings to the animal's needs than to build new animals.

When there is no other choice, then it should be possible to build a new building dedicated to bats, but the requirements for a new building are much higher than those required when adapting an already existing building.

However the idea of using bats as pest control is quite interesting. It is important that this idea not be commercialized until we know if it works. Otherwise the idea is no longer a sustainable idea.

There are very few examples of bat towers in Europe. In the Netherlands there is a tower build by Peter Lina that has been known to host only one bat.

They build their own tower, but it is not proven if buildings like these work, so they managed to get a license to build a tower as research, and it must be monitored for five years after its construction. This tower is a little too small and has no temperature and humidity loggers. These are important because there is data on the roosting need (e.g. temperature, humidity) for different species. If there are no bats in your tower it might be because the tower does not meet the needs of the species or because the species has not found its way into the tower. If you have temperature and humidity loggers you can change the microclimate of the tower if it is needed. They have tried to bring an American design to Europe, the Bat condo.

This tower is usually used by little brown bat and big brown bat. Both species typically found in big cities. Both species are typical wood roosting species. Most European species are brick or stone roosters. Wood is good for the pigmy pipistrelle, not present in the Netherlands. There are three types of bat species depending on their roosting preferences: Crevice species (*P. nathusii*- pipistrelles and serotines), Hollow species (*M. daubentonii*- has very high humidity requirements as it loses water through the skin quite fast. They roost above water) and attic species (brown-eared bat, and grey bat).

You could build a tower that suits all types of roosting species, but it will work better if you pick only one. It is probably best to avoid attic species, as they need big spaces and not many animals will make use of the tower. Also if the aim would be pest control, maternity roosts can be perfect, as they usually host a very large number of animals.

Roosting areas have to be properly heated, even in the summer. Roosting bats have very high energy requirements. This is why they usually prefer massive brick buildings or the inside of trees, which can sometimes get very hot. If the roost gets too warm, the bats need to move. The height of the tower is very important, as it provides different microclimates.

A tower should be able to provide different microclimates, as different sides of the wall will provide different temperatures. When their roost offers all microclimates, they will not change roosts. However, bats are known to have networks of roost sites, connected by linear landscape features such as hedges and trees, so you could offer two separate towers that offer different climatic options (e.g. facing different directions) as long as they were connected. Bats rarely fly over open spaces, most likely to avoid predation. If it is windy, bats will not fly over open spaces at all. It's important to keep this in mind in the placing of the towers. Towers should be close to hedges for two reasons: bats can find the tower better when it is near hedge rows and bats feel safer to leave their roost if near hedges. This is important as the feeding requirements of lactating mothers is quite high and they often leave the roost before it is completely dark. If bats do not feel sufficiently protected they will not leave their roost until night time, which shortens their feeding time.

Close to what we want to build are artificial trees. There are a few articles on this on Bats Magazine. These have been researched. They are artificial hollow constructions situated on a humid area emulating an old tree, for those forested areas in which dead trees are not common. To find these articles we could 'google' his name, and in the same magazine as his article: A bigger bat house for the Netherlands, we can find two articles about artificial trees.

#### **Requirements for the tower:**

There should be up to two small entrances (no bigger than 2x10cm) situated high, so that bats can safely fly from the tower without being caught. It should be above 3 metres, this way you avoid vandalism (and predation). Entrances to roosting areas are rarely found under 2 metres. When this happens it is usually in small houses in the forest, with nearby trees for the bats to seek safety. In cities entrances can be much higher.

The entrance should be protected by a wooden panel. It should be separated by the wall by no more than two centimetres to prevent birds from nesting in the space.

There are no limits in how high the tower can be, however there are some building restrictions with buildings over 6 metres that make it interesting to build a tower under such heights.

It is best to have one open space between the walls under 4cm wide, as it may otherwise attract bees.

This space should be situated between two brick walls (ceramic is best as it keeps the warmth, cement may overheat). The space between the brick walls could be divided in two by a wooden panel, offering a new microclimate and the possibilities to avoid the outer walls. In such a way that the bats do not immediately touch the outer wall (which might be cold) when sitting between the outer wall and wooden panel.

The bricks should be rough, in his own tower they wrongly started using satin or glazed bricks, he was on time to tell them to turn some of the bricks at the top around, to provide a rough surface with grip. The wooden panels inside should be rough as well, maybe with slits or plastic mesh, thicker than mosquito net.

In the tower they already build, some of the inside stones were hollow and facing inwards, some were hollow and facing the wooden panel. In the second tower he designed, but was not built, one of the inside walls is filled with sand, as with more mass comes more heat, and it has been proved in some bat boxes in America that those with sand filled walls were warmer.

A similar double roof is also a good idea.

Ceramic is a good material in general. Also for the roof tiles and hollow bricks. Even though this is ideal as a maternity roost, males will use the outside of the tower, although not many.

The tower should have numerous crevices. Bats need to hide. Rats are a very important problem for bats, as they are good climbers and can eat them while bats are in lethargy.

To avoid vandalism, it is a good idea to build the wall down to the ground, as well as building the monitoring hatch at a height that is difficult to reach (maybe accessible with a ladder that is not present in the tower. Also good is to place a high voltage sign or an explanatory sign to ask for the place to be left alone.

Both for the tower and the hibernacula, it is important to remember that buildings with a door must be brought up to human health conditions. There are ways around it, such as building an inspection hatch (smaller than a door).

The inspection should be accompanied by removal of bat droppings, which make a very good fertilizer.

Roof tiles (such as those for birds) can only be used in very steep rooftops, as predators can easily access them otherwise. Also, bats need to fall a little before they start flying.

Bats can hibernate together and in groups that vary a lot in size.

Jeltje: Is there research being done in the tower you already built?

Erik: The monitoring started immediately after and happened every summer after. The owner is obliged to monitor the tower for at least five years. So far they have only found one long eared bat. They are quite opportunistic. The pipistrelles in the area before the demolition of the previous building were maybe killed in the demolition process, as the guidelines set by the experts were not followed. There are 5-6 males with a territory in the area. Some mothers with sub-adults might have moved in. They will not know more till next summer. He considers an important question whether wooden panels actually work as maternity roosts, and this has already been proved. Nursery panels with crevices work to host bats.

He shows us an example in Germany where they are turning telephone houses into fauna houses.

Jeltje: Is the article about bats and pest control available?

Erik: The article is quite new and has not been published yet. It was presented in a conference this year. The authors (Flaquer, Guerrieri, Monti, Rafols, Ferrer, Gisbert, Torre, Puig-Monserrat, Arrizabalaga) worked in rice plantations and added big bat boxes (which have housed up to 1000 bats) and could at some point completely stop the use of fertilizers. There are also good articles on bats and pest control in USA (Check organic farming and bats and the works of Mark and Selena Kiser). For more literature or comments on our project draft, we could ask Thijs Bosch.

Bats are family animals. If there is a roost close to the new provided roost (close means within 100 meters along hedge connection, so no open spaces) there is a chance that the tower will not be occupied for up to 5 years. One female might find it and move to it. And after a while others will follow till eventually the whole colony moves to the new location. It is possible however to build a perfectly suitable tower that is not colonized right away because it is too far to a roosting area or too far from other hedges or trees.

## Nanning-Jan Honingh, Zeeland Expert

**Expert:** Nanning-Jan Honingh, Stichting Landschapsbeheer Zeeland.

**Present:** Djoeke Langeloo and Julia Samson.

**Date:** October 12<sup>th</sup>, 2011

Het interview begon met een korte uitleg over ons project, de vleermuistoren en de faunatoren. Nanning-Jan had al met Peter over de torens gepraat en een paar beelden gezien van het uiterlijk van de torens. Julia vertelde dat het team niet denkt dat de faunatoren als zodanig kan werken en dat veel verschillende dieren samen in een toren zetten niet haalbaar lijkt. Nanning-Jan zei dat er een grote kans is dat de dieren elkaar opvreten. We hebben hem verteld dat we aan alternatieven voor de faunatoren aan het werken zijn.

De eerste vraag was of er in Zeeland soorten zijn die een zetje goed kunnen gebruiken en die er ook echt op vooruit zouden gaan met een beetje hulp. Nanning-Jan vertelde over de kustbroedvogels waarvan het broedgedrag moeilijk met menselijke belangen te combineren is. De vogels starten voor het toeristenseizoen met broeden; tegen de tijd dat de (Duitse) toeristen er zijn, zijn de vogels druk bezig hun nageslacht te voeren en groot te brengen. De broedplaatsen worden met hekken afgeschermd en toeristen hebben er begrip voor en komen niet in de afgeschermd gebied maar toch veroorzaakt de komst van toeristen (en hun honden) op het strand een verstoring, met name omdat de vogels minder strand hebben om te foerageren.

Een andere diersoort die een steuntje zou kunnen gebruiken is de kamsalamander in Zeeuws Vlaanderen. De populatie van de kamsalamander is verspreid en verschillende groepen kunnen moeilijk bij elkaar komen. De maximale afstand tussen twee populaties is 400m; echter, sommige groepen zitten een paar kilometers van elkaar af maar omdat er geen verbinding is tussen hun leefplekken kunnen ze niet bij elkaar komen. Ecologische verbindingen zouden hier kunnen helpen; een probleem is echter dat veel land waar de kamsalamander voorkomt privé eigendom is en er dus met de eigenaren een overeenkomst moet komen over deze oplossing.

Onze volgende vraag was of er meer behoefte was aan zomer- dan wel winterverblijven voor de vleermuizen in Zeeland. Nanning-Jan had niet echt een idee over welke soort verblijf het meest nodig is. Hij zei dat er genoeg bunkers in Zeeland zijn, die als (winter)verblijven ingericht kunnen worden. Ook kerkzolders zijn geschikte plekken maar meestal niet toegankelijk genoeg; kerkzolders zouden bewoonbaar gemaakt kunnen worden voor de Grootoorvleermuis. Bij het inrichten van een vleermuisverblijf is het biotoop waar het verblijf zich in bevindt van groot belang. Nanning-Jan dacht dat een goede plek tussen strand en bos zou zijn (in de buurt van Schouwen bijvoorbeeld); vleermuizen stellen een paar eisen aan de omgeving rondom hun verblijven: er moeten bomen staan die beschutting bieden, insecten aanwezig zijn en zo mogelijk moet er ook open water in de buurt zijn. Locaties met oude bomen zijn meestal moeilijk te vinden en gemeentes zouden gestimuleerd moeten worden bomen aan te planten en te laten staan. Nanning-Jan was niet zeker of de vleermuistorens echt een verschil voor de vleermuizen zouden betekenen. Volgens hem zou in Zeeland de toren de volgende vleermuizen kunnen huisvesten: de Grootoorvleermuis, de Watervleermuis, de Ruige dwergvleermuis en misschien de Baardvleermuis en de Franjestaart.

Op ons idee om de vleermuistoren van sensoren (camera's, vleermuisdetectoren) te voorzien en in een vleermuizenexcursie op te nemen zei Nanning-Jan dat hij excursies op aanvraag geeft. In de zomer worden sommige verblijven bezocht en worden de vleermuizen geteld. In de winter kan men niet in de bunkers komen omdat de aanwezigheid van mensen de temperatuur in de

bunkers doet stijgen en daarmee het risico genomen wordt de vleermuizen uit hun winterslaap te halen. Het lijkt hem ook geen goed idee om de binnenkant van de toren toegankelijk te maken voor publiek vanwege het risico de dieren te verstoren. De beste plek om een camera neer te zetten zou de invliegopening zijn; in de toren zelf houden de dieren zich schuil en is het lastig om ze goed in beeld te krijgen. Buiten de toren moet men het gebruik van licht en flitsen zo veel mogelijk beperken; dit verstoort de vleermuizen.

De tweede helft van het interview zijn we verder ingegaan op het concept van de toren en andere kunstmatige dierverschillen in het algemeen. Nanning-Jan zei dat de Stichting Zeeuwse Landschap een dergelijke (vleermuis)toren niet zelf zou kopen omdat de Stichting zelf geen land heeft. Als er financiering vanuit de overheid (op basis van de Flora- en faunawet) zou komen, zou de Stichting wel met bijvoorbeeld een bedrijf een samenwerking aan kunnen gaan en een toren aanschaffen en laten plaatsen. In het verleden is er al een samenwerking geweest met de gemeente Terneuzen; een verblijf voor vleermuizen is toen ingegraven en is nu ook in gebruik genomen door de dieren.

Op de vraag of alternatieven op de fauntoren zijn inziens zouden werken zei Nanning-Jan dat de kans dat verschillende dieren zo dicht op elkaar blijven leven klein is vanwege de overlap in (jacht)territorium. Dieren met verschillende voedselbronnen zouden wel in elkaars buurt kunnen leven. Dit gebeurt soms al op boerenerven met verschillende uilsoorten: de Kerkuil en Steenuil kunnen op een erf “samenwonen” omdat de ene soort verder van zijn nest jaagt dan de andere; ze kunnen echter niet in dezelfde kast verblijven. Nanning-Jan vertelde ook over een combinatie van nestmogelijkheden voor een Ooievaar en een Winterkoninkje maar was niet zeker van de noodzaak hier een speciaal product voor te ontwikkelen. Over de combinatie van vogel en zoogdier in een verblijf moeten we erop letten dat jagende zoogdieren niet bij de vogelnesten kunnen komen; het is namelijk bekend dat kleine uilsoorten niet in de buurt van een Steenmarter nesten.

Volgens Nanning-Jan is het belangrijkste punt niet hoe de nestdozen etc. eruit zien of wat ze bieden maar waar ze geplaatst worden. De biotoopkeuze is van groot belang voor het succesvol zijn van een dergelijk verblijf. Een bestaand dierverschil dat we besproken hebben is de Huiszwaluwtil. Nanning-Jan kende het concept maar wist niet of het ook in de praktijk werkt. Op internet hadden we gevonden dat het idee van de Huiszwaluwtil uit Duitsland komt en gebruikt wordt wanneer gebouwen, waarin Huiszwaluwen woonden, afgebroken moesten worden. Blijkbaar maakten de Huiszwaluwen ook gebruik van deze torens als er andere nestmogelijkheden waren dus het idee blijkt al te werken.

Het laatste punt van het interview was het plaatsen van (functionele) kunst in de natuur. Nanning-Jan noemde een project in Flevoland en een kunstwerk met luidsprekers op Terschelling; dat laatste was voor hem te veel van het goede en werkte eerder verstorend dan functioneel. Als we kunst in bossen etc. zouden willen plaatsen kunnen we beter contact opnemen met Staatsbosbeheer.

Tot slot hebben we Nanning-Jan bedankt voor alle uitleg en hem uitgenodigd voor onze eindpresentatie.

## André Hannewijk, Mammal expert

**Expert:** André Hannewijk, Natuurmonumenten (nature monuments) Zwaakse Weel.

**Present:** Djoeke Langeloo and Julia Samson.

**Date:** October 13<sup>th</sup>, 2011

Het interview begon met een korte uitleg over ons project, de vleermuistoren en de faunatoren. André had al contact gehad met Hein over dit project en wist van het idee. We hebben verteld dat het team niet denkt dat de faunatoren kan werken en dat veel verschillende dieren samen in een toren zetten niet haalbaar lijkt, maar dat we aan alternatieve ideeën voor faunahuisvesting werken.

De eerste vraag was of André wist welke diersoorten die in het Zeeuwse onder druk staan een zetje zouden kunnen gebruiken en daarvan echt op vooruit zouden gaan. Hij zei dat er een lijst van dergelijke Zeeuwse soorten bestaat en dat we die lijst (uit het Soortenbeleid) waarschijnlijk op de website van de provincie Zeeland konden vinden. André voegde eraan toe dat er in het verleden, en nu nog steeds, samenwerking is (geweest) tussen Staatsbosbeheer, het Zeeuwse Landschap, Stichting Landschapsbeheer Zeeland en Natuurmonumenten en Provincie Zeeland om soorten in dit gebied te beschermen. Echter, de provinciale subsidie die initiatieven bekostigde is recent stopgezet; of diersoorten er echt op vooruit gaan vergt vaak een jarenlange consequente inzet van middelen en geld en dan nog is er geen garantie op succes.

Op de vraag of er meer zomer- of winterverblijven nodig zijn, voornamelijk voor vleermuizen, antwoordde André dat dat waarschijnlijk 50/50 was. Hij voegde er meteen aan toe dat Nanning-Jan Honingh ons daar beter mee kon helpen. Reparatie en onderhoud aan gebouwen (daken repareren, gaten dichten etc.) maakt het voor vleermuizen wel moeilijker een verblijf te vinden.

André had ook advies voor de alternatieve faunaverblijven. Het is niet mogelijk om alle diersoorten tegelijkertijd te helpen, we moeten een keuze maken in de soorten die we willen promoten. We zouden op holenbroeders (uilen etc.) kunnen focussen. Het risico dat een andere soort het verblijf kraakt is echter niet helemaal te vermijden; Kerkuilkasten worden bijvoorbeeld vaak door andere vogels gebruikt waardoor het beoogde resultaat niet behaald wordt. Ook als het initiatief wel succesvol is en er inderdaad een Kerkuil op een boeren erf komt nestelen, verlaten andere vogels, zoals de Boerenzwaluw, vaak het erf vanwege de nieuwe bewoner.

We hebben André het probleem van de kustbroeders voorgelegd (zie interview met Nanning-Jan Honingh, appendix IV) en hij zei dat deze vogels inderdaad in de problemen zijn gekomen toen de stranden drukker werden met de komst van toeristen. Sommige vogels gaan naar rustigere plekken in het binnenland maar die zijn vaak niet voorhanden; daar worden de vogels dan geconfronteerd met moeilijkheden die aan het biotoop gelinkt zijn (moeite met aanpassen aan de nieuwe omgeving, wat nagenoeg niet mogelijk is).

Vervolgens hebben we André gevraagd of Natuurmonumenten geïnteresseerd zou zijn in een (vleermuis)toren. André dacht dat dat waarschijnlijk niet het geval zou zijn gezien het feit dat Natuurmonumenten alles zo natuurlijk mogelijk wil houden (cf. het snoeien van knotwilgen door vrijwilligers en het ingraven van bunkers langs de Zwaakse Weel). Een nieuwgebouwde toren past dus niet goed in dat streven van Natuurmonumenten. Een punt waarvan André denkt dat Traas er een rol in kan spelen is het behouden en onderhouden van gebouwen in het algemeen. Natuurmonumenten heeft bijvoorbeeld een slooppand in de omgeving van

Nieuwkoop opgekocht omdat er een populatie Meervleermuizen in zat. Door zo iets aan te kopen zou Traas zich kunnen onderscheiden. Het probleem van plaagdieren zit vaak rond de mensen en niet zozeer in de natuurterreinen... Natuurmonumenten heeft niet snel last van plagen. Door iets dergelijks als een vleermuistoren of juist het aankopen en/of inrichten van een (sloop)pand waar vleermuizen in (kunnen) verblijven, komt men meer in de buurt van de mensen.

Volgens André moet een (vleermuis)toren in het landschap passen, zeker als het om een natuurgebied gaat (en dat is soms moeilijk in het weidse open Zeeuwse landschap). Kleinere alternatieven op de torens zouden wellicht op stukken grond van Natuurmonumenten geplaatst kunnen worden, mits ze een zo natuurlijk mogelijk beeld geven. De kleinere alternatieven (maar ook grotere torens?) zouden ook campings zoals camping Scheldeoord in Baarland kunnen interesseren; mogelijk willen dit soort recreatie bedrijven de producten voor dierhuisvesting ook sponsoren.

We hebben het ook kort over het educatieve karakter van de torens gehad en André vond het idee van de camera's erg leuk. De beelden zouden op de website van de Zoogdierverseniging of op sites van klanten (campings, bedrijven) geplaatst kunnen worden.

Tot slot hebben we het heel kort over speciale dakpannen voor zwaluwen gehad en hoe men de vogels kan aantrekken; een idee was om geluidopnames van de zwaluwen in de buurt van de daken en verblijven af te spelen om zo de gewilde zwaluwen aan te trekken.

We hebben André bedankt voor de informatie die hij met ons gedeeld heeft en hebben hem uitgenodigd voor onze presentatie op 21 oktober



## V. Dutch Summary (Nederlandse samenvatting)

### Deel I: Vleermuistoren (Part I: Bat tower)

#### Theorie (Hoofdstuk 3)

#### Redenen voor achteruitgang van vleermuizen (Hoofdstuk 3.1)

De vleermuizen die in Nederland voorkomen zijn allemaal beschermd volgens de Flora- en faunawet (1998). Een aantal soorten (zoals de Hoefijzerneuzen) staan op de Rode lijst als 'bedreigd' of zijn zelfs in Nederland uitgestorven (IUCN, 2011). Er zijn een aantal oorzaken aan te wijzen voor de achteruitgang van sommige vleermuissoorten. De belangrijkste zijn het verstoren van verblijfplaatsen ('roosts' in het Engels); veranderingen in landschap (zoals het weghalen van lineaire elementen zoals bomenrijen waar de vleermuizen zich op oriënteren); het gebruik van pesticiden en chemicaliën om hout te behandelen tegen insecten en houtrot; en watervervuiling (zie onder andere Hutson *et al.*, 2001).

#### Geselecteerde soorten (Hoofdstuk 3.2 en 3.3)

Een vleermuistoren zou een verblijfplaats kunnen bieden voor vleermuizen in Nederland, mits goed ontworpen. In eerste instantie is het doelgebied de provincie Zeeland, en dan voornamelijk de gemeente Borsele, aangezien hier de proeftoren waarschijnlijk geplaatst zal worden. We hebben een aantal vleermuissoorten geselecteerd om de ontwerpcriteria op te kunnen baseren. Het zijn vleermuizen die: a) in spleet-achtige ruimtes verblijven (in tegenstelling tot soorten die in holle bomen of grotere ruimtes zoals zolders verblijven of overwinteren, kunnen soorten die in spleten verblijven in grote aantallen per kubieke meter tegelijkertijd voorkomen); b) het Zeeuwse landschap kunnen gebruiken; c) niet heel algemeen zijn (het is lastiger hier ontwerpcriteria voor te vinden) en d) niet heel zeldzaam zijn (deze soorten zullen naar alle waarschijnlijkheid geen gebruik maken van een vleermuistoren).

Gebaseerd op deze selectiecriteria zijn vooral de Meervleermuis (*Myotis dasycneme*) en de Ruige dwergvleermuis (*Pipistrellus nathusii*) geschikt om de toren op te ontwerpen (Janssen en Schaminée, 2008; Bekker *et al.*, 2010). Zie ook tabel 1, en tabel 2 en 3 in de hoofdtekst voor soorten die respectievelijk de toren mogelijk wel en waarschijnlijk niet zullen gebruiken.

Behalve de vraag of de individuele vleermuizen de toren mogelijk zullen gebruiken, is het ook belangrijk om te weten of verschillende soorten vleermuizen in het zelfde bouwwerk kunnen samenleven. Uit onderzoek blijkt dat de Dwergvleermuis redelijk tolerant is tegenover andere soorten, deze soort werd onder andere naast de Meervleermuis gevonden in hetzelfde verblijf (Mickeyeieene *et al.* 1999).

#### Bestaande vleermuistorens (Hoofdstuk 3.4)

Vleermuistorens zijn niet een geheel nieuw idee; al in 1929 bouwde C. Perky in Florida, Verenigde Staten, een vleermuistoren ("Perky's bat tower", zie figuur 1a in de hoofdtekst) om een lokale muggenplaag te bestrijden. Helaas is deze toren nooit gebruikt, de erin uitgezette vleermuizen (afkomstig uit Cuba) vlogen weg en zijn nooit meer teruggekeerd (Frank, 1997). Een meer succesvol ontwerp is de 'Vleermuiscondo' ('Bat Condo') van het Amerikaanse bedrijf Bat Conservation and Management, Inc. (2011), zie figuur 1b in de hoofdtekst, alhoewel wetenschappelijk onderzoek naar de werking en succes van deze torens ontbreekt.

In Nederland zijn vooral ontwerpen gericht op soorten die voorkeur geven aan stenen gebouwen (in tegenstelling tot de houten constructies uit Amerika). Een voorbeeld is de 'torenbunker' in de Mariapolder, Hoekschewaard (HSWL-bunker Strijen), waar een toren (buitenverblijf) gebouwd op een oude WO II-bunker (winterverblijf) voorziet in een verblijfplaats voor enkele Gewone Grootoorvleermuizen (*Plectorius auritus*) (Geerts and Meerburg, 2010; figuur 1c in de hoofdtekst).

Een enkele keer (in 2009) is er een vleermuistoren speciaal gebouwd ter compensatie voor het afbreken van gebouwen waarin vleermuizen verbleven, omdat er geen andere opties waren om de vleermuizen te beschermen (Erik Korsten, persoonlijke communicatie; Zoogdiervereniging, 2009A; Dienst Landelijk Gebied, 2011). Er werd besloten de aanwezigheid van vleermuizen in de toren minstens 5 jaar te monitoren, een studie waarvan de resultaten nog niet beschikbaar zijn.

### Biologische bestrijding en compensatie (Hoofdstuk 3.5)

Vleermuizen staan er om bekend veel insecten te kunnen eten, en kunnen daarom een belangrijke bijdrage leveren aan biologische bestrijding. Een Amerikaanse studie wees uit dat in de VS insect-etende vleermuizen voor tussen de 3,7 en 53 miljard Amerikaanse dollars bijdragen aan landbouw (Boyles *et al.*, 2011). Ook een Spaanse studie wees uit dat door vleermuizen in te zetten ter bestrijding van een rijstmot, het gebruik van pesticiden sterk verminderd of zelfs helemaal gestopt kan worden (Flaquer *et al.*, 2011). Uit deze en Nederlandse onderzoeken (Geerts and Meerburg, 2010) blijkt dat vleermuizen inderdaad een belangrijke bijdrage kunnen leveren aan de insectenbestrijding in de landbouw. Dit doel wordt echter alleen bereikt met een vleermuistoren als het omliggende landschap al voldoende leefomgeving biedt voor aanwezige vleermuizen, maar voldoende geschikte verblijfplaatsen een limiterende factor zijn.

Alhoewel in de bovenstaande paragraaf een geval wordt genoemd waarin een vleermuistoren werd gebouwd ter compensatie, raden wij het af om dit ook toe te passen op toekomstige vleermuistorens, zonder dat verder onderzoek is gedaan. Compensatiemaatregelen hebben alleen nut als er daadwerkelijk bewezen is dat er voldoende gecompenseerd wordt, iets wat bij dergelijke vleermuistorens nog niet het geval is. Bovendien verschaft een vleermuistoren alleen een verblijfplaats en eventueel overwinteringsplaats, terwijl het omringende landschap (lineaire elementen, schoon water, voldoende insecten) minstens zo belangrijk zij. Hiervoor wordt niet gecompenseerd door het bouwen van een toren.

### Ontwerp van de toren (Hoofdstuk 4.1)

Vleermuizen hebben een zomer- en winterverblijfplaats nodig. In de zomer jagen de vleermuizen vanaf zonsondergang en brengen ze hun jongen groot; in de winter overwinteren de meeste soorten, al dan niet in een (vaste) winterslaap. Als er vooral insectbestrijding beoogd wordt, is het vooral belangrijk zomerverblijfplaatsen aan te bieden, maar sommige soorten verblijven in de winter in hetzelfde gebied als in de zomer.

Een vleermuistoren biedt vooral een zomerverblijfplaats aan soorten die in spleten van (stenen) gebouwen verblijven. De geselecteerde vleermuizen stellen de volgende eisen aan een winterverblijfplaats (gebaseerd op een interview met Erik Korsten, en diverse eerdere ontwerpen en literatuur; zie hoofdtekst).

### Ontwerp buitenkant

Er is in principe geen beperking voor de hoogte van de toren, maar vanwege het aanvragen van vergunningen wordt geadviseerd onder de 6 meter te blijven. Ingangen voor de vleermuizen moeten boven de 3,5 meter geplaatst worden.

Ruwe materialen, zoals ongeglazuurde bakstenen zorgen voor grip voor de vleermuizen. Keramisch materiaal (dakpannen) zijn aan te bevelen boven beton, omdat beton te heet of te koud kan worden.

Kleinere vleermuissoorten kunnen ten prooi vallen aan bijvoorbeeld ratten. Een gladde metalen plaat (zowel aan de buitenzijde als binnenzijde) kan voorkomen dat deze dieren de toren in komen.

Het ontwerp dat wij nu geschetst hebben (zie figuur 4 in de hoofdttekst) heeft de vorm van de toren, maar in principe kan daarvan afgeweken worden, zolang de benodigde elementen maar aanwezig zijn. Gedacht kan worden aan een andere vorm, of decoratie kan worden aangebracht (evt. in overleg met een kunstenaar).

Voor de buitenzijde kan aan een aantal elementen worden gedacht die niet strikt noodzakelijk zijn, maar wel het succes (voor ofwel de vleermuizen, ofwel educatiedoeleinden) van de toren kunnen bevorderen.

Ten eerste kunnen houten luiken ook een toegang bieden tot de toren, deze moeten iets in de muur bevinden zodat ze beschermd zijn tegen wind en regen, en de vleermuizen al kruipend binnen komen, na landing op een 'vensterbank'. De houten luiken kunnen ook een decoratief of artistiek karakter hebben (zie bijvoorbeeld figuur 5 in de hoofdttekst).

Ten tweede kunnen enkele holle bakstenen in de buitenmuur ingemetseld worden (zie figuur 6 van de hoofdttekst). Deze zijn bedoeld voor (solitaire) mannetjes vleermuizen die zich aan de buitenkant verschuilen (de binnenzijde van de toren is voornamelijk bedoeld voor jagende en zogende vrouwtjes).

Ten derde zouden enkele dakpannen verhoogd kunnen worden als toegang voor de vleermuizen. De openingen moeten niet te groot zijn om te voorkomen dat wind, regen, en vogels de toren binnen komen.

### Ontwerp binnenzijde

De ingang voor de vleermuizen (2 cm hoog en 5-10 cm breed) bevindt zich achter een houten paneel dat aan de buitenzijde de ingangen afdekt, met ongeveer 2 cm ruimte tussen paneel en buitenmuur.

De binnenzijde bestaat bij voorkeur uit een dubbele bakstenen muur, met daartussen een houten schot (ong. 2 cm dik) (figuur 7 hoofdttekst). De tussenruimte tussen buitenmuur en paneel moet ongeveer 3,5 cm zijn (de vleermuizen raken dan niet de koude of hete buitenmuur en er komen geen wespen in), terwijl de ruimte tussen paneel en binnenmuur 3 cm is. Ook hier moeten de bakstenen en paneel van een ruw materiaal zijn, en onbewerkt (of met non-toxische middelen).

Ook hier is het belangrijk een (aan de buitenkant) gladde metalen plaat aan te brengen die voorkomt dat ratten de dubbele muren in kunnen (zie figuur 7 in de hoofdttekst). De binnenzijde van deze plaat is ruw, zodat eventueel naar beneden gevallen vleermuizen nog omhoog kunnen kruipen.

Ook raden we een dubbel dak aan om meer microklimaten te creëren. De ruimten tussen de muren en dak zijn vanaf de ingangen (onder het afdekkende paneel) van alle kanten bereikbaar, zodat de vleermuizen zelf de meest geschikte plek binnen de toren kunnen kiezen.

Het is erg belangrijk om te monitoren of de toren geschikt is voor de vleermuizen, en met name of er geschikte microklimaten zijn (d.w.z. Een temperatuur tussen 20 en 25 °C en een relatieve luchtvochtigheid van 80-100%. Hiertoe kunnen één of meerdere dataloggers in de toren worden gehangen.

De toren moet eens per jaar worden schoongemaakt, een (biologisch afbreekbare) plastic laag op de bodem zou dit kunnen vergemakkelijken. Bovendien zijn vleermuisuitwerpselen een waardevolle meststof.

Een toegangsluik voor inspectie en schoonmaken (geen deur, aangezien je dan met het 'Arbeidsomstandighedenbesluit' (1997) te maken hebt) wordt bij voorkeur hoog gebouwd, om vandalisme te voorkomen (eigen ladder meenemen).

#### Ontwerp bunker (winterverblijf) (Hoofdstuk 4.2)

Het belangrijkste van een winterverblijf is dat het klimaat (temperatuur, luchtvochtigheid) stabiel blijft; tussen de 0 - 10 °C en ongeveer 80 - 100% luchtvochtigheid. In ondergrondse gebouwen (zoals bunkers, oude fundamenten) is dit makkelijker te bereiken. De muren van de bunker zijn het liefst dik, en aan de bovenzijde afgedekt met minstens 1 meter laag aarde (of puin), om een stabiel klimaat te garanderen.

Om tocht te voorkomen moet de toegangsdeur leiden tot een soort hal, met daarachter een tweede deur. De ingang van de bunker moet 50 cm lang en 12 cm hoog zijn (zodat de vleermuizen vliegend binnen kunnen komen).

Voor een hogere luchtvochtigheid (deze moet van tevoren gecontroleerd worden) kan eventueel een laag water in de bunker gepompt worden (afgedekt met een net om te voorkomen dat de vleermuizen verdrinken)

De temperatuur open van koeler bij de toegangsdeur en warmer verder van de deur verwijderd, en hoger in de bunker. Verschillende plafondhoogtes zorgen voor verschillende temperaturen, zodat de vleermuizen verschillende plaatsen op kunnen zoeken.

Verblijfplaatsen voor verschillende vleermuissoorten worden gecreëerd door holle bakstenen (of speciaal daartoe ontworpen vleermuisstenen; zie bijvoorbeeld zoals geproduceerd door Norfolk Bat Group or IBSTOCK) in de muur (of evt. plafond) in te metselen. Ook hier is de aanwezigheid van ruwe muren (onafgewerkte gemetselde muren) en verschillende plekjes en nissen van belang.

De bunker moet ongeveer 2,80 m hoog zijn om predatie van overwinterende vleermuizen te voorkomen.

Ook hier is het belangrijk, net als met de vleermuistoren, dat de vleermuizen niet verstoord worden, en derhalve moet vandalisme voorkomen worden. Eventueel kan worden gemonitord door een camera toe te voegen; deze kan ook worden gebruikt voor educatieve doeleinden.

## Conclusies (Hoofdstuk 5)

Enkele belangrijke conclusies uit de voorgaande hoofdstukken zijn de volgende:

- We raden sterk aan om voor het commercialiseren van een vleermuistoren, eerst een pilotstudie uit te voeren van 5-10 jaar. Elke zomer zou hierbij de aanwezigheid van vleermuizen gecontroleerd worden, en ook, met behulp van de dataloggers, de temperatuur en luchtvochtigheid. De laatste geven dan een indicatie of de toren daadwerkelijk geschikt is voor vleermuizen, zelfs als deze (nog) niet aanwezig zijn
- de vleermuistoren zou vooral biologische bestrijding als doel moeten hebben, en niet compensatie, aangezien dit laatste onvoldoende gegarandeerd kan worden
- de toren moet bij voorkeur in de buurt van bomen (maar niet te dicht bos) geplaatst worden (op ongeveer 5-8 m afstand). Ook verbinding van de toren met een bestaande vleermuiskolonie door middel van lineaire elementen (bomenrij, kanaal, etc.) verhoogd de kans op bewoning door vleermuizen
- stenen van de toren moeten ruwe oppervlakten hebben om voldoende grip te bieden voor vleermuizen. Meerdere microklimaten moeten in de toren worden gerealiseerd.
- vermijd vandalisme door de toren onaantrekkelijk te maken
- vermijd predatie door ratten ed. door gladde oppervlakten aan te brengen aan de onderzijde van de toren
- gebruik educatie om de functie van de toren toe te lichten en meer bewustzijn te creëren.