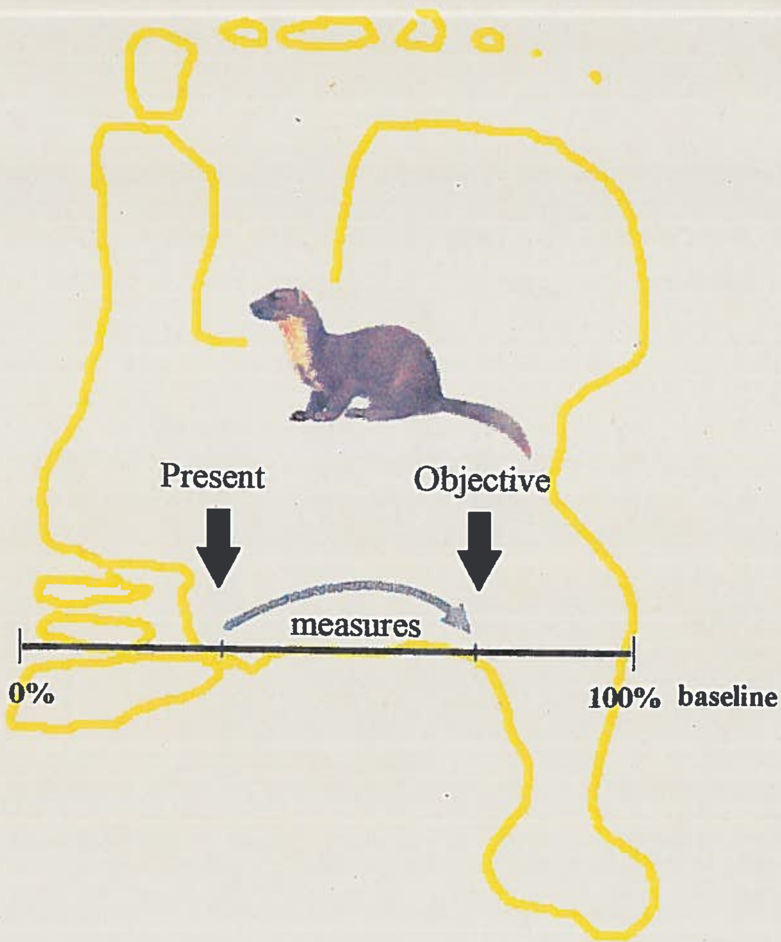
Estimating the quality of Dutch mammal populations

A study within the framework of the Dutch Natural Capital Index

J.P.G.M. Cromsigt, V.A.A. Dijkstra, D. Wansink and S. E. van Wieren



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1. Introduction

Increasingly often questions pop up regarding the liveability of the environment. Economic factors put increasing pressure on ecological factors. Therefore, methods are being developed that allow a comparison of ecological values with economic values.

One of these methods is the development of the Natural Capital Index (NCI) by the National Institute of Public Health and the Environment (RIVM) of the Netherlands. This index is defined as the product of the total area of an ecosystem (ecosystem quantity) and the quality of this ecosystem. Ecosystem quality is defined as the ratio between the current and a baseline state (% of baseline) (Figure 1). The baseline state is defined as the natural state or a pragmatic approach of it[1]. The NCI is a value between 0 and 100% and gives the percentage nature area of 100% quality (UNEP, 1997; Brink, 2000; Brink et al, 2000). This index can be used as a tool to quantify the remaining natural capital in the natural areas of the Netherlands. The NCI framework has been developed and discussed under the Convention on Biological Diversity (UNEP, 1997).

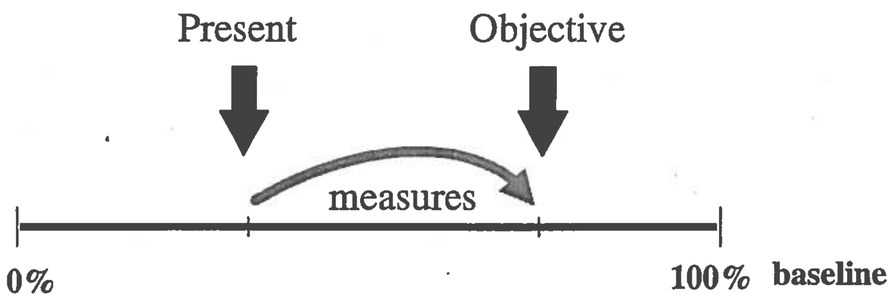

Figure 1. Ecosystem quality is calculated as a percentage of the baseline state.

The quantification of ecosystem quality is, obviously, not an easy task. An ecosystem as a whole is a complex system of a never-ending number of interconnected factors. For the purpose of determining ecosystem quality, however, the ecosystem has been divided in a number of variables. Among these variables are the species of flora and fauna and more specifically the quality of populations of these species in relevant ecosystems or nature types. This quality value has been defined as the ratio between the present abundance of the species and baseline abundance. This baseline abundance is, ideally, the potential, natural, abundance of the species. This report discusses the estimation of quality values for Dutch mammal species in different nature types.

Quality values have been estimated for 14 Dutch mammal species for 14 nature types. These nature types are defined further on in this report. The values have been calculated for the current situation and for a baseline in time. For this baseline in time the situation in the 1950s has been chosen. The next chapter explains the methods that have been followed to come to the mentioned quality values. Chapter 3 discusses each species separately. It describes the general

[1] The 1st Liaison Group on biodiversity indicators of the Convention on Biological Diversity has defined the baseline similarly as the "postulated baseline, set in pre-industrial times" (UNEP, 1997).

ecology of the 14 mammal species, the baseline abundance and the actual abundance of the species in the relevant nature types in the 1950s and currently and the quality values, which are the ratio of the actual and baseline abundance. Chapter 4 gives recommendations on how to improve the monitoring of the different mammal species to come to more specific and useful values of the present abundance. Finally, chapter 5 generally discusses the calculation of the quality values for the 14 mammal species.

This report has been commissioned by RIVM in order to support its reporting functions such as the Nature Balance and Nature Outlook and has been under supervision of Mr. B. ten Brink of RIVM. The report is presented as a first important step in coming to quality values for the Dutch mammal populations. It is the result of collaboration between Wageningen University and Research Centre and the 'Vereniging voor Zoogdierkunde en Zoogdierbescherming'. The process of improving the reliability of the values will be continued.

2. Methods

Quality values have been calculated for 14 Dutch mammal species: the Wild Boar (*Sus scrofa*), the Red Deer (*Cervus elaphus*), the Roe Deer (*Capreolus capreolus*), the Aurochs (*Bos primigenius*), the European Wild Horse (*Equus ferus*), the Brown Hare (*Lepus europaeus*), the European Rabbit (*Oryctolagus cuniculus*), the European Beaver (*Castor fiber*), the Red Squirrel (*Sciurus vulgaris*), the Pine Marten (*Martes martes*), the Badger (*Meles meles*), the Eurasian Otter (*Lutra lutra*), the Red Fox (*Vulpes vulpes*) and the Lynx (*Lynx lynx*). For each species a general species description is given, describing its distribution and external appearance. Furthermore, a short outline is given on the species ecology; mainly divided in habitat preference, diet composition and behaviour. The remaining part of the report discusses the baseline abundance, the actual abundance in the 1950s and currently, and the quality values for each species separately. Chapter 2.1-2.3 explain how these values have been determined.

2.1 Baseline abundance

We expressed the baseline abundance, described in the introduction, as baseline densities. The baseline densities have been proposed for 14 species for 14 different nature types. Not all species-nature type combinations were relevant. The following combinations have been regarded (+):

Table 1. The table presents the species-nature type combinations that have been regarded in this study. The + means that the combination has been regarded.

	Forest on higher sandy soils	Forest in riverine area	Forest on marine clay	Forest in peat area	Forest in hilly area	Dune forest	Hjeath on higher sandy soils	Open dune	Marsh in riverine area	Marsh on marine clay	Marsh in peat area	Lakes	Rivers and streams
Wild Boar	+	+	+	+	+	+	+	+	+	+	+	-	-
Red Deer	+	+	+	+	+	+	+	+	+	+	+	-	-
Roe Deer	+	+	+	+	+	+	+	+	+	+	+	-	-
Aurochs	+	+	+	+	+	+	+	+	+	+	+	-	-
Wild Horse	+	+	+	+	+	+	+	+	+	+	+	-	-
Brown Hare	-	-	-	-	-	-	+	+	-	-	-	-	-
Rabbit	-	-	-	-	-	-	+	+	-	-	-	-	-
Beaver	-	-	-	-	-	-	-	-	+	+	+	+	+
Red Squirrel	+	+	+	+	+	+	-	-	-	-	-	-	-
Pine Marten	+	+	+	+	+	+	-	-	-	-	-	-	-
Badger	+	+	+	+	+	+	+	+	-	-	-	-	-
Otter	-	-	-	-	-	-	-	-	+	+	+	+	+
Red Fox	+	+	+	+	+	+	+	+	-	-	-	-	-
Lynx	+	+	+	+	+	+	+	+	-	-	-	-	-

Chapter 2.5 gives a more detailed description of each nature type, defining the biotic and abiotic conditions.

The baseline densities for the combinations, as explained above, were based on a literature survey. Articles were selected from three literature databases (Biological Abstracts from 1989-2000/09, Zoological Record from 2000/01-2000/09 and CAB Abstracts from 1972-2000/09). From these articles densities for the different species were extracted, together with information on area of the census, type of habitat in the census area, census period and census method. This information from the literature was completed with a limited expert review. Emails were sent out to several species experts in the Netherlands and internationally (i.e. IUCN species specialist groups). These experts are mentioned within the text of the relevant species.

Finally, the baseline densities were proposed for each species estimated from the densities found in literature and suggested by experts, and the ecology of the species. One value is given for each species, which represents the minimal long-term density of the species that can be expected under natural circumstances (without human interference) in an optimal habitat within the relevant nature type. This value is based on the median value and the average range of densities found in literature and given by species experts on the one hand and on the ecology of the species on the other hand. Because for most species no data were found for each specific nature type, the ecology of the species is used to differentiate baseline densities between different nature types. Descriptions of the habitat and diet preference are most important in this respect. For each species, chapter 3 describes the assumptions on which the baseline densities have been based.

It has to be noted that we followed the precautionary principle while estimating the baseline abundances. In other words, the proposed baseline densities are at the lower end of the natural density ranges of the species. Abundances in the field that are lower than the baseline abundances are the result of human impact.

2.2 Baseline number

The actual abundance in the 1950s and currently was preferably expressed in numbers, as will be explained in chapter 2.3. To be able to compare these numbers with the baseline densities, the baseline densities are transformed in baseline numbers according to the following formula:

$$N_{baseline,i,j} = \rho_{baseline,i,j} \times A_j \, ,$$

where $\rho_{\text{baseline, i, j}}$ is the baseline density for species i in nature type j in No. of individuals per km^2. as explained in chapter 2.1 and A_j represents the surface of nature type j in km^2.. These baseline numbers have been calculated for the area sizes of the nature types in 1950 and currently, resulting in baseline numbers for 1950 and currently. Table 2 gives the area sizes of each nature type in 1950 and currently.

Table 2. Area sizes (km^2.) for each nature type in 1950 (A_{1950}) and currently ($A_{\text{currently}}$, area sizes in 1990). The figures for 1990 have been obtained from Meij & Van Duuren (2000), for 1950 from Meij (1999) and Meij & Van Duuren (2000).

Nature type	A_{1950} (km^2.)	$A_{\text{currently}}$ (km^2.)
Forest on higher sandy soils	2102.9	2634.2
Forest in riverine area	162.5	136
Forest on marine clay	56.3	285.2
Forest in peat area	29.2	70.9
Forest in hilly area	38.8	49.1
Dune Forest	68.7	118.5
Heath on higher sandy soils	1415.7	441.3
Open Dune	359.09	294.39
Marsh in riverine area	41.6	40.4

Marsh on marine clay	81.6	170.8
Marsh in peat area	249	205.4

2.3 Actual abundance in the 1950s and currently

We, preferably, expressed the actual abundance in the 1950s and currently in total numbers of individuals per nature type instead of densities. We preferred numbers because these give a better representation of the actual situation. Densities give a worse representation, because they are often based on a limited number of plots where the density is measured. This number of plots often gives a distorted representation of the actual situation, for example because the density is only measured in plots where the habitat is optimal or where the species is known to be present.

The total number of individuals per nature type of each species at present was found through different sources. These sources are discussed for each species separately in chapter 3. The type of information, which was found, differs per species. For some species, the data for the present numbers had to be adapted to be able to calculate the quality values. This is also explained for each species separately in chapter 3. For some species only density data were available. For these species the total number of individuals per nature type are unknown. Therefore, for these species the density data were used for the calculation of the quality values. For these species the baseline densities were not converted into baseline numbers.

The number or density of the species in the 1950s has already been investigated by Hollander (2000). We adopted the figures, which he presents in his report.

2.4 Quality value

The quality value for each species is calculated according to the following formula:

$$QV_{present,i,j} = \left(Abundance_{present,i,j} \Big/ Abundance_{baseline,i,j} \right) \times 100,$$

where $QV_{currently,\,i,\,j}$ is the present quality value for species i in nature type j expressed as a % value between 0 and 100%, $Abundance_{currently,\,i,\,j}$ is the actual abundance of individuals for species i in nature type j currently, as explained in 2.3 (i.e. number or density), $Abundance_{baseline,\,i,\,j}$ is the baseline number or baseline density for species i in nature type j depending on the dimension of the actual abundance.

The quality value for 1950 is calculated in the same way with $Abundance_{1950,\,i,\,j}$ instead of $Abundance_{currently,\,i,\,j}$.

The quality values for all the combinations of species and nature types are given in chapter 3 and summarised in appendix III, together with the values for the baseline densities, baseline numbers and actual numbers or densities for the 1950s and currently. The quality values are discussed for each species separately in chapter 3.

2.5 Definition of the nature types

Chapter 2.1 described that baseline densities have been proposed for 14 nature types. In the introduction the baseline value is described as the potential, natural, abundance. These values depend on the definition that is used for naturalness. This is, generally, a philosophical discussion. However, to stay pragmatic, we decided to use the new 'Natuurbeleidsplan 21' (Ministry of Agriculture, Nature Management and Fisheries, 2000) to define the concept of naturalness. This plan describes the Dutch governmental nature policy for the coming decades. One of the goals of this policy is to create areas of natural nature, described in a programme called 'Groots Natuurlijk'. Main goal is to create a network of high-quality nature areas. This network exists of core areas, where ecological processes are uninfluenced by man, connected by wet axes (streams, rivers) or terrestrial corridors. In this way nature has the chance to spontaneously develop itself. The, below described, baseline nature types are the result of such an approach of spontaneous development without human influence. In other words, the nature types are self-regenerating ecosystems, according to the Natural Capital Index framework (UNEP, 1997). The description of the forest types is based on Van der Werf (1991). The description of the dune type is based on Westhoff et al (1970) and of the heath on Westhoff et al (1973).

2.5.1 Forest on higher sandy soils

The type of forest depends on the level of groundwater and the type of soil. On the non-loamy, sandy soils the Birch-Pedunculate Oak forests (Betulo-Quercetum roboris) is found and the Sessile Oak-Beech forests (Fago-Quercetum petraea) can be found on the loamy, sandy soils and the poor loamy soils. These two forest types, naturally, dominate the higher sandy soils in the Netherlands. Within these two types in seepage areas with upcoming oxygen-rich water you will find Alder spring forests (Chrysoplenio oppositifolii-Alnetum) and in the case of lime-rich water, Ash spring forests (Carici remotae-Fraxinetum).

The Alder-Oak forest (Lysimachio-Quercetum) is growing on the very wet loamy, sandy soils in stead of the earlier mentioned Sessile Oak-Beech forests. On the very wet poor sandy soils the Birch marsh forest (Periclymeno-Betuletum pubescentis) has developed. On the fen-lands, distributed over the sandy areas, the potentially natural vegetation exists of Common Alder marsh forest (Carici elongatae-Alnetum).

Other potentially important types of forest are the Honeysuckle-rich Oak-Hornbeam forest (Stellario-Carpinetum periclymenetosum) of the loamy sandy soils with acid loam or clay under the surface (resulting in stagnating water) and the mesoneutophilous and acidicline beech groves (Milio-Fagetum) of the loess areas and other, moderately, nutrient-rich loamy soils.

A more detailed description of the vegetation of the discussed forest types can be found in appendix I.

2.5.2 Forest in riverine areas

Close to the river, on regularly flooded parts, the White Willow forest (Salicetum albae) is found. Further away from the river the Alder-rich Ash-Elm forest (Fraxino-Ulmetum alnetosum) is growing which passes into the dry Ash-Elm forest (Fraxino-Ulmetum) when the surface water has no direct influence. On the higher parts of the riverine areas (e.g. river dunes) the Abele-Elm forest (Violo odoratae-

Ulmetum) is growing. The Common Oak-Hornbeam forest (Stellario-Carpinetum) grows on places, that have not been flooded for a long time or that have a sub-soil of old river clay.

In brook valleys the Bird cherry-Ash forest (Pruno-Fraxinetum) is found and on nutrient-poor places, the Alder Carr (Carici laevigatae-Alnetum).

A more detailed description of the vegetation of the discussed forest types can be found in appendix I.

2.5.3 Forest on marine clay

The type of forest depends on the level of the surface water. The dryer parts exist of dry Ash-Elm forest ((Fraxino-Ulmetum). On the places with a high level of surface water the Alder-rich Ash-Elm forest (Fraxino-Ulmetum alnetosum) is growing.

A more detailed description of the vegetation of the discussed forest types can be found in appendix I.

2.5.4 Forest in peat area

Early on in the succession the Marsh Fern-Alder marsh forest (Thelypterido-Alnetum) is growing on the young peat areas. This forest turns into the Common Alder marsh forest (Carici-elongatae Alnetum). On some dryer parts the Alder-Oak forest can be found (Lysimachion Quercetum). Through acidification the Common Alder marsh forest can turn into Birch-Alder marsh forest (Alno-Betuletum pubescentis) or even Birch marsh forest (Periclymeno-Betuletum pubescentis). On the clayey peat soils, especially in the western provinces, the Brush-Alder forest (Filipendulo-Alnetum) is found.

A more detailed description of the vegetation of the discussed forest types can be found in appendix I.

2.5.5 Forest in hilly area

On the loess soils of the hilly area the mesoneutophilous and acidicline beech groves (Milio-Fagetum) are growing. On the calcareous soils Beech forests as the Melico-Fagetum and Carici-Fagetum are found. On places with stagnating water Oak-Hornbeam forest (Stellario-Carpinetum) is growing, like on the higher sandy soils. In seepage areas with upcoming oxygen-rich water you will find Alder spring forests (Chrysoplenio oppsotifolii-Alnetum) and in the case of lime-rich water, Ash spring forests (Carici remotae-Fraxinetum). Along streams the Bird cherry-Ash forest (Pruno-Fraxinetum) can be found. The Sessile Oak-Beech forests (Fago-Quercetum petraea) can be found on the nutrient-poor soils on the plateaus and upward slopes. Above 150 metres the for the Netherlands rare Luzulo-Fagetum is growing.

A more detailed description of the vegetation of the discussed forest types can be found in appendix I.

2.5.6 Heath on higher sandy soils

In contrast with the heath in the dunes and as a part of the mosaic forest landscape, the large, open heath of the higher sandy soils have not arisen without pre-industrial human interference. They have evolved from the original Birch-Pedunculate Oak forests through a process of constant slashing, burning and grazing. This baseline nature type, therefore, needs a different approach then the other types. A human interference on the ecological basic processes is necessary and part of this nature type. So, as a part of the abiotic processes there is a constant impoverishment by the mentioned combination of slashing, burning and grazing. In other words, in this nature type extensive human use is part of the baseline system. Based on the percentage of moisture of the soil, three types of heath vegetation can be distinguished.

On the dry soils (surface water is inaccessible for the vegetation) the heather species *Calluna vulgaris* is dominating. Other species are Wild Mountain ash (*Sorbus aucuparia*), Juniper-berry (*Juniperus communis*) and on richer spots Common Hair Grass (*Deschampsia flexuosa*).

On moist soils (surface water at 1,5-2,5 meter depth) the intermediate type is found with *Calluna vulgaris* as well as Cross-leafed Heather (*Erica tetralix*). Other species are Wild Mountain ash (*Sorbus aucuparia)*, the Willow species *Salix repens* and Purple Moor Grass (*Molinia caerulea*).

In the wet heath (surface water up to the ground level, in the summer up to max. 1,5 meter depth) the Cross-leafed Heather (*Erica tetralix*) is dominating. Other species found in this type are Purple Moor Grass (*Molinia caerulea*), the Willow species *Salix repens* and species like Tall Cotton grass (*Eriophorum angustifolium*) and *Scirpus cespitosus.*

The richness of other higher vascular plant species, next to Heather, is dependent of the nutrient richness of the soil. As mentioned earlier, this nutrient richness is strongly determined by the extent of impoverishment by humans. For this project we take the view that there is a constant, intensive process of impoverishment, like it was practised in the heath of the 19th and early 20th century. This means that the heath mainly exists of Heather and that the abundance of herb and grass species is low (in contrast with the situation of the present heath).

Shifting sands and high peat areas are also a part of the system described in this section.

2.5.7 Dunes

In this chapter the dunes are described as one nature type, existing of open dune and dune forest. In the below-defined baseline type 'dune' there is no fixation of the dunes nor has it been done in the past (by e.g. planting of European Beech grass (*Ammophila arenaria*)). There is no intake of water and water filtration only takes place if there is no influence on the surface (e.g. by infiltration at great depth). Furthermore, agriculture does not exist in de dunes and there is only natural grazing.

Typical for the dunes is the large variation in abiotic circumstances on spatial as well as temporal scale. On the first hand the dynamics of water and wind have created a varied landscape of slopes and valleys. Within this landscape lime content and nutrient richness vary from place to place.

The lime content divides the Dutch dunes into two parts. The relatively lime-poor 'Waddendistrict' north of Bergen aan Zee and the relatively lime-rich 'Duindistrict' southwards of Bergen aan Zee. The dune sand holds water badly, so that the top of the dunes is dry and the dune valleys are relatively wet. Layers of fen are also responsible for relatively wet places. The temperature in the dunes varies enormously from 50 degrees Celsius in summer up to nightly temperatures below zero during possibly all months of the year. Furthermore the difference in temperature between northern and southern slopes can be very large and often results in strongly overgrown northern slopes and almost bare southern slopes. Finally the wind is responsible for a constant arrival of salt and sand, inhibiting the growth of many plant species.

The described dynamic and variation in the abiotic circumstances is responsible for a very large variation in vegetation types on a relatively small scale.

On protected places in the dune valleys or further away from the coastline forest arises. In the 'Duindistrict', firstly Dune Birch forest (Crataego-Betuletum) arises (a highly developed shrub layer of mainly Hawthorn (*Crataegus* spp.), Common Privet (*Ligustrum vulgare*) and Dog rose (*Rosa canina*); because of the very open character of the forest, there is a highly diversified and dense layer of herb-, grass- and sedge species), after acidification of the soil a Dune Oak forest (Convallario-Quercetum dunense) appears (moderately developed shrub layer of mainly Wild Mountain-ash (*Sorbus aucuparia*) and a/o. Hawthorn(*Crataegus* spp.) and Dog rose (*Rosa canina*); reasonably developed, often not closed, herb layer of different herb-, grass- and sedge species) and after further rinsing out of nutrients a Sessile Oak-Beech forests (Fago-Quercetum petraea) arises (see forest on higher sandy soils), especially further away from the coast. On moist places an Ash-Elm forest (Fraxino-Ulmetum) is growing (see forest in riverine areas) and after disturbance sometimes an Abele-Elm forest develops (see forest in riverine areas).

On the lime-poor, acidic soils of the 'Waddendistrict' a Crowberry-Birch forest (Empetro-Betuletum pubescenti-carpaticae) arises in the dune valleys (moderately developed shrub layer of Wild Mountain-ash (*Sorbus aucuparia*), the Willow species *Salix repens*, Alder Buck-thorn (*Rhamnus frangula*) and Sweet Gale (*Myrica gale*); the herb layer is dominated by Crowberry (*Empetrum nigrum*)). On the more protected places behind the scarce high dunes a forest can be found that largely coincides with the Birch-Pedunculate Oak forests (Betulo-Quercetum roboris) of the poor sandy soils (see forest on the higher sandy soils). In general, forests cover the dunes of the 'Waddendistrict' far less than the dunes of the 'Duindistrict'.

On the more disturbed spots other vegetation types can be found, like shrubs (mainly around the forests, existing of a/o. Sea Buckthorn (*Hippophae rhamnoides*), Elder (*Sambucus nigra*), Common Privet (*Ligustrum vulgare*) and Rose species (*Rosa* spp.)) and Heath (species like Crowberry (*Empetrum nigrum*), Cross-leafed Heather (*Erica tetralix*), *Calluna vulgaris* and *Salix repens*) and grass meadows (existing of a large variety of herb-, grass and sedge species, with moistness and lime richness as main determinants of species combinations).

A last type of vegetation can be found in the moist dune valleys, where marsh formation can take place, with many sedge- and some herb species.

2.5.8 Marsh

This nature type represents the relatively large marsh systems of the bog areas of Noord- and Zuid-Holland, Friesland and parts of Groningen and Overijssel and the marshes of the riverine area and on marine clay. The areas have an open character and keep this openness by natural grazing. The water is unpolluted, clear and meso-trophic. The water level follows a natural process (high during winter, low during summer). Creeks intersect the marshes. The banks of these creeks are formed naturally and not influenced by man. Finally, no hunting or fishing takes place.

The marshes are rich in highly nutritious plants. A wide variety of bog-mosses, sedge-, grass- and herb-species is found in this nature type. Furthermore, the water is fish-rich, existing of a variety of species.

2.5.9 Rivers

This nature type represents the large rivers and their flood plains. Winter dikes limit the flood plains. There are no summer dikes or other artificial elements to control the river, like dams and groynes. Agriculture is not practised in the outer marshes and only natural grazing is present. There is no hunting or fishing. Water and soil are not polluted with PCB's or any other pollutant. Finally the rivers are not canalised in any way.

The largest part of the flood plains exists of riverine forests, interspersed with rich meadows and marshes, especially where the disturbance of incoming water is large. The riverine forests have already been described in Cromsigt & Van Wieren (2000). The meadows and marshes exist of a wide variety of high-quality sedges, grasses and herb species.

This description, but on a much smaller scale, also applies to the small rivers and brooks of the higher sandy soils.

2.5.10 Lakes

This nature type represents the lakes of Noord- and Zuid-Holland and Friesland that arose after the large-scale exploitation of bog in these areas. The lakes exist of unpolluted, meso-trophic, clear water with a varying water level. The banks are naturally formed, often overgrown with thick reed-lands. The reed is not managed. There is no hunting or fishing. The lakes are typically very fish-rich, with a large variety of species.

Often the shores of the lakes are part of the nature type marsh.

Appendix II shows the position of the above-described nature types in the Netherlands in 1999 (A) and the physico-geographical areas, where the nature types are part of (B).

3. Species descriptions

3.1 The Wild Boar

3.1.1 General description

The Wild Boar (*Sus Scrofa*, L., 1758) is the only European member of the pigs family (Suidae) of the order of even-toed mammals (Artiodactyla). It is widely distributed throughout the Eurasian continent. The Wild Boar is a heavy-built, dark-coloured, bristly animal. Throughout the distribution range it exhibits a considerable variation in size and certain body traits (e.g. the development of the mane). In general, the western races are smaller and less heavily built than the races in the eastern part of the distribution range. For the western races, the weight ranges from 50-185 KGs. for males and from 35-160 KGs. for females. Body length ranges between 1.10 and 1.55 m., shoulder height from 0.70-1.15 m.. (Van den Brink, 1978).

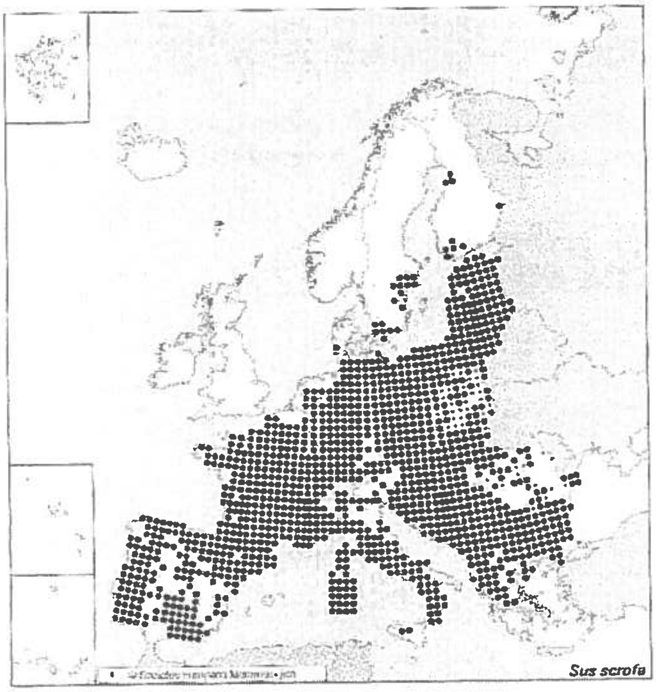

Figure 3. Distribution of the Wild Boar (*Sus scrofa*) in western and central Europe (© Societas Europaea Mammalogica).

Wild Boar used to be distributed throughout the Netherlands. Agricultural development and hunting, however, brought it to the edge of extinction. In the beginning of the 20th century it was reintroduced in the Veluwe area, where it still survives in fairly large numbers. Next to this population there is a second, free-living population in the Meinweg area of northern Limburg. (Broekhuizen et al, 1992).

3.1.2 Species ecology

The Wild Boar is a highly adaptable species. It can be found in a wide range of habitats, from semi-deserts to tropical rainforests and temperate forests. The highest densities of the species are found in areas with deciduous or mixed-deciduous forest (where mast of the Oak or Beech is present), especially with abundant water, e.g. floodplains. An important condition is also the availability of cover.

It is an omnivorous species, but vegetable matter constitutes the major part of its diet. Main components are seeds (like acorns and Beechnuts), roots and tubers, completed with animal matter like earthworms and a variety of invertebrate species. This animal matter seems to be an essential part of their diet. In years when food abundance in winter is low (low quantity of mast) grass is eaten in large quantities. The diet is usually very varied. High densities of Wild Boar, therefore, are usually found in habitats where the variety of food sources is high.

The Wild Boar is a gregarious species, forming sounders of usually between 6-20 individuals. These sounders exist of one or more females with their litter and possibly sub adults. Adult males use to live a solitary life. It is a fairly high reproductive species, with a litter size of usually between 4 and 7 piglets in western Europe. Juvenile mortality can be fairly high. Populations of Wild Boar are known to show wide fluctuations in the number of animals, due to fluctuations in reproductive rate and juvenile mortality. These two factors are dependent on availability of food (very important is the quantity of mast from the Oak and Beech) and other environmental factors, e.g. infection of diseases (e.g. Swine fever) and weather. (Oliver, 1993).

3.1.3 Densities found in the literature

Table 3. Population densities (No. km.$^{-2}$) for the Wild Boar as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant. The word 'in' before a reference means that the density figure is mentioned in the reference, but originates from a different reference.

Area	Habitat type	Census Period	Census Method	Density (No. km^{-2})	Reference
Europe	Various	-	General estimate	<=5	Oliver, 1993
Bialowieza, Poland	Coniferous forest (exploited)	Winter	Drive census + snow tracking	3.5	Jedrzejewska et al, 1994
"	Deciduous forest	"	"	13.1	"
Bialowieza, Poland	Coniferous/ Deciduous forest	March	Drive census	3.0	Jedrzejewski et al, 2000
"	"	May	"	5.3	"
Slovakia	Agricultural area	?	Track count	0.07-0.89	Homolka and Mrlik, 1989
"	Spruce forest	?	?	0.5	"
"	Oak/ Floodplain forest	?	?	>2.5	"
Zielonka	Young	Winter	Drive census	0	Pucek et al, 1975

forest, Poland	plantation		+ snow tracking		
"	Thicket	"	"	3.8	"
"	Pole-sized stand	"	"	1.7	"
"	Timber stand	"	"	0	"
Poland	Several forest areas	"	"	1.4	"
Bialowieza forest, Belarus (1890-1910)	Forest	?	?	0.4-3.1	in Heptner et al, 1966
Astrakhan nature reserve, Russia (1930)	Deciduous forest	?	?	2.7	in Heptner et al, 1966
Central Asia	Floodplains	-	General estimate	5-6	Heptner et al, 1966

3.1.4 Baseline densities

As shown in table 3 the densities in the literature vary between 0 and 6 animals per sq. km., with a peak of 13 individuals per sq. km. and a median density value of 3 No. km^{-2}.. The results also show the preference for deciduous forests above coniferous forests (e.g. Jedrzejewska et al, 1994; Homolka and Mrlik, 1989). Furthermore the relatively high densities of water-rich areas are clear (Homolka and Mrlik, 1989; Heptner et al, 1966).

It must be noted that due to the natural cyclic behaviour of Wild Boar populations densities can temporarily be much higher than 6 animals per sq. km.. Based on the descriptions of the nature types in chapter 2.5 (looking at food availability, variety and cover availability) and taking into account the mentioned range and median value, the following long-term densities for the different nature types are postulated:

Table 4. Baseline densities for the Wild Boar. Density is given in No. km^{-2}. for early spring.

Nature Type	Baseline density (No. $km.^{-2}$)
Forest on higher sandy soils	3
Forest in riverine area	5
Forest on marine clay	1
Forest in peat area	1
Forest in hilly area	3
Dune forest	3
Open dune	1
Heath on higher sandy soils	1
Marsh in riverine area	5
Marsh on marine clay	1
Marsh in peat area	1

The differences between the nature types can be elucidated as follows.

As described, the forest on the higher sandy soils generally exists of Birch-Oak or Oak-Beech forest with fairly well developed undergrowth. The availability of food (including mast of Oak and Beech) and cover is high. These forests, therefore, present a fairly optimal Wild Boar habitat, especially when the forest has a mosaic-like structure as described by Vera (1997). The same accounts for the forest in the hilly area and the dune forest, which represent more or less the same habitat.

The forest in the riverine areas presents an even more optimal habitat, because of the constant availability of water and the highly developed undergrowth of shrubs and herbs together with the presence of oaks (and subsequently mast) at the higher situated parts (resulting in a wide variety and abundance of food and cover). This habitat is also the area, where very high densities have been found (e.g. in the Wolga Delta in Russia (Heptner et al, 1966)). For the same reasons, the marshes will also present an optimal habitat, when oaks and beech trees are near. This is the case for the marshes in riverine area.

Ash and Elm dominate the forests on marine clay and in the peat area. The absence of mast makes these forests a less suitable habitat. The long-term density in this nature type will be very low. The same accounts for the heath on the higher sandy soils, which forms a very poor habitat regarding food as well as cover and for the marshes on marine clay and in peat area, where mast is not available.

The dunes present a highly variable habitat. Especially in the forested regions (with oak) densities of Wild Boar can be high, as is mentioned earlier. The open dune, however, is far less suitable. Food availability and cover are poorly available. Therefore, the long-term density in the open dune will be very low.

3.1.5 Actual numbers in the 1950s and currently

Currently Wild Boar is only present on the higher sandy soils of the Veluwe area in the province of Gelderland and of the Meinweg area in the province of Limburg.

The Wild Boar of the Veluwe live in unfenced areas, the so-called 'Vrije Wildbaan' and in two fenced areas, 'Koninklijke Houtvesterijen' and 'Nationaal Park de Hoge Veluwe'. Data on the number of Wild Boar in the unfenced areas for the spring of the years 1996-2000 have been received from the 'Vereniging Wildbeheer Veluwe' (VWV) through the 'Vereniging tot Behoud van het Veluws Hert' (VWV, unpublished results). We used the average number over these years, to take the cyclic behaviour of Wild Boar populations into account. The number of Wild Boar in the fenced areas of the Veluwe for the spring of 2001 has been obtained from the management authorities of both areas (unpublished results).

'Veluws Hert' also provided us with data on the number of Wild Boar in the Meinweg area. These were data on the number of Wild Boar that were shot during the hunting season 1996/1997 (125 individuals) ('Veluws Hert', unpublished results). More recent data are not available. We, therefore, assume a minimal population of 125 Wild Boar in the Meinweg area.

Hollander (2000) investigated the situation in the 1950s. He states that the distribution as well as the number of Wild Boar has not really changed since the 1950s. We, therefore, assume that the number in the 1950s is equal to the present number.

The table below summarises the present number and the number of Wild Boar in the 1950s for each nature type separately. Forest and heath on higher sandy soils have been combined, because the present numbers are counted for both habitats as one.

Table 5. The number of Wild Boar in the 1950s and currently (1996-2001) for different nature types.

Nature type	Actual number 1950	Actual number currently
Forest and heath on higher sandy soils	2118	2118
Forest in riverine area	0	0
Forest on marine clay	0	0
Forest in peat area	0	0
Forest in hilly area	0	0
Dune forest	0	0
Open dune	0	0
Marsh in riverine area	0	0
Marsh on marine clay	0	0
Marsh in peat area	0	0

3.1.6 Quality values

The quality values are calculated on the basis of the actual numbers of table 5 and the baseline numbers (calculated from the area sizes in table 1 and the baseline densities of table 4). The results are presented in table 6.

Table 6. Quality values for the Wild Boar for the different nature types in 1950 and currently. Nature types have been combined because the species uses them as one habitat. The baseline and actual numbers, on which the quality values are based, are also presented in the table.

Nature type	Baseline number 1950 area	Baseline number current area	Actual number 1950	Actual number currently	Quality value 1950	Quality value currently
Forest and heath on higher sandy soils	7724	8344	2118	2118	27	25
Forest and marsh in riverine area	1021	882	0	0	0	0
Forest and marsh on marine clay	138	456	0	0	0	0
Forest and marsh in peat area	278	276	0	0	0	0
Forest in hilly area	116	147	0	0	0	0
Dune forest and open dune	565	650	0	0	0	0

The Wild Boar is not present in most parts of its potential living area. This results in 0 quality values for most of the nature types. The reason behind this limited distribution is the government policy to keep the Wild Boar distribution restricted to the present distribution areas. This policy is based on the fear that Wild Boar form a source of Swine Fever. This policy is also the reason that the quality has not really changed since the 1950s. Managers have kept Wild Boar populations at a stable level.

The limited distribution is also the main reason for the low quality value of the populations of the forest and heath on the higher sandy soils. Wild Boar are more or less distributed over 20% of the total area of nature types on the higher sandy soils. This indicates that the quality value of these nature types is to a large extent determined by this limited distribution. The quality within the distribution range seems to be fairly well. In this respect, it must be noted that the present number of Wild Boar is the result of a number of very good mast years. So the quality is probably somewhat lower when the effect of good mast years is filtered out.

It has to be noted that the habitat quality in general is poor (see also Groot Bruinderink et al, 1999), especially due to the large proportion of relatively unsuitable pine forests planted for commercial purposes. Due to the new approach of more natural forest management this is changing and the habitat is getting better from the perspective of a Wild Boar. An additional improving factor is the aging of the forests, resulting in a larger amount of mast.

3.1.7 Monitoring

The monitoring of the Wild Boar is co-ordinated by the 'Vereniging Wildbeheer Veluwe'. Every year in early spring counts are organised to monitor the Wild Boar populations of the Veluwe. Below the monitoring method is described.

Monitoring of the Wild Boar is for 90% done with the help of supplementary feeding. For the purpose of monitoring the whole Veluwe area is divided in several management areas. Per area Wild Boar are counted on two evenings in the period from the end of May to the beginning of June. The animals are counted with a group of surveyors divided over a number of counting groups. The density in each management area is more or less 1 counting group per 200-250 ha. Two to 3 weeks before the counts food is placed on specific places. After 2-3 weeks all he Wild Boar will strongly gather around these places. The counting groups count all animals that they observe around these places. For each management area the results of the two evenings are compared. Based on these results the number of Wild Boar is estimated per management area.

3.2 The Red Deer

3.2.1 General description

The Red Deer (*Cervus elaphus*, L., 1758), is one of the four species of the deer family (Cervidae) in western Europe. It is a red to grey-brown medium-sized deer. Like the Wild Boar, the Red Deer exhibits a wide variety in body size. Body length on average varies between 1.65 and 2.50 m. (shoulder height between 1.05 and 1.50 m.) and the weight ranges between 90 and 220 kg. (in eastern Europe up to 300 kg.). The species is distributed throughout the temperate regions of the Eurasian continent, northern Africa and North America. (Van den Brink, 1978).

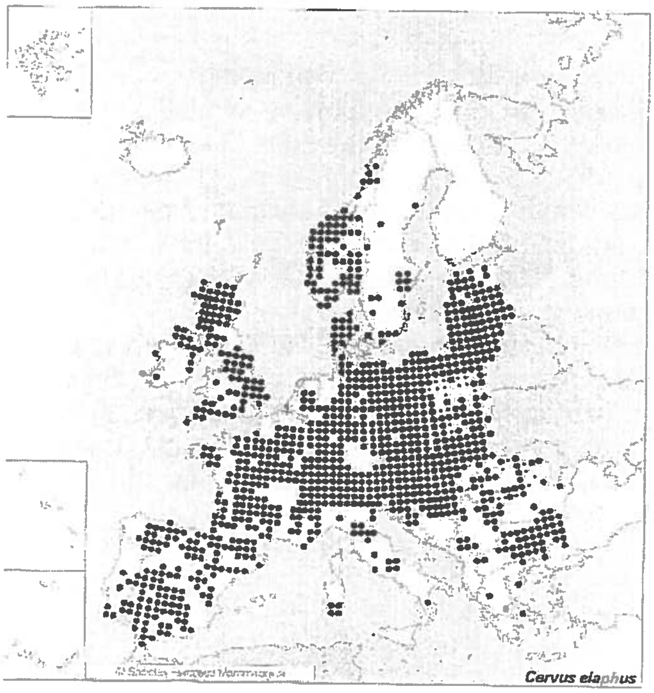

Figure 4. Distribution of the Red Deer (*Cervus elaphus*) in western and central Europe (© Societas Europaea Mammalogica).

During the Holocene period, the Red Deer was distributed throughout the Netherlands. Agriculture forced the species back in less suitable habitats on the higher sandy soils of the Veluwe and Utrechtse Heuvelrug. Currently it is mainly restricted to forested areas in the Veluwe area and to the Oostvaardersplassen reserve where it has been reintroduced. (Broekhuizen et al, 1992).

3.2.2 Species ecology

Like the Wild Boar, the Red Deer is a highly adaptable species. It is found from lowlands to mountainous areas and from Taiga forests to steppe areas. As mentioned earlier the Red Deer is often forced back into less favourable habitats (forests on poor soils). Because of this, often the wrong assumption is found that the Red Deer is a typical forest species. The most favourable habitat of Red Deer exists of open, mosaic-like deciduous forest areas with open heath and grassland areas.

The highest densities can be found in riverine areas, which were probably also the most important original habitat in the Netherlands (Broekhuizen et al, 1992).

The Red Deer is an intermediate grazer, which means that next to grasses and herbs it also feeds on browse (e.g. bark, leaves and twigs from trees and shrubs). Acorns and Beech nuts are also a part of its diet. Furthermore, it can thrive well on a diet of heather, *Calluna*, together with Billberry (*Vaccinium myrtillus*) and Common Hairgrass (*Deschampsia flexuosa*) (Mitchell et al, 1977). The diet is varied and the Red Deer, therefore, prefers habitats with a large variation in food sources.

Many Red Deer populations might migrate between winter and summer habitats. In the summer riverine areas are preferred, where there is a large abundance and variety of grass and herb species. In the winter they migrate to the higher sandy soils to feed on browse. It is not clear whether this also used to take place in the Netherlands. The sexes live separately in herds during most of the year. Old males often live solitary. The species is not highly reproductive, having on average one calve per female per year. (Van den Brink, 1978; Heptner et al, 1966).

3.2.3 Densities found in the literature

Table 7. Population densities (No. km.$^{-2}$) for the Red Deer as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant. The word 'in' before a reference means that the density figure is mentioned in the reference, but originates from a different reference.

Area	Habitat Type	Census Period	Census Method	Density (No. km^{-2})	Reference
Ardennes, Belgium	Coniferous forest	Spring	Transect count + annual cull data	3.8-4.8	Bertouille and de Crombrugghe, 1995
"	Mixed deciduous forest (30% coniferous)	"	"	5.0	"
Scotland	Various	?	?	0.8-10	Nowak, 1999
Scotland	Plantation	?	Vantage-point count	2	in Ratcliffe, 1984
"	Pre-thicket,	?	"	6.5	"
"	Thicket	?	"	11	"
"	High-forest	?	"	2	"
"	Checked-growth	?	"	2	"
Scotland	Commercial (coniferous) forests	?	?	5-15	Ratcliffe, 1984
Poland	(Coniferous) Forest-Dune landscape	Winter	Snow tracking	12	Dzieciolowski et al, 1996
Bialowieza, Poland	Coniferous/ Deciduous forest	March	Drive census	6.1	Okarma et al, 1997
Bialowieza, Poland	Coniferous forest (exploited)	Winter	Drive census + snow tracking	5.4	Jedrzejewska et al, 1994
"	Deciduous	"	"	12.8	"

	forest				
United Kingdom	Establishment	?	Faecal pellet count	2	Mayle, 1996
"	Prethicket	?	"	5-8	"
"	Thicket	?	"	10-40	"
"	Prefell	?	"	2	"
Bialowieza, Poland	Coniferous/ Deciduous forest	March	Drive census	4.6	Jedrzejewski et al, 2000
"	"	May	"	6.5	"
Slovakia	Agricultural area	?	Track count	0.04	Homolka and Mrlik, 1989
Zielonka forest, Poland	Young plantation	Winter	Drive census + snow tracking	0	Pucek et al, 1975
"	Thicket	"	"	0.6	"
"	Pole-sized stand	"	"	4.2	"
"	Timber stand	"	"	4.3	"
Poland	Several forest areas	"	"	2.7	"
Bialowieza (<1914), Poland/ Belarus	Forest	?	?	4.5-6.4	in Heptner et al, 1966
Krim nature reserve (1950), Ukraine	Deciduous forest, no hunting	?	?	>7	in Heptner et al, 1966
The Netherlands	Proposed optimal density	-	-	<=3	Groot-Bruinderink et al, 1988
Oostvaarders plassen, The Netherlands	Pioneer vegetation, bushy grassland		General estimate	>10, still growing	Van Wieren (unpubl. res.)
-	Estimated natural density	-	General estimate	1-2	in Niethammer et al, 1978-1994

3.2.4 Baseline densities

Of the densities found in the literature 75% fall within the range of 1-10 animals per sq. km., with a median density value of 4.9 No. km.$^{-2}$. Especially for the Scottish commercial forests and heath higher densities are found. These populations are not supplementary fed and quite heavily hunted (Van Wieren, unpubl. res.). Furthermore, most densities in the table above are from hunted populations from exploited forests. Densities from unexploited forests in Eastern Europe (Krim Nature Reserve and Bialowieza deciduous forest, see table 5) are considerably higher. The same is true for the unhunted population in the Oostvaardersplassen Reserve in The Netherlands. Therefore, we decided to raise the median value to 6 No. km^{-2}.. Based on this median value and the species ecology, the following, long-term, adult densities are proposed:

Table 8. Baseline densities for the Red Deer. Density is given in No. km^{-2}. for early spring.

Nature type	Baseline density (No. km.$^{-2}$)
Forest on higher sandy soils	6
Forest in riverine area	8
Forest on marine clay	8
Forest in peat area	8
Forest in hilly area	6
Dune forest	6
Open dune	4
Heath on higher sandy soils	4
Marsh in riverine area	8
Marsh on marine clay	8
Marsh in peat area	8

The division between the nature types is explained as follows.

The suitability of the forest on the higher sandy soils and in the hilly area is varied. The density in the dense, closed parts of the forest will be low. In these parts the undergrowth is minimal and, therefore, food availability is low. In this respect, the density in the described Beech forests (chapter 2.5) will also be relatively low. The situation in areas where water is abundant (near streams or sources) will be much more suitable. The densities will be highest in parts of the forest with open spaces, like grasslands and heath. Summarising, the forests on the higher sandy soils will form an intermediate habitat and we therefore propose the median value as baseline density. The same accounts for the dune forest, which forms a comparable Red Deer habitat.

The forests in riverine areas, on marine clay and in the peat areas, and the marshes are very rich, with a large variety and abundance of grasses, herbs and shrubs. Food is abundant and cover is widely available. These nature types form the optimal habitat of the Red Deer and will exhibit the highest densities of Red Deer. We, therefore, propose a somewhat higher density than the median density for these nature types as the baseline density (8 No. km^{-2}.).

The densities in heath areas will strongly depend on the type of heath. A *Calluna* heath, with a considerable amount of Common Hairgrass can support fairly high densities of Red Deer (Van Wieren, unpubl. res.). This will especially be the case when the heath area is part of a forest system (with valuable species, like the Billberry). However, heath areas with unpalatable species like *Erica* and *Molinia* are far less suitable. Furthermore, the in chapter 2.5 described extensive heath areas, with an intensive impoverishment process resulting in a very low abundance of herb and grass species, will support only very low densities of Red Deer, especially when forest is not near. Concluding, the heath areas form a relatively poor habitat. We, therefore, propose a somewhat lower density than the median density for this nature type as the baseline density (4 No.km^{-2}.). The same accounts for the open dune, which exists of a significant proportion of unsuitable patches (e.g. bare soil, heath with unpalatable species).

3.2.5 Actual numbers in the 1950s and currently

At present Red Deer are only present on the higher sandy soils of the Veluwe area and in the swampy area of the Oostvaardersplassen reserve in the province of Flevoland.

The 'Vereniging Wildbeheer Veluwe' (VWV) counts the number of Red Deer in the 'Vrije Wildbaan' of the Veluwe every year in early spring. The most recent data have been received of the VWV through the 'Vereniging tot Behoud van het Veluws

Hert'. These were data from the spring of 2000 (VWV, unpublished results). The number of Red Deer in the spring of 2001 in the fenced areas (Koninklijke Houtvesterijen en Nationaal Park de Hoge Veluwe) has been obtained from the management authorities of these areas (unpublished results).

The number of Red Deer in the Oostvaardersplassen reserve in 1999 has been obtained from Kampf (2000). Hollander (2000) investigated the situation in the 1950s. He gives numbers of Red Deer for the Veluwe area in 1959.

The table below summarises the present number and the number of Red Deer in the 1950s for each nature type separately. The nature types forest and heath on higher sandy soils have been combined, because the present numbers are counted for both habitats as one.

Table 9. The number of Red Deer in the 1950s and currently (1999-2001) for different nature types.

Nature type	Actual number 1950	Actual number currently
Forest and heath on higher sandy soils	2050	1607
Forest in riverine area	0	0
Forest on marine clay	0	0
Forest in peat area	0	0
Forest in hilly area	0	0
Dune forest	0	0
Open dune	0	0
Marsh in riverine area	0	0
Marsh on marine clay	0	450
Marsh in peat area	0	0

3.2.6 Quality values

The quality values are calculated on the basis of the actual numbers of table 9 and the baseline numbers (calculated from the area sizes in table 1 and the baseline densities of table 8). The results are presented in table 10.

Table 10. Quality values for the Red Deer for the different nature types in 1950 and currently. Nature types have been combined because the species uses them as one habitat. The baseline and actual numbers, on which the quality values are based, are also presented in the table.

Nature type	Baseline number 1950 area	Baseline number current area	Actual number 1950	Actual number currently	Quality value 1950	Quality value currently
Forest and heath on higher sandy soils	18282	17570	2050	1607	11	9
Forest and marsh in riverine area	1633	1411	0	0	0	0
Forest and marsh on marine clay	1103	3648	0	450	0	0
Forest and marsh in peat area	2226	2210	0	0	0	0
Forest in hilly area	233	295	0	0	0	0
Dune forest and open dune	1849	1889	0	0	0	0

It is clear that the quality values for the Red Deer are very low. The quality value is 0 for most of the nature types, because the Red Deer is not present in these nature types. The quality values for the forests and heath on higher sandy soils are also very low. Within these nature types the Red Deer is present in the Veluwe.

There are several reasons for the low quality value of the populations of the higher sandy soils. First of all the Veluwe represents only a small part of its potential living area on the higher sandy soils, more or less 18%. Its absence in most forests of the higher sandy soils obviously lowers the quality value strongly. This places the quality values of 9 and 12% in a different perspective. To a large extent these values are low due to the limited distribution range. The quality within the distribution range seems to be reasonable, but still somewhat low. A second important reason of the low quality values is that the habitat of the Red Deer in the Veluwe is in a poor condition, as already explained for the Wild Boar. The forests are very low in food species diversity, because for long the main practice has been wood production resulting in dark pine forests. Furthermore, the forests have been affected in the past by acidification, strong fragmentation and other detrimental effects. Finally, Red Deer are strongly regulated by hunting, which probably keeps the population below a lower level than it can reach under conditions without hunting.

The quality value for the forest and marsh on marine clay is somewhat higher because the Oostvaardersplassen area, where the Red Deer are present within this nature type, exhibits very high densities. A reason for this high density could be that the population of the Oostvaardersplassen has been unaffected by any disturbance (including hunting) for the last decades. Moreover, the Oostvaardersplassen Reserve is still a fairly young system, originating from land reclamation by humans at the end of the 1960s. Large grazer populations reach a very high density in this young area. The question is what will happen with those densities when the system gets older and the vegetation changes.

3.2.7 Monitoring

Monitoring of the Red Deer is also co-ordinated by the Vereniging Wildbeheer Veluwe. The monitoring is executed in more or less the same way as for the Wild Boar. The differences are explained here.

Red Deer are monitored somewhat earlier in the year, from the end of March up to the end of April. For the Red Deer the Veluwe is divided in 5 management areas. The density of counting groups per management area is somewhat lower, around 1 per 300 ha. In contrast with the Wild Boar, supplementary feeding is hardly used anymore for the monitoring of the Red Deer. Instead, the counting groups gather around areas, which are known to attract large groups of Red Deer in the mentioned period. Because Red Deer typically live in herds during this period, most animals are counted in this way.

3.3 The Roe Deer

3.3.1 General description

The Roe Deer (*Capreolus capreolus*, L., 1758) is the most widely distributed member of the deer family (Cervidae) in Europe. It is a brownish, small-sized deer with small antlers. Its body length ranges from 0.75-1.35 m. (shoulder height from 0.60-0.80 m.), weighing on average 14-27 kg. (up to 35 and even 50 kg. in the eastern part of its range). It is still distributed throughout Europe up to the western part of Russia. (Van den Brink, 1978).

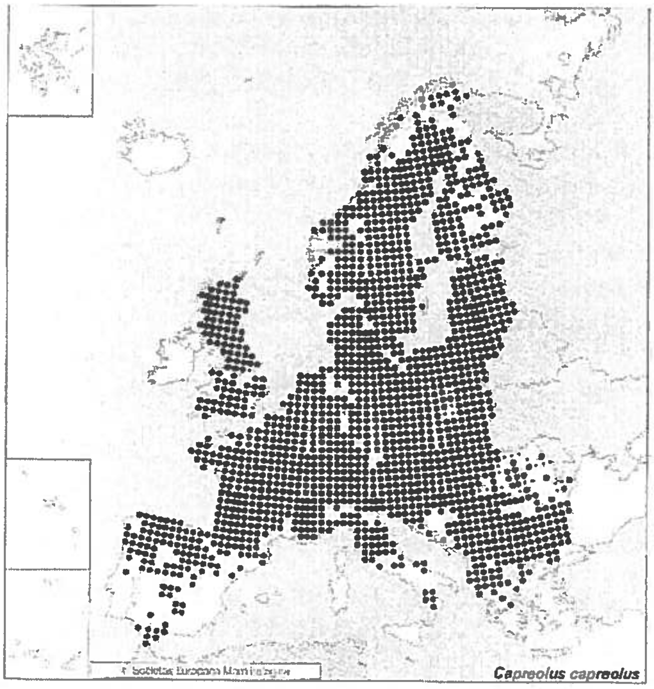

Figure 5. Distribution of the Roe Deer (*Capreolus capreolus*) in western and central Europe (© Societas Europaea Mammalogica).

In the Netherlands it used to be restricted to the forested areas of the eastern and southern part. Nowadays, the Roe Deer has spread throughout the country and can also be found in the dunes in the west and in open agricultural areas. (Broekhuizen et al, 1992).

3.3.2 Species ecology

The Roe Deer is extremely adaptable and has adapted very well to different human made landscapes. It can be found in high densities in agricultural landscapes. Its original, optimal, habitat exists of (especially deciduous) forests with a rich undergrowth, young forest patches and forest edges. It can be found from lowlands to mountainous areas.

The Roe Deer needs lightly digestible, high quality food. Furthermore, it is a typical browser species. The diet mainly exists of herb species and high-quality browse, like young twigs, leaves and buds. The fact that the Roe Deer needs this high quality food is the reason that its optimal habitat exists of young forest patches or forest edges, where a lot of high quality undergrowth and young sprouts can be found.

In contrast with Red Deer and Wild Boar, the Roe Deer is a much more solitary species. Especially the males are territorial. Females and young can form small groups, especially in winter. The Roe Deer is more reproductive than the Red Deer with on average 1-2 calves per female. (Van den Brink, 1978; Broekhuizen et al, 1992; Heptner et al, 1966).

3.3.3 Densities found in the literature

Table 11. Population densities (No. km.$^{-2}$) for the Roe Deer as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant. The word 'in' before a reference means that the density figure is mentioned in the reference, but originates from a different reference.

Area	Habitat type	Census Period	Census Method	Density (No. km^{-2})	Reference
Bialowieza, Poland	Coniferous /Deciduous forest	March	Drive census	3.8	Jedrzejewski et al, 2000
"	"	May	"	6.4	"
Bialowieza, Poland	Coniferous /Deciduous forest	March	Drive census	4.9	Okarma et al, 1997
Europe	Various	?	?	13-63	in Bobek, 1977
Poland	Deciduous/ mixed deciduous forests	-	General estimate	13-17	Bobek and Perzanowski, 1993
"	Coniferous/ mixed coniferous forests	-	"	18-23	"
Poland	Mixed deciduous forest	Autumn	Calculated estimate	26.9	Bobek and Perzanowski, 1993
"	Deciduous forest	"	"	28.6	"
"	Alder forest	"	"	64.2	"
Amsterdamse waterleidingduinen, The Netherlands	Dunes	Spring	Transect count	18.4-21.8	Almasi and Grandia, 1998
Alde Faenen, The Netherlands	Peat-moor area	Spring	?	6-9	in Stichting Kritisch Faunabeheer, 1994
Walcheren, Goeree and Schouwen-Duiveland, The Netherlands	Dunes	?	?	10	Stichting Kritisch Faunabeheer, 1994
Denmark	Forest and	?	?	60	Stichting Kritisch

	meadows				Faunabeheer, 1994
Denmark	Mosaic landscape of heath, grassland, forest (no hunting/ predation)	Spring	Drive census	34.5	Andersen and Linnell, 2000
Mountains N Spain	Beech forest	Autumn	Drive census	7.5	Saez-Royuela and Telleria, 1991
Europe	Various	?	?	0.1-63	in Saez-Royuela and Telleria, 1991
England	forest/ Farmland	Spring	Mark-resighting method	34-76	Gill et al, 1996
Europe	Agricultural areas	?	?	7-17	in Gill et al, 1996
Europe	Forest areas with wolves	?	?	0.7-19	in Gill et al, 1996
Norway	Norway spruce with clearcuts	Spring	Faecal pellet count	19.2, 23.5	Bergquist and Örlander, 1998
Bialowieza, Poland	Coniferous forest (exploited)	Winter	Drive census + snow tracking	4.9	Jedrzejewska et al, 1994
"	Deciduous forest	"	"	3.2	"
United Kingdom	Establishmen t	?	Faecal pellet count	8-30	Mayle, 1996
"	Prethicket	?	"	13-30	"
"	Thicket	?	"	1-7	"
"	Prefell	?	"	3	"
Slovakia	Agricultural area	?	Transect count	14	Homolka and Mrlik, 1989
Poland	Young plantation	Winter	Drive census + snow tracking	34.9	Pucek et al, 1975
"	Thicket	"	"	19.2	"
"	Pole-sized stand	"	"	20.3	"
"	Timber stand	"	"	9.6	"
"	Several forest areas	"	"	8.9	"
Russia (1920s)	Forest areas	-	General estimate	0.07	Heptner et al, 1966
Krim nature reserve, Ukraine (1950)	Deciduous forest, no hunting	?	?	4	Heptner et al, 1966
Poland	Coniferous forests with dense thicket and adjacent agriculture	?	?	16.1	in Nowak, 1999

3.3.4 Baseline densities

Table 11 gives densities ranging from close to 0 up to 76 animals per sq. km.. Most densities (ca. 90%), however, fall within the range of 0-35 individuals per sq. km.. The median value for the found densities is 15 No. km^{-2}.. Noting that much higher densities are possible on a local and possibly, temporal scale (e.g. during migrations), the following baseline densities are proposed for each nature type, based on the median value and species ecology:

Table 12. Baseline densities for the Roe Deer. Density is given in No. km^{-2}. for early spring.

Nature type	Baseline density (No. $km.^{-2}$)
Forest on higher sandy soils	15
Forest in riverine area	25
Forest on marine clay	25
Forest in peat area	25
Forest in hilly area	15
Dune (open dune/ dune forest)	20
Heath on higher sandy soils	5
Marsh in riverine area	25
Marsh on marine clay	25
Marsh in peat area	25

The ranges are elucidated as follows.

The highest densities will be found in the rich forests of the riverine area, on marine clay and in peat area. As described in chapter 2.5, these forests have a well-developed undergrowth of many herb species as well as a large variety of shrubs. The abundance of high quality browse during winter (like *Salix* and *Rubus*) is an important reason for the high density in these forests.

The forest on higher sandy soils will, in general, sustain lower densities. The main reasons are that these forests have a relatively poor undergrowth and low food availability during winter. However, within these forests fairly high densities can be reached in specific cases. Near streams and in seepage areas, for example, the undergrowth is much richer and more winter food is available (as described in chapter 2.5). The density in these areas is more comparable to the densities in riverine areas and on marine clay. Furthermore, in open areas in the forest (e.g. forest edges) the density can also reach these high values, because of the high availability of food. In this respect, the extent to which a forest displays a mosaic structure has a large influence on Roe Deer density. Summarising, the forest on higher sandy soils represents an intermediate habitat, regarding the quality for Roe Deer. We, therefore, propose the median density for this nature type.

The Heath on higher sandy soils, on average, has a low availability of high quality food and cover. Densities of Roe Deer will, therefore, be low.

The Dunes are a fairly optimal habitat for the Roe Deer, because of the large variety of habitats and the relatively high abundance of high-quality browse species (dwarf shrubs). The situation in the Amsterdamse Waterleidingduinen (Almasi and Grandia, 1998) has been followed for several years and the population seems to be stabilising between 18 and 22 animals per sq. km.. This seems to present a fairly natural situation for the Dutch Dune system (no hunting, predation of fox and presence of all other herbivores, with Fallow Deer instead of Red Deer). This makes it possible to give a reliable estimate for the dunes. This estimate, however, regards the dunes as one nature type. Therefore, for the Roe Deer the baseline density is given for dunes as one nature type, including open dune and dune forest.

The marshes are a very suitable habitat for the Roe Deer due to the large quantity of high quality food and the availability of cover.

3.3.5 Actual numbers in the 1950s and currently

For the Roe Deer data have been obtained through the 'Vereniging Het Reewild', who received this data from LASER. This organisation collects the spring counts of the different regional Wildlife Management Units (WBE's) throughout the Netherlands. Data existed of the number of Roe Deer, counted in the spring of 2000, for each province separately (LASER, unpublished results). More specified data on the level of nature types could not be obtained. Table 13 shows the data for the present number of Roe Deer.

Table 13. The present number of Roe Deer for each province separately. The data present the number of Roe Deer in the spring of 2000.

Province	Actual number currently
Groningen	3082
Friesland	2803
Drenthe	8376
Overijssel	9432
Flevoland	2270
Gelderland	9441
Utrecht	1802
Noord Holland	444
Zuid Holland	470
Zeeland	177
Noord Brabant	7385
Limburg	3247
Total	48929

Hollander (2000) gives the number of Roe Deer for the end of the 1950s. He shows that during this period Roe Deer were only present on the higher sandy soils. He gives a number of 15,000-18,000 Roe Deer. We take an average of 16,500 Roe Deer for the higher sandy soils at the end of the 1950s. Table 14 summarises the results for the 1950s. Hollander (2000) did not specify for nature types. Therefore, the forest, heath and marsh on higher sandy soils have been combined.

Table 14. The number of Roe Deer at the end of the 1950s (1959)(Hollander, 2000).

Nature type	Actual number 1959
Forest and heath on higher sandy soils	16500
Forest in riverine area	0
Forest on marine clay	0
Forest in peat area	0
Forest in hilly area	0
Dune	0
Marsh in riverine area	0
Marsh on marine clay	0
Marsh in peat area	0

3.3.6 Quality values

The quality values are calculated on the basis of the actual numbers of table 13 and 14 and the baseline numbers (calculated from the area sizes in table 1 and the baseline densities of table 12). The results are presented in tables 15 and 16.

Table 15. Quality values for the Roe Deer for the different nature types in 1950. Nature types have been combined because the species uses them as one habitat. The baseline and actual numbers, on which the quality values are based, are also presented in the table.

Nature type	Baseline number 1950 area	Actual number 1950	Quality value 1950
Forest and heath on higher sandy soils	38622	16500	43
Forest and marsh in riverine area	5103	0	0
Forest and marsh on marine clay	3448	0	0
Forest and marsh in peat area	6955	0	0
Forest in hilly area	582	0	0
Dune forest and open dune	8556	0	0

Table 16. Quality values for the Roe Deer for the different nature types currently. Values are calculated per province instead of nature types because of the form of the available data. The baseline and actual numbers, on which the quality values are based, are also presented in the table.

Province	Baseline number current area	Actual number currently	Quality value currently
Groningen	937	3082	329
Friesland	4521	2803	62
Drente	5007	8376	167
Overijssel	6705	9432	141
Flevoland	5159	2270	44
Gelderland	15285	9441	62
Utrecht	3128	1802	58
Noord-Holland	5373	444	8
Zuid-Holland	2842	470	17
Zeeland	1036	177	17
Noord-Brabant	10957	7385	67
Limburg	4856	3247	67

The average quality of Roe Deer populations is very high. The average quality of the present populations in the 12 provinces lies above 80% (average of QV's from appendix IV). Especially if we realise that estimates of the size of mammal populations are often underestimates, it seems clear that the quality of Dutch Roe Deer populations is very reasonable.

There is, however, a large difference between the provinces. Appendix IV shows that the Roe Deer populations of the western provinces (Noord-Holland, Zuid-Holland and Zeeland) on sea-clay and peat have a very low quality, ranging between 8-17%. Most important reason for these low quality values is probably the strong fragmentation of the habitat in these provinces. Figure 2.A in the methods section shows the extent to which the forests in these provinces is fragmented and scattered.

On the other hand the populations of the northeastern provinces of Groningen, Drente and Overijssel clearly have a much higher quality value than the average. The reason for these higher values is less clear. It may be that the Roe Deer in these provinces have adapted more to the agricultural landscapes and reach high densities in these areas as well. The agricultural area was not taken into account in our calculations.

A different reason for the different quality values per province could also be the different hunting pressure. The hunting pressure is possibly not equal in all parts of the Netherlands and may be higher in some provinces than in other provinces. This may also result in differences in the quality values.

The analysis for the 1950s clarifies that the situation for the Roe Deer has strongly improved since these times. In the 1950s the Roe Deer was absent in large parts of the country (resulting in the 0-values for most of the nature types in appendix IV). Since these years the Roe Deer has successfully re-colonised the country again. The Roe Deer was present on the higher sandy soils in the 1950s. However, the quality value for this region was also fairly low. Reasons for this could be a high hunting and poaching pressure during the first part of the 20th century and a limited distribution within the area of the higher sandy soils (e.g. in the province of Noord-Brabant). (Hollander, 2000).

3.3.7 Monitoring

Roe Deer are monitored by the different Wildlife Management Units (Wild Beheer Eenheden, WBE's), which are spread over the country. These units exist of hunters and they are obliged by law to manage a specific area. This among other things means that they have to monitor the Roe Deer populations in their areas. The monitoring method, however, is not prescribed. Within the time frame of this study it was not possible to get insight in the way all the WBE's monitor the populations in their area. We obtained data from LASER, a governmental organisation, that gathered data from the different WBE's and calculated the number of Roe Deer per province. More study is necessary to get insight in the way the different WBE's monitor Roe Deer populations.

In general, Roe Deer populations are monitored all-year round by hunters in the field. The hunters count the Roe Deer in their individual hunting area. These counts are often supplemented with specific early morning and evening counts in spring. It must be noted that these counts give a very variable picture of the actual numbers in the field.

3.4 The Aurochs

3.4.1 General description

The Aurochs (*Bos primigenius*, Bojanus, 1827) was a large bovine species, once distributed throughout the Eurasian continent. In early historic times it was found from northern Africa to south Sweden and from England in the west up to southern Siberia and China in the east. The geographical variation of this species must have been large, but there is not much known about this aspect. The species has been extinct since a long time. The last individual officially died in 1627 in Jaktorow forest, Poland. The reasons for this extinction were habitat destruction by increasing agriculture, hunting and competition with domestic livestock. According to Heptner et al (1989-1992) the males of the species, on average, weighed 600-800 KGs, with a shoulder height of 170-180 cm.. Females were much smaller, probably weighing in the range of 400-600 KGs (Van Vuure, personal communication). Heptner et al (1989-1992) emphasises that the species was highly dimorphic.

Bone remnants of Aurochs have been found in different parts of the Netherlands. It, therefore, is clear that the species was a part of the original Dutch fauna (see e.g. Zeiler, 1999). It is, however, unclear in what numbers and in what habitat the animal originally lived, because it is very difficult to relate findings of species remnants to species numbers and exact distribution.

3.4.2 Species ecology

The habitat preference of the species is not exactly clear. During the last decades of its existence it lived in the extensive and dense forests of Poland and Lithuania. This, however, is probably the result of human persecution. During this last period the Aurochs was forced back into less suitable habitats. It is generally assumed that the Aurochs naturally lived in open grass-rich areas, especially near rivers and marshes (Van Vuure, personal communication). In this respect the structure of the forest plays an important role. Aurochs would have preferred open, park-like forest landscapes (like described by Vera, 1997). In such forest types it would have reached much higher densities than in closed, dense forests.

The diet of the Aurochs mainly existed of grasses, supplemented with shoots and bark of trees and shrubs, especially during the winter. During autumn acorns formed an important additional food source. (Nowak, 1999; Heptner et al, 1989-1992).

According to Heptner et al (1989-1992) the species lived in small family groups, especially during winter. Old bulls probably lived a solitary life. This type of behaviour can be seen in present wild bovine species, like the Wildebeest, European Bison and also the Heck-Cattle in the Oostvaardersplassen area in the Netherlands. Not much is known about the reproductive behaviour of the Aurochs. Probably it showed much the same behaviour as present-day wild bovine species, having on average 1, rarely 2 calves per female per year. The Aurochs, probably, was not very susceptible to slight human interference, except for hunting, competition with livestock and being forced back in less optimal habitats. However, the Aurochs occupied a fairly large home range and, more important, exhibited natural migration between winter and summer habitats. Within those seasonal habitats it most probably also wandered around quite a lot. This migratory behaviour must have made it more susceptible to human behaviour.

3.4.3 Densities found in the literature

There are no data available on the density of the Aurochs, only rough estimates. The only figure, that we found, was given by Van Vuure (personal communication) on the density of the last population of Aurochs (see table 12). This population, however, was heavily managed and hardly represents a natural density. We gathered data on similar species, that can still be found in the wild today, to indicate a range of possible densities (table 17).

Table 17. Population densities for the Aurochs and similar species as found in literature. Next to the literature reference, where possible census area, species, habitat type and relevant comments are given for each density. -: information is not relevant.

Area	Species	Habitat type	Comments	Density (No. km^{-2})	Reference
Jaktorow forest, Poland	Aurochs (Bos primigenius)	Forest	Last population, supplementary feeding, competition with livestock	0.2	Van Vuure, personal communication
SE Asia	Gaur (Bos gaurus)	Forested hills and grassy clearings	Comparable weight, social behaviour and diet preference	0.6	Nowak, 1999
Poland	European Bison (Bison bonasus)	Forests and grassland	Comparable weight and social behaviour, different diet and habitat preference	1.2	"
Caucasus	"	"	"	0.3-0.4	"
Poland	"	-	Winter density in good habitat	0.5	Perzanowski, personal communication
Bialowieza forest, Poland	"	Forest and artificial grasslands	19th century, supplementary feeding	0.5	Van Vuure, personal communication
Tjikepuh Private Game sanctuary, West Java	Banteng (Bos javanicus)	Forest with open and marshes	Comparable weight, social behaviour and diet preference	1	Hoogerwerf, 1970
Oostvaarders plassen, the Netherlands	Heck Cattle (Bos taurus)	Very rich, open, grassland area	Semi-wild cattle breed (bred to resemble Aurochs). Unmanaged population	> 10, still growing	Unpublished results

3.4.4 Baseline densities

The densities, found in literature, for species, that are similar in size, behaviour and food and habitat preference (Gaur, European Bison and Banteng) range from 0.3-1.2 No. km^{-2}.. Of these species, the European Bison has a different preference regarding food and habitat. This species feeds more on woody species and tends to live more in closed forests than the original Aurochs. This may result in a lower potential natural density for the European Bison compared with the Aurochs. The data for the Heck-Cattle in the Oostvaardersplassen suggest that wild Bovine populations of animals, resembling the Aurochs can reach much higher densities than 1 per square km.. This could have been true for the Aurochs in e.g. food rich riverine and marshes.

Based on the comments above and the data for the density of the similar species, we assume a density of 1 adult individual per square km. as a minimal long-term natural density for the Aurochs in its natural habitat, probably being the riverine and marshes.

3.4.5 Actual numbers in the 1950s and currently

As was mentioned in chapter 3.4.1 the Aurochs has been extinct since long. The reason that this species is included in this report is that nowadays large grazers are more and more seen as indispensable elements of the Dutch natural landscape. At present Cattle populations are present in Dutch nature reserves, which are seen as the future substitutes of the original Aurochs. These are, for example the so-called Heck-Cattle in the Oostvaardersplassen and the Scottish Highland Cattle in the Imbosch. These populations are partly functioning as an experiment to see how these primitive Cattle breeds function in this ecosystem and whether they can play the envisaged role of the extinct Aurochs.

Cattle are present in many nature reserves in the Netherlands. However, in many cases they are still regarded as domestic animals, which serve as natural lawn mowers. Only in very few cases the cattle are seen as part of the surrounding ecosystem. The differences, however, are often unclear. Moreover, at the moment it is very difficult to decide which populations of cattle in nature reserves should be taken into account to calculate quality values. Therefore, we suggest that at the moment the Aurochs is not included in the calculation of quality values. First of all it has to become clear which populations of cattle are regarded as part of the ecosystem and, therefore, should be incorporated in the calculation of quality values in the future. We, therefore, hope that the fact that the Aurochs (and Wild Horse) are included in this report stimulates the discussion on the role of these 'species' in ecosystems and the way this should be defined.

3.5 The European Wild Horse or Tarpan

3.5.1 General description

The European Wild Horse or Tarpan (*Equus ferus*, Pallas, 1811) was once distributed throughout the steppe and semi-desert zones of southern and central Eurasia and Europe. However, the species went extinct and was replaced by domestic forms in most parts of its range. The only wild-living populations can be found in central Asia (Mongolia and possibly northern China), also known as the Przewalski Horse. Nowadays, the Przewalski Horse is regarded as a separate species. The Wild Horse disappeared from most of western Europe around 10,000 years ago, surviving in Poland, Belarus and Lithuania until 1814, when the last wild individuals were killed. It survived even longer on the steppes of the Ukraine, where the last known wild individual was killed in 1879. The Wild Horse exhibited a large geographical variation throughout its range, varying in coloration as well as size. The Horse mainly lived on steppe areas, but was also found in forested areas (these individuals were smaller and probably darker coloured). It's shoulder height varied from 115-146 cm., weighing probably around 200-300 KGs.. (Nowak, 1999; Heptner et al, 1989-1992).

The number of bones of the Wild Horse, found in the Netherlands, is very small (Van Vuure, personal communication). This does not necessarily mean that they were rare. Most archeo-zoological objects are found in ancient human settlements. Of course, the preferred game species will be found most. Therefore, it is very difficult to say anything about the original presence of the Wild Horse in the Netherlands. It is clear that it was present, but it is not clear in what numbers and in what regions and habitats.

3.5.2 Species ecology

The Wild Horse was found on open steppe areas and semi-deserts throughout most of its range. It seemed to have a strong preference for these open areas, like present-day wild horse species. However, it is clear that the Wild Horse was also found in the forests of western, central and eastern Europe. This Wild Horse is often called the Forest Tarpan, other than the Steppe Tarpan of the open areas. It must be noted that, as was the case with the Aurochs, the Wild Horse suffered severe human pressure during the last centuries of its existence and that this could be a reason that it retreated in the dense, extensive forests of eastern Europe (Heptner et al, 1989-1992). We did not find information on the structure of the forest habitat, this subspecies lived in. Regarding the preference of the horse for open areas, it probably depended on open areas within the forest (e.g. marshes, riverine areas, Van Vuure, personal communication). This is also shown by the Horses in the New Forest area in the United Kingdom, where the Horses prefer the open park-like forest landscape.

The diet of the Wild Horse, like that of domestic and feral populations throughout the world, mainly consists of grasses, supplemented with several herb species (Nowak, 1999). This diet preference also indicates that the Forest Tarpan depended on open areas within the forest, where grass was sufficiently available.

The Horse is a highly social animal, living in bands of 10-20 individuals throughout the year. Within these bands a dominance hierarchy exists. Two types of herds exist, a breeding herd with 1 adult stallion and several females plus young and a bachelor's herd of sub-adult or adult stallions. The Horse, typically, lives a wandering existence, probably to prohibit local overgrazing. Often, it also shows seasonal migrations. The described behaviour is found in present-day feral Horse populations in e.g. the U.S.A. (Nowak, 1999), but has also been described for the extinct Steppe Tarpan (Heptner et al, 1989-1992). The litter size of the Horse, on average, exists of 1 foal. A female maximally produces 1 litter per year, but the actual reproductive rate strongly depends on environmental as well as social factors (Nowak, 1999). Due to its migrating character, the Wild Horse is relatively highly susceptible to fragmentation of its habitat by man.

3.5.3 Densities found in the literature

Just as for the Aurochs, no data are available on the original natural density for the European Wild Horse. In table 18 we, therefore, included data on the density of similar species that we found in literature. Furthermore, we included data on the density of feral populations of domestic horses.

Table 18. Population densities for the European Wild Horse, feral horse and similar species as found in literature. Next to the literature reference, where possible census area, species, habitat type and relevant comments are given for each density. -: information is not relevant.

Area	Species	Habitat type	Comments	Density (No. km^{-2})	Reference
Oostvaarders plassen, the Netherlands	Konik Horse	Very rich, open, grassland area	Primitive horse breed (resembling forest Tarpan). Unmanaged population	> 10, still growing	Unpublished results
World-wide	Feral horse populations	Different	Densities depend on availability and concentration of food, water and cover	0.1-11	Nowak, 1999
Turkmenistan	Kulan (Equus hemionus)	Semi-desert	Comparable species	0.024	"
Africa	Grevy's Zebra (Equus grevyi)	Sub-desert, scrub-country	Comparable species regarding diet and social behaviour, though somewhat larger	0.1-0.2	"
Kruger NP, South-Africa	Burchell's Zebra (Equus burchelli)	Savanna, scrubland	"	0.7-2.2	"
Great Basin area, U.S.A.	Feral horse populations	Open grass steppe, scrubland	Medium to poor quality habitat	1-2	Berger, 1986
"	"	"	High quality habitat	4-7	"

3.5.4 Baseline density

A wide range of densities is shown by table 18 from 0.024-11 No. km^{-2}.. The figure for the Kulan, however, originates from a population, which is heavily persecuted by man. This, therefore, presents an unnaturally low population density. The data for the Zebra and the feral horse populations show a wide range in possible densities. The density strongly depends on the availability of water, food and cover. The data for the feral population in high quality habitat of the Great Basin Area and the Oostvaardersplassen suggest that the Wild Horse can reach fairly high densities of 7-10 No. km^{-2}. in optimal habitats. The data from table 18, however, are from open habitats. It is not clear what densities can be expected in a forest landscape, like originally in eastern Europe and further back in time, in the Netherlands. These densities, probably, were much lower. Though, densities in the rich riverine and marshes could have been fairly high, because food, water and cover were plentiful in these areas.

Based on all the comments above, we suggest a density of 2 adult animals per square kilometre as a minimal estimate for a long-term baseline density for an optimal habitat in the riverine and marshes.

3.5.5 Actual numbers in the 1950s and currently

For the European Wild Horse the same accounts, as was discussed for the Aurochs in chapter 3.4.5.

3.6. The Brown Hare

3.6.1 General description

The Brown Hare (*Lepus europaeus*, Pallas, 1778) is the largest European member of the Leporidae family. On average the Brown Hare has a body length between 0.485 and 0.69 m.. It weighs between 2.5 and 6.5 KGs. (even heavier in the east). The hair-colour is brownish to grey, with remarkably long ears. It is distributed throughout Europe. (Van den Brink, 1978).

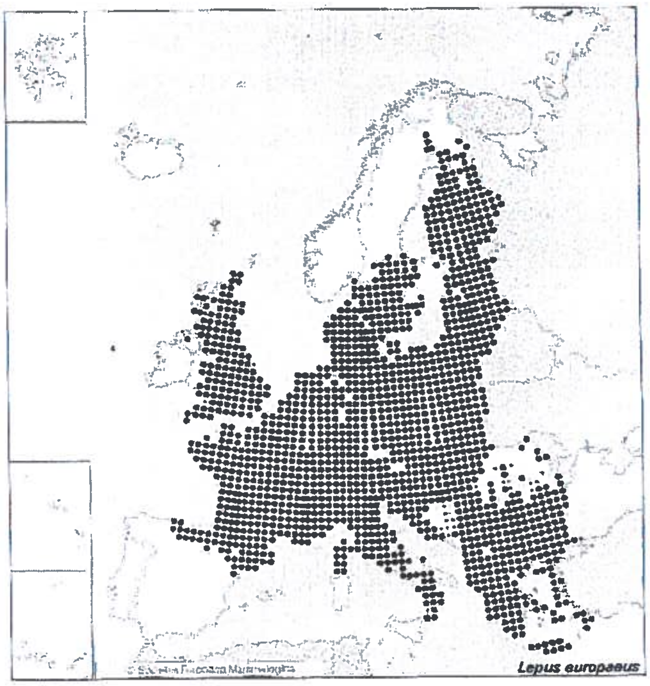

Figure 6. Distribution of the Brown Hare (*Lepus europaeus*) in western and central Europe (© Societas Europaea Mammalogica).

In the Netherlands the Brown Hare can be found throughout the country, including the Wadden islands (Broekhuizen et al, 1992).

3.6.2 Species ecology

Originally the Brown Hare is an inhabitant of the steppes (Broekhuizen et al, 1992). It prefers open landscapes with cover in the form of scattered shrubs and hedges. It naturally inhabits open landscapes, like heathlands, dunes, alpine grasslands, steppes and open forests. It has adapted very well to the large-scale agricultural areas of Europe, where it reaches very high densities.

Compared with the Rabbit, the Hare needs food of higher quality (Van Wieren, unpubl. res.). Main components of its diet are green, nutritious, grasses, completed with high-quality browse (especially when grass is not abundant or of low quality).

The Hare is generally a solitary species, with a nocturnal life. It is a highly reproductive species with on average 3 to 5 litters per year. The total number of young per female per year lies around 10. (Chapman and Flux, 1990). Hares are relatively sensible for outbreaks of diseases. In the last decades, the European brown hare syndrome (EBHS) has had a negative impact on Hare population numbers throughout Europe.

3.6.3 Densities found in the literature

Table 19. Population densities (No. km.$^{-2}$) for the Brown Hare as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant. The word 'in' before a reference means that the density figure is mentioned in the reference, but originates from a different reference.

Area	Habitat type	Census Period	Census Method	Density (No. km^{-2})	Reference
Mid-Wales, East Midlands, East Anglia, United Kingdom	Extensive agricultural area	Prebreeding	Line transect count	3.29-8.99	Heydon et al, 2000
The Netherlands	?	Autumn	?	50-60	in Frylestam, 1979
Poland	?	?	?	10-50	"
Germany	?	?	?	20-60	"
Poland	Good Hare habitat	-	?	50-60	"
Sweden	Agricultural area (island), little predation	Spring	Spotlight count	67-91	"
"	"	Autumn	"	137-196	"
"	Agricultural area	Spring	"	38-55	"
"	"	Autumn	"	54-62	"
"	Military area, grassland, cattle-grazed	Spring	"	14-15	"
"	"	Autumn	"	16-24	"
England	Unstocked pastures	May-July	Sight counts	30-62	Barnes et al., 1983
"	Cattle-stocked pastures	"	"	4-5	"
France	Agricultural area	March	Spotlight, circular-plot count	0.9-10.2	Verheyden, 1991
Italy	Poplar cultures	Spring	Drive census	52.6	Meriggi and Verri, 1990
"	"	Autumn	"	38.1	"
Poland	Agricultural fields	Autumn	Strip census (on foot)	8-28	Panek and Kamieniarz, 1999
Slovakia	Agricultural area	Spring	Strip census	30 (old census up to 200)	Homolka and Mrlik, 1989
The Netherlands	'Very good' Hare	-	General estimate	100	Pielowski and Pucek, 1976

	population				
The Netherlands (1970s)	Schiphol Airport	Autumn	?	235	"
"	Average Hare population	-	General estimate	20-35	"
Germany	Agricultural area	Spring	Spotlight count	3-51	Blew (unpublished)
"	"	Autumn	"	5-56	"
"	"	Spring	?	16.5-35.7	"
Scotland, Poland	?	?	?	50	in Nowak, 1999

3.6.4 Baseline densities

Almost all densities found in literature are figures from agricultural areas. These densities, on average, range around 50-60 animals per sq. km., with a median value of 38. In highly optimal situations (rich soil resulting in high quality grass and no grazing of cattle or other herbivores) densities of up to several 100s of individuals per sq. km. have been observed (e.g. Schiphol Airport). These, however, hardly present natural densities of Hare that can be expected in the nature types described in chapter 2. Food availability will be much lower and of lower quality in these nature types. The densities, therefore, will be lower.

Angelici (pers. comm.) suggests a natural density range of 15-35 Hares per sq. km.. He also suggests that the density in dunes will be higher than in Heath on higher sandy soils. This seems to be likely, regarding the fact that the availability of high quality grass and browse is higher in the dunes than in heathland (especially under constant impoverishment as described in chapter 2). Van Wieren (unpubl. res.) reaffirms the lower density in heathland, but suggests a lower minimal density of 10 animals per sq. km.. The following, average, spring densities are proposed:

Table 20. Baseline densities for the Brown Hare. Densities are given in No. km.$^{-2}$ in early spring.

Nature type	Baseline density (No. km.$^{-2}$)
Heath on higher sandy soils	15
Dunes	25

The explanation for the difference between these two nature types has already been given above. For the Brown Hare the proposed baseline density differs quite a lot from the median value of the densities that were found in literature. Most literature densities, however, represented figures for a monotonous agricultural landscape of high-quality grasses. These figures are far from representative for a natural Heath or Dune habitat. The proposed densities in the above table are, therefore based on the comments of Angelici and Van Wieren (unpubl. res.).

Hares can also be found in very low densities (0-5 No. km.$^{-2}$) in forest areas, like e.g. in the Veluwe area (Van Wieren, unpubl. res.). There, they are mainly found on small meadow patches within the forest.

3.6.5 Actual densities in the 1950s and currently

Data on the actual densities of Brown Hare for the different nature types at present were obtained from the Vereniging voor Zoogdierkunde en Zoogdierbescherming (VZZ). These data result from the breeding-bird monitoring network of SOVON, as explained in section 3.6.7. The data are the average over the period from 1994 to 1998 (VZZ, unpublished results).

Hollander (2000) gives data on the situation in the 1950s. He gives the average off-take around 1950 for the dunes and the higher sandy soils. Research has shown that the off-take represents more or less 30-40% of the population (Hollander, 2000). We, therefore, multiplied the average off-take around 1950 with 2.5 to get an estimate of the density of Hare in this period in the dunes and on the higher sandy soils. In this respect, we assume that the density on heath on higher sandy soils equals the average density on higher sandy soils. Table 21 summarises the densities of Brown Hare for different nature types in the 1950s and currently.

Table 21. The density of Brown Hare in the 1950s and currently (1994-1998) for different nature types. Density is given in number of Brown Hares per square kilometre.

Nature type	Actual density 1950 (No. km-2.)	Actual density currently (No. km-2.)
Heath on higher sandy soils	28.1	2.2
Open dune	28.5	0.8

3.6.6 Quality values

The quality values are calculated on the basis of the actual densities of table 21 and the baseline densities of table 20. The results are presented in table 22.

Table 22. Quality values for the Brown Hare for the different nature types in 1950 and currently. The baseline and actual densities, on which the quality values are based, are also presented in the table.

Nature type	Baseline density	Actual density 1950	Actual density currently	Quality value 1950	Quality value currently
Heath on higher sandy soils	15	28.1	2.2	187	15
Open dune	25	28.5	0.8	1.14	3

The quality values for the Brown Hare at present are extremely low. This is caused by the very low actual densities at present, which have been obtained through VZZ. It seems that these estimations of the present densities are severe underestimates of the actual densities, especially in the open dune. The current monitoring system, described in the following chapter, seems to be useable for comparing trends, but not for the determination of the current quality.

The idea that the densities are underestimates is strengthened when we regard the data of the National Hunting Society (KNJV). This society calculates the average yearly off-take for different species. For the Brown Hare this off-take has been stable for the last decade, on average 8.9 Hares per square kilometre. This off-take is clearly higher than both densities in table 21. The actual density will even be higher than the off-take. The problem, however, is that these figures mainly come from hunting ground in the agricultural areas. As explained in the species ecology section, the densities in these areas are on average higher than in natural areas.

It is evident that the situation of the Brown Hare in the nature types of table 21 is not clear and that at this moment it is not possible to calculate reliable quality values for these nature types. There is a strong need for a good monitoring programme for this species. This need has become even stronger because there are indications that the Brown Hare populations of western Europe have suffered from the European Brown Hare Syndrome during the last years. The exact impact of this disease on the populations in Dutch nature areas is not clear.

3.6.7 Monitoring

There is no specific monitoring of the number of Brown Hare in the Netherlands. Brown Hares are counted among the mammals, which are counted since 1994 by the participants of the network of breeding-bird monitoring, which is co-ordinated by SOVON. These participants monitor breeding-birds, but also count mammals, which are seen by coincidence. The surface of the plots, where the birds are monitored, is known and the plots are distributed over different nature types. In this way the density of the observed mammal species can be calculated for the plots for different nature types. These densities are given for the Brown Hare in table 21. However, the relation between the observed number of Brown Hares and the actual number is unclear. The usefulness of these densities for the determination of the quality values is, therefore, very limited, as was already mentioned in the former section.

The described method is useful for the registration of trends in the number of individuals of a species and to compare values between nature types (Daemen et al., 2000). The assumption is that, with an equal yearly effort of the bird-watchers, the changes in the observed number of animals per year give a realistic picture of the actual changes in the number of individuals. However, the monitoring of mammals remains a side-product of the bird monitoring. To get a more realistic idea of the abundance of Brown Hares in the different nature types other monitoring methods should be applied. Below two of these methods are described:

1) Nightly counts on a fixed transect. On pre-determined points the observer lights up an area in his walking direction within a radius of 150 meters. All Hares within the beam are counted. It is necessary to execute several simultaneous counts, because the variation between days within 1 month has been shown to be very large. The season of the count is also a factor which should not be ignored. Generally, Brown Hares are monitored in the pre-breeding season (early spring), only counting the individuals of 1 year and older. (Bestman & Cornelissen, 1998).
2) Counting pellets in plots of 2,5 m^2.. The assumption is that 375 pellets correspond with one Brown Hare individual. This figure is the number of pellets that a Brown Hare produces in one day. This method is very much labour intensive. (Bestman, 1997).

3.7 The European Rabbit

3.7.1 General description

The European Rabbit (*Orytolagus cuniculus*, L., 1758) is the second European member of the Leporidae family. It is a small, brownish to black herbivore species with relatively short ears (compared with the Hare). The body length varies between 0.34 and 0.48 m.. It weighs, on average, 1.3-2.2 KGs.. The origin of the European Rabbit is unclear. It did not appear in north central Europe until the Middle Ages. Around this time it was (re) introduced by man in this region from the Iberian peninsula. From this time on, it spread throughout Europe up to eastern Poland and southern Sweden. (Chapman and Flux, 1990; Van den Brink, 1978).

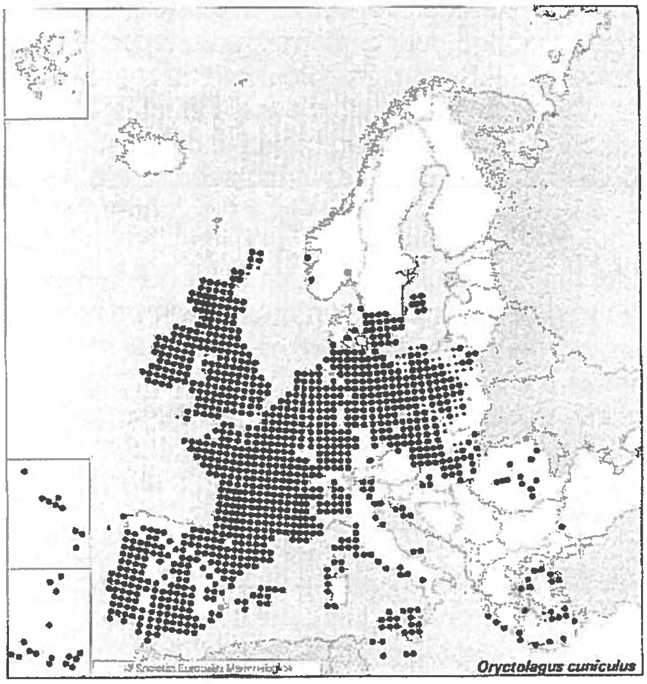

Figure 7. Distribution of the European Rabbit (*Oryctolagus cuniculus*) in western and central Europe (© Societas Europaea Mammalogica).

In the Netherlands the species is spread throughout the country (Broekhuizen et al, 1992).

3.7.2 Species ecology

The European Rabbit prefers sandy soils, where it is easy to dig their holes. Furthermore, it prefers open landscapes, with a significant amount of cover. In the Netherlands, the most optimal combination of sandy soils, cover and open grass landscapes are the dunes and to a lesser extent the heath on higher sandy soils. Besides this Rabbits also live, in much lower densities, in forest areas and agricultural landscapes.

Rabbits mainly feed on grass. Unlike the Hare, it can also live on relatively low quality grass (Van Wieren, unpubl. res.). The Rabbit needs short herbage to feed on. In this respect, the presence of large herbivores, that shorten the vegetation, can improve the habitat for rabbits.

Rabbits are social animals, forming groups with a strict linear hierarchy. They are highly reproductive with several litters per year, depending on climatic conditions and e.g. population density. One litter, on average, exists of 3 to 9 young. On average, the number of young per female per year ranges from about 15 to 45. This very high reproductive capacity enables Rabbit populations to grow very fast. In years of good climatic conditions and high food abundance very high population densities are reached. However, predators and diseases often heavily influence Rabbit populations. Especially outbreak of diseases, like Myxomatosis and, at present, Viral Haemorrhagic Disease (VHD), can result in population decreases of up to 99% (Broekhuizen et al, 1992). Populations of European Rabbit are, therefore, characterised by fluctuations within a very wide range. (Chapman and Flux, 1990; Drees, 1988).

3.7.3 Densities found in the literature

Table 23. Population densities (No. km.$^{-2}$) for the European Rabbit as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant. The word 'in' before a reference means that the density figure is mentioned in the reference, but originates from a different reference.

Area	Habitat type	Census Period	Census Method	Density (No. km^{-2})	Reference
Scotland	Coastal sand dunes	Prebreeding	Trapping out	1210-1680	Kolb, 1991
Scotland	Coastal sand dunes	Prebreeding	?	60-110	in Kolb, 1991
?	Chalk Grassland	?	?	1600 adults	"
?	Coastal sand dunes	?	?	2200	"
?	"	Postbreedin g	?	7500	"
-	Europe	-	General estimate	2500-3700	Nowak, 1999
Slovakia	Agricultural area	Winter	Visual census	9	Homolka and Mrlik, 1989
"	"	"	"	0.9 (after myxomatosis)	"
Noord-Hollands Duinreservaat. The Netherlands	Coastal sand dunes	September	Field counts divided by percentage above-ground	>3600	Drees, 1988
"	"	March	"	>350	"

3.7.4 Baseline densities

Densities of Rabbit populations are very hard to estimate, especially because it is very difficult to tell which percentage of the population can be found below-ground. It is, however, likely that most estimated densities are underestimates. The found densities ranged from close to 0 up to 7500 animals per sq. km., with a median density of 1600 animals per sq. km.. Homolka and Mrlik (1989) show the dramatic decrease after an infection with Myxomatosis. Furthermore, Drees (1988) shows the effect that a severe winter can have on Rabbit populations. The data clearly show the wide range of potential densities, depending on climatic conditions, season and the effect of diseases. The following, long-term (average over 5-10 years), prebreeding densities are proposed:

Table 24. Baseline densities for the European Rabbit. Density is given as the prebreeding density in No. km.$^{-2}$.

Nature type	Baseline density (No. km.$^{-2}$)
Heath on higher sandy soils	1000
Open dune	1500

The baseline densities have been based on the median value of the densities that were found in the literature. On average, the density in the dunes will be higher than in the Heath, because of the higher abundance of high-quality grass in the dunes. The literature densities almost all came from dune areas. We, therefore, proposed a baseline density for the heath below the median density.

Finally, it must be noted that the original, natural densities in the Netherlands have been much higher, before the outbreak of Myxomatosis in 1953. Myxomatosis is an exotic disease from South-America that has strongly influenced Rabbit populations. The proposed baseline densities could, therefore, be fairly precautious estimates.

3.7.5 Actual densities in the 1950s and currently

Data on the actual densities of European Rabbit for the different nature types at present were obtained from the VZZ. These data result from the breeding-bird monitoring network of SOVON, as explained in section 3.7.7. The data are the average over the period from 1994 to 1998 (VZZ, unpublished results). Table 25 summarises the densities of European Rabbit for different nature types at present. No data were available on the situation in the 1950s.

Table 25. The density of European Rabbit in the 1950s and currently (1994-1998) for different nature types. Density is given in number of European Rabbits per square kilometre.

Nature type	Actual density 1950 (No. km-2.)	Actual density currently (No. km-2.)
Heath on higher sandy soils	No data	11.2
Open dune	No data	26.2

3.7.6 Quality values

The quality values are calculated on the basis of the actual densities of table 25 and the baseline densities of table 24. The results are presented in table 26.

Table 26. Quality values for the European Rabbit for the different nature types in 1950 and currently. The baseline and actual densities, on which the quality values are based, are also presented in the table.

Nature type	Baseline density	Actual density 1950	Actual density currently	Quality value 1950	Quality value currently
Heath on.higher sandy soils	1000	No data	11.2	No data	1
Open dune	1500	No data	26.2	No data	2

Even more than for the Brown Hare, the quality values for the European Rabbit are extremely low. Again, this is the result of very low actual densities at present, given by VZZ. It is known that the estimation of Rabbit densities often results in severe underestimates. This is probably also the case for the data in table 25. Therefore, the quality values, based on the figures in table 25, are not very reliable. As for the Brown Hare, it is necessary to set up a monitoring network to get an idea of the quality of Rabbit populations in the mentioned nature types. The next chapter gives more insight in the monitoring system on which the data in table 25 are based and recommendations for better monitoring. In this way it becomes possible to get insight in the effect of diseases like myxomatosis and VHD.

3.7.7 Monitoring

As for the Brown Hare, there is no monitoring of the numbers of European Rabbit specifically. It is only monitored to some extent by the breeding-bird monitoring network of SOVON. The same remarks are valid for the Rabbit, as have been mentioned for the Brown Hare in section 3.6.7.

Again, to get a more realistic idea of the abundance of Rabbits in the different nature types other monitoring methods should be applied. Below two of these methods are described:

1) Nightly counts from a car. All Rabbits in the car's spotlight are counted. This method does not really give insight in the actual number of rabbits, because only the animals are counted which are present on the road. Furthermore, the method is very sensitive for disturbance. For example, when joggers or walkers have preceded the observer just after sundown, the effect of disturbance is still significant one hour later. Obviously, the season has also effect on the result of the count. Rabbits are best counted during spring (March-April) and autumn (September-October). (Snater & Baeyens, 1995).
2) The nightly counts by foot, as described for the Brown Hare under point 1 in section 3.6.7.

Preference is given to method two, because in this case Rabbits and Hares can be monitored according to the same method, simultaneously and in the same plots. In this respect, a network of counting areas should be set up for the Brown Hare and the European Rabbit, distributed over the different nature types (open dune and heath on higher sandy soils) to get estimates of the present abundance of these species in these nature types.

3.8 The European Beaver

3.8.1 General description

The European Beaver (*Castor fiber*, L., 1758) is a large-sized rodent. The species used to be widespread and abundant in the whole of Eurasia. It has, however, severely suffered from habitat destruction and hunting, resulting in the fact that only 5 isolated populations were left in Europe in the early 20th century. This was the start for large-scale protection of the species and numerous re-introductions were executed. Nowadays, they are distributed across Europe again, though populations are very much scattered. Main populations are found near the Rhone, Danube and Elbe rivers, in Scandinavia and in the Baltic countries. (Mitchell-Jones et al, 1999). The European Beaver weighs 12.5-40 KGs. with a body length ranging from 71-90 cm., with an additional tail of 30 cm. (Van den Brink, 1978).

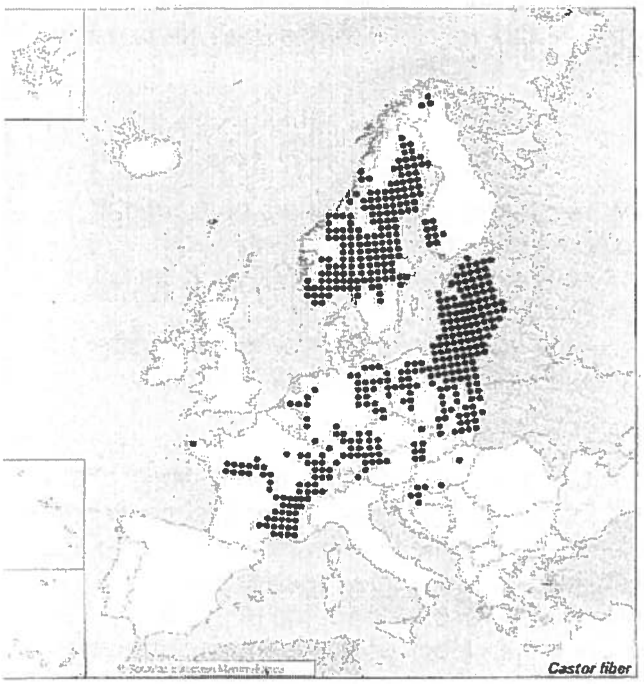

Figure 8. Distribution of the European Beaver (*Castor fiber*) in western and central Europe (© Societas Europaea Mammalogica).

The Beaver was once distributed in the southern and eastern parts of the Netherlands, living in the riverine areas, the small rivers of the higher sandy soils (except for the Veluwe area) and the inner dune area of Holland. After heavy persecution and habitat destruction, the Beaver went extinct in the early 19th century. In 1988 the first Beavers were reintroduced in the Biesbosch area. (Broekhuizen et al, 1992). Nowadays, there are four separated populations of Beaver in the Netherlands: in the Biesbosch, Gelderse Poort area near Nijmegen, Flevopolder (population results from animals that escaped from a game park) and in Limburg.

3.8.2 Species ecology

The Beaver is found in water-rich areas with significant availability of (deciduous) trees or shrubs. Its main demands are a minimal water level of 50 cm. and a sufficient amount of woody plants and herbs for food. Furthermore, they need a water level, which results in the fact that the entrance of their burrow or lodge is permanently under water. The Beaver, to a large extent, is able to create its own habitat by building dams to increase the water level. The water is important for the Beaver as an escape route and to store food for winter. Furthermore, it supplies the Beaver with water plants for food. (Broekhuizen et al, 1992).

The diet of the Beaver fully exists of plant material. In the winter the diet mainly exists of tree bark, supplemented with the roots of water plants. During the summer, the diet is supplemented with grasses, water plants and other herb species. Of the tree species, the Willow (*Salix*) and Poplar (*Populus*) are preferred. (Broekhuizen et al, 1992).

The Beaver is a monogamous species, living in small family groups around a burrow or self-built den. A family group may exist of 10-14 individuals, but on average exists of a breeding pair with a couple of young from previous years. The young normally stay with their parents for 2-3 years. The Beaver is a territorial species, using scent to mark its territory. (Lieverse and Nilwik, 1981). The Beaver has one litter per year, with an average litter size of 1-3 young (Nolet and Rosell, 1998). The Beaver, generally, has a large impact on its environment, due to its selected feeding on certain tree species and the fact that it can create large ponds by building dams. In this way it strongly influences the vegetation structure and, ultimately, the other species living in the Beaver habitat. In the U.S.A. it is shown that the activity of Beavers creates large marshes and natural meadows, which are optimal habitat for deer, moose and several other species. (Lieverse and Nilwik, 1981). This described habitat is not very suitable for humans to live in. Therefore, Beavers need a fairly large area, without human interference, where they have the space to freely manipulate their environment.

3.8.3 Densities found in the literature

Table 27. Population densities for the Eurasian Beaver as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant.

Area	Habitat Type	Census Period	Census Method	Density (colonies km^{-1})	Reference
Middle Elbe, Germany	River	Autumn	Colony survey	0.24	Dijkstra & Broekhuizen, 1997
Several study areas	River	?	?	0.15-0.77	"
Bialowieza, Poland	Medium - sized forest rivers (width 11-15 m.)	Winter	Track counts	0.39	Sidorovich et al, 1996
Bialowieza, Poland	Small forest rivers (width 6-10 m.)	"	"	0.24	"
"	Very small forest rivers (width 1-5 m.)	"	Track counts	0.14	"

3.8.4 Baseline densities

For the Beaver very little data was found on the density of the species. No. of colonies per kilometre is the most general way of measuring Beaver density and we, therefore, used this dimension for the proposed baseline density. These densities range from 0.14 to 0.77 colonies km^{-1}.. Looking at the mean (0.322) and median (0.24) value of the found figures it seems acceptable to suggest a minimal long-term density of 0.2 colonies per kilometre of river for the Beaver. This is a mean baseline density for rivers. The data of Sidorovich et al (1996) suggest that the density of the Beaver will be higher near medium-sized woodland rivers than near smaller woodland rivers, as was noted for the Otter.

We did not find specific data for the density of the Beaver (in No. of colonies per km.) for lakes and marshes. For the Beaver it is unclear whether the density is related to the total water surface. We, therefore, assumed that the baseline density for these nature types is equal to that for the rivers (0.2 colonies km^{-1}).

To calculate the number of Beavers per km. from the colony density we assumed that the average number of Beavers older than 1 year per colony is 4 (a breeding pair plus 2 young of more than 1 year old). This assumption is based on the species ecology information (chapter 3.8.2).

Summarising, the colony densities were multiplied by 4 to come to the following long-term baseline densities for the Beaver:

Table 28. Baseline densities for the European Beaver. Density is given in number of Beavers (older than 1 year) per kilometre of shore.

Nature type	Baseline density (No $km.^{-1}$)
Rivers	0.8
Lakes	0.8
Marshes	0.8

3.8.5 Actual densities in the 1950s and currently

Because it was not possible to calculate baseline numbers for the Beaver, densities were used to calculate the quality values. For the Beaver data on the present density were obtained through the VZZ, except for the data for the Gelderse Poort area which came from Niewold & Müskens (2000). The VZZ presented density numbers from different areas in the Netherlands divided over the different nature types. The mean density for each nature type was calculated from these density numbers (n=13 for the rivers and streams, n=4 for the lakes). The density data are given for the year 2000 (VZZ, unpublished results). In the 1950s the Beaver was extinct in the Netherlands (Broekhuizen et al, 1992) and, consequently, the density was 0. Table 23 summarises the mean density of Beaver for the different nature types in 1950 and currently.

Table 29. The density of European Beaver in the 1950s and currently (2000) for different nature types. Density is given in number of Beaver per kilometre shore length.

Nature type	Actual density 1950 (No. km-1.)	Actual density currently (No. km-1.)
Rivers and streams	0	0.2
Lakes	0	0.17
Marshes	0	0

3.8.6 Quality values

The quality values are calculated on the basis of the actual densities of table 29 and the baseline densities of table 28. The results are presented in table 30.

Table 30. Quality values for the European Beaver for the different nature types in 1950 and currently. The baseline and actual densities, on which the quality values are based, are also presented in the table.

Nature type	Baseline density	Actual density 1950	Actual density currently	Quality value 1950	Quality value currently
Rivers and streams	0.8	0	0.2	0	25
Lakes	0.8	0	0.17	0	21
Marshes	0.8	0	0	0	0

The quality values for the European Beaver are low. In the 1950s the species was still extinct and therefore the quality was 0. The present quality is not directly caused by a limited distribution, as for e.g. the Red Deer. These quality values were calculated on the basis of densities, not total numbers. Furthermore, these densities came from areas where the species was present. In most of the Netherlands the Beaver is still absent. This is not taken into account with this method and, therefore, the quality for the Beaver is intrinsically higher than for the other species.

Nevertheless, the quality values at present are low. The reason for this is probably that the time since re-introduction is still relatively short. The territories of especially the Beavers in the Biesbosch area are very large compared with Beavers from foreign areas, where they have been present for much longer periods. Furthermore, a relatively large amount of the Dutch Beavers are solitary animals, resulting in a low density. Probably, the territories will decrease in time, resulting in higher densities. However, for the coming years possibly first re-colonisation of new areas will occur before the territories in the occupied areas decrease. Based on this assumption it seems likely that the quality of the Dutch Beaver populations will stay fairly low in the near future.

3.8.7 Monitoring

Since the re-introduction of the Beaver in the Netherlands the species has been intensively monitored. This has resulted in the data of table 29. Below a description is given of the monitoring method.

During the winter the position of the Beaver dens is determined and during summer and winter the borders of the territories are estimated. Further, every year during the summer two simultaneous counts are executed in the territories near the dens. All animals older than 1 year are counted. The density is then given in the number of Beavers per kilometre of shore that is used by the Beavers.

The described method gives a good idea of the number and density of Beavers in the Netherlands. It is quite labour intensive, but due to the limited distribution of the Beaver this is not a problem yet. In the future, when the Beaver has more widely spread, it will be more efficient to set up a system of counting areas, where the Beaver is counted on a regular basis. These areas should be representative of the whole distribution range of the Dutch Beaver populations.

3.9 The Red Squirrel

3.9.1 General description

The Red Squirrel (*Sciurus vulgaris*, L., 1758) is a medium-sized rodent species with a reddish coat and a typical long tail and small plumes on the ears. It is distributed throughout the Eurasian continent and generally still quite common. In some places, mainly southern England, the introduced Grey Squirrel (*Sciurus carolinensis*) from North America has replaced the species. Especially the coat colour varies over its distribution range. The Red Squirrel weighs 0.23-0.48 KGs., with a body length ranging between 19.5 and 28 cm.. (Mitchell-Jones et al, 1999; Van den Brink, 1978).

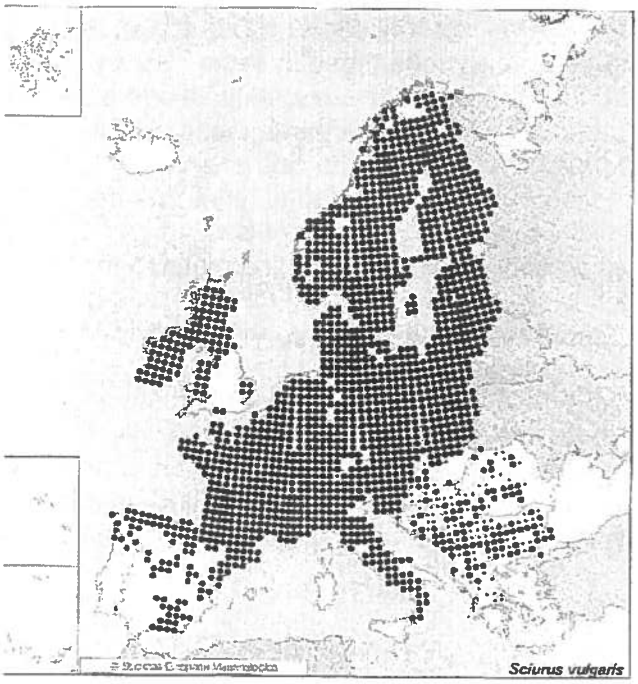

Figure 9. Distribution of the Red Squirrel (*Sciurus vulgaris*) in western and central Europe (© Societas Europaea Mammalogica).

In the Netherlands the species experienced a population crash in the late 1960s, early 1970s. In the following years the species re-established itself (but probably on a lower level) and nowadays it is found in forested areas throughout the country, but mainly in the south, middle and eastern parts. (Broekhuizen et al, 1992).

3.9.2 Species ecology

The Red Squirrel is a typical forest animal. It depends on the presence of trees for food and nesting. In this respect, it prefers old forests, where tree seeds and nesting sites are abundant. The North-American species have significantly lower densities in coniferous forests compared with deciduous and mixed-deciduous forests. However, the Red Squirrel in Eurasia does not show this preference. Some authors even state that the species prefers coniferous forests (Kenward et al, 1998;

Van den Brink, 1978). In general, however, it seems that the Red Squirrel can reach equal densities in coniferous as well as deciduous forests (Gurnell, 1987; Wauters and Lens, 1995). Habitat fragmentation significantly influences population densities of the Red Squirrel. The population density is lower in more fragmented habitats (Mitchell-Jones et al, 1999).

The Red Squirrel mainly feeds on tree seeds of coniferous and deciduous trees. This diet is supplemented with tree buds, young leaves, eggs, young birds and fungi, depending on the season and availability of seeds. (Broekhuizen et al, 1992). Due to the fact that tree seeds form the main component of the diet of the Red Squirrel, annual population density fluctuates strongly, depending on the availability of the seed crop. This results in a typical cyclic behaviour of Red Squirrel population numbers, with high population densities in years following a year with high seed availability and low densities in years following a year with low seed availability (see e.g. Andrén and Lemnell, 1992). The fact that Red Squirrels do not exhibit higher densities in deciduous forests (like their American counterparts) is explained by their stable, solitary and highly territorial social organisation, which keeps their density relatively low (Gurnell, 1987). Red Squirrels are highly reproductive, with 1-2 litters per year and on average 1-5 young per litter (Gurnell, 1987). Humans affect the species in two ways. First of all it is positively influenced by the creation of parks and other human made forest landscapes. On the other hand, as mentioned earlier, fragmentation of its habitat negatively influences the Squirrel's population density.

3.9.3 Densities found in the literature

Table 31. Population densities (No. km.$^{-2}$) for the Red Squirrel as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant.

Area	Habitat Type	Census Period	Census Method	Density (No. km^{-2})	Reference
SC Sweden	Coniferous production forest	Winter	Transect counts (snow tracks, food remains)	27.8 ('78-'79), 13.3, 5.6, 12.2, 2.2, 10.0, 16.1, 10.6, 5.6, 31.7 ('87-'88)	Andren & Lemnell, 1992
Cumbria, N England	Coniferous production forest	Year round	Capture-recapture	7, 28, 11 ('92), 31, 18, 19 ('93), 40, 19, 21 ('94)	Lurz et al, 1998
Scotland	"	"	"	80	"
S England	Coniferous forest	Prebreeding	Capture-recapture	210, 230, 344	Kenward et al, 1998
"	Deciduous forest, Oak-Hazel	"	"	76	"
-	-	-	General estimate	10-150	Mitchell-Jones et al, 1999
Belgium	Deciduous oak-beech forest	Year round	Total capture	80-220, year-round long-term average 100	Wauters and Lens, 1995
Belgium	Deciduous/ coniferous forest	Adult density	Total capture	42, 44, 52, 64, 68, 88 (all <= 55 ha.), 110 (600 ha.), 112 (300 ha.)	Wauters et al, 1996

Belgium	Coniferous forest	Autumn density	Total capture	104 ('83), 136, 141, 101, 114 ('87)	Wauters & Dhondt, 1990
"	Deciduous forest	"	"	86 ('84), 99, 84, 116 ('87)	"
Belgium	Urban park	Prebreeding	Total capture	50	Wauters et al, 1997
-	-	-	General estimate based on data from several W European studies	30-150	Gurnell, 1987
Belgium	Oak-Beech forest	-	General estimate based on extensive research experience	80-230, long-term average 100	Wauters, personal communication
-	(Willow) Ash-Elm forest	-	"	very low, unsuitable habitat	"
S England	Oak-Hazel	-	"	70-110	"

3.9.4 Baseline densities

The found densities range between 2.2 and 344 No. km^{-2}.. Most of them (84%), however, range between 10 and 150 No. km^{-2}., showing the wide density range due to the explained cyclic behaviour of Red Squirrel populations. Species experts estimate long-term averages at 90 (Gurnell, mean of 30-150 in table 31) and 100 No. km^{-2}. (Wauters, personal communication). The median value of the literature densities is 64 No. km^{-2}.. This brought us to the suggested minimal baseline densities for the different nature types, shown in table 32. These densities can be seen as minimal long-term natural Squirrel densities for the described nature types. Regarding the cyclic behaviour of Red Squirrel populations, the baseline density is an average over several years (at least 5).

Table 32. Baseline densities for the Red Squirrel. Number of adult (1 year or older) Squirrels per square kilometre is given.

Nature type	Baseline density (No. km.$^{-2}$)
Forest on higher sandy soils	65
Forest in riverine area	30
Forest on marine clay	0
Forest in peat area	0
Forest in hilly area	65
Dune forest	50

We found no data for the forest types of the riverine area, on marine clay and in peat area (Ash-Elm and Willow forests). However, as mentioned by Dr. L. Wauters (personal communication), especially the forests on marine clay are very unsuitable for Red Squirrels because of a lack of seed bearing tree species. Therefore, the density for these areas is set at 0. The same accounts for the Ash-Elm and Willow forests of the riverine area. The forests on the dryer and higher parts of the riverine areas, where species like Hazel and Oak are available, are suitable for the Red

Squirrel. Depending on the size of these forests of the dryer parts, densities can reach the same level as in the forest on the higher sandy soils. Kenward et al (1998) found a density of 76 No. km^{-2}. for Red Squirrel in a Oak-Hazel forest (see table 23). For this study we assume that the amount of unsuitable forest (Ash-Elm and Willow forests) in the riverine area is equal to the amount of suitable forest (Oak-Hazel forest). In this case the overall baseline density for the riverine forest area will be intermediate between those two types (0 and 65 for unsuitable and suitable forests, respectively). Based on this assumption, we suggest an intermediate baseline density of 30 adults km^{-2}. for the overall riverine forest area.

As mentioned by Wauters (personal communication), the density of Red Squirrels is significantly lower in heterogenous landscapes of good and bad patches and in fragmented forest patches. The forest patches in the dunes are, in general, relatively small patches of forest. The forest itself is comparable with the forest on higher sandy soils in habitat quality for the Red Squirrel. Because of the relatively small forest patches, we expect a lower density in the dune forest than in the forest on the higher sandy soils. However, we didn't have any quantitative data on the relation between forest patch size and squirrel density. We made the broad assumption that the baseline density for dune forest will be between that in the forest in riverine area and the forest on higher sandy soils, 50 No. km^{-2}..

3.9.5 Actual densities in the 1950s and currently

Data on the present densities of Red Squirrel for some nature types were obtained from the VZZ for the year 2000 (VZZ, unpublished results). The VZZ has a yearly monitoring programme for the Red Squirrel, based on counts of Squirrel nests. This monitoring method is described in section 3.9.7. No data were available for the situation in the 1950s. Table 33 summarises the densities of Red Squirrel for different nature types in 1950 and currently.

Table 33. The density of Red Squirrel in the 1950s and currently (2000) for different nature types. Density is given in number of Red Squirrels per square kilometre.

Nature type	Actual density 1950 (No. km-2.)	Actual density currently (No. km-2.)
Forest on higher sandy soils	No data	18
Forest in riverine area	No data	No data
Forest on marine clay	No data	No data
Forest in peat area	No data	No data
Forest in hilly area	No data	16
Dune forest	No data	6

3.9.6 Quality values

The quality values are calculated on the basis of the actual densities of table 33 and the baseline densities of table 32. The results are presented in table 34.

Table 34. Quality values for the Red Squirrel for the different nature types in 1950 and currently. The baseline and actual densities, on which the quality values are based, are also presented in the table.

Nature type	Baseline density	Actual density 1950	Actual density currently	Quality value 1950	Quality value currently
Forest on higher sandy soils	65	No data	18	No data	28
Forest in riverine area	30	No data	No data	No data	No data
Forest on marine clay	0	No data	No data	No data	No data
Forest in peat area	0	No data	No data	No data	No data
Forest in hilly area	65	No data	16	No data	25
Dune forest	50	No data	6	No data	12

Quality values were calculated for the forest on higher sandy soils, in the hilly area and the dune forest. These quality values were calculated on the basis of densities instead of numbers. These densities are based on a number of plots, distributed over the nature types, of which the density is estimated. This can result in a distorted image of the quality of the Red Squirrel populations in the nature types, when the number of plots is low. The number of plots was 60, 12 and 2 for the mentioned nature types respectively. So, especially for the forest in the hilly area and the dune forest the number of plots was very low. It is therefore questionable whether the densities for these nature types represent the situation in the whole nature type.

In general the quality values for the Red Squirrel are low. The main reasons for these low quality values are the fact that most forests in the Netherlands are young and fragmented. As mentioned in the species ecology section, these factors strongly determine Squirrel density.
Unfortunately, no data were available on the situation in the 1950s.

3.9.7 Monitoring

The actual present densities of the Red Squirrel, presented in 3.9.5, are derived from the number of counted nests. This monitoring method is working well and will be shortly discussed here.

The number of Red Squirrel nests are counted yearly in a smaller area within the forest, the counting area. The desirable size of such a counting area is 10 to 25 ha.. Furthermore, the area has to be representative for the surrounding forest area. Red Squirrels normally built several nests in their territory, on average more or less 5 nests. Therefore, the number of counted nests has to be divided by 5 to give the number of Red Squirrels. Every year the nests are counted in the same counting area to make comparison between years possible.

This method is working well. An important aspect of this method, however, is that the counting areas are representative for the whole nature type. Obviously, the more counting areas there are per nature type, the better the estimate of the average density for the nature type will be. At present, Red Squirrels are counted in the forest in the hilly area, the dune forest and the forest on higher sandy soils (the other forest types are unsuitable). The number of counting areas is still fairly low; 60 on the higher sandy soils, 12 in the hilly area and 2 in the dune forest. Compared with the total surface of the nature types (see table 1), especially the number of counting areas on the higher sandy soils and in the dune forest is low. This number has to be extended to get a more reliable estimate of the average density in these nature types.

It is important that the number of Red Squirrels is monitored yearly to weigh out the cyclic behaviour of Squirrel populations, which has been described in the species ecology section.

3.10 The Pine Marten

3.10.1 General description

The Pine Marten (*Martes martes*, L., 1758) is a medium-sized member of the Marten family (Mustelidae). It is a slender, brown animal with a yellowish throat. Its body length ranges from 0.42 to 0.58 m. and it weighs on average 0.8-1.6 KGs.. It is still distributed throughout Europe, but its numbers have been strongly reduced. (Van den Brink, 1978).

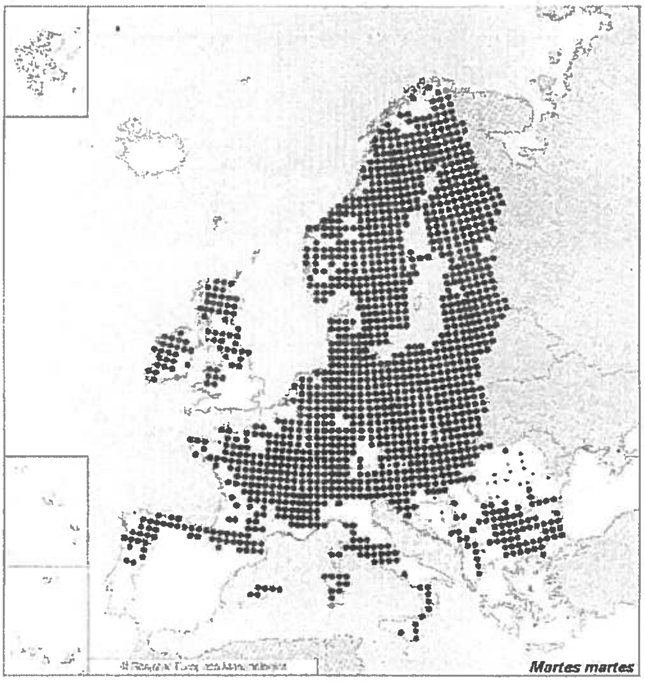

Figure 10. Distribution of the Pine Marten (*Martes martes*)'in western and central Europe (© Societas Europaea Mammalogica).

In the Netherlands the species is more or less restricted to three breeding populations. Two in the middle of the country (the Utrechtse Heuvelrug and the Veluwe) and one in the northern part (Drents-Friese Woud). (Broekhuizen et al, 1992).

3.10.2 Species ecology

The Pine Marten is a typical forest species. It prefers large, extensive forests of different types. In the Netherlands it seems to prefer old Beech forests and dark coniferous forests (Tamis et al, 1998). However, for feeding the Pine Marten depends on forest parts with a rich undergrowth, where the abundance of small mammals is high (Müskens, pers. comm.). Tamis et al (1998) also showed a negative relation between Pine Marten nesting sites and Alder forest. The species seems to prefer the relatively dry environment of the forests on the higher sandy soils. It can also be found in the dune forests in the western part of the Netherlands (Tamis et al, 1998).

The Pine Marten is an omnivorous species. Its diet contains what is available most and consists of fruits, berries, eggs, small mammals and birds. Birds and small mammals form the major part of its diet.
The Pine Marten is a highly territorial and solitary species. Territories of animals of the same sex do not overlap. The territory of a male often overlaps with territories of several females (Tamis et al, 1998). Territorial sizes have been found, ranging from 50 - 500 ha. (Müskens, pers. comm.). Males can reach even larger territory sizes of up to 1500 ha.. For breeding purposes, often, tree holes are used, especially in Beech trees. However, other breeding sites are old nests from birds of prey and houses. The young are born in the nesting hole, on average 3-5 young per female per year (Heptner and Naumov, 1974).

3.10.3 Densities found in the literature

Table 35. Population densities (No. km.$^{-2}$) for the Pine Marten as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant. The word 'in' before a reference means that the density figure is mentioned in the reference, but originates from a different reference.

Area	Habitat type	Census Period	Census Method	Density (No. km^{-2})	Reference
Slovakia	?	?	?	1-1.4	in Niethammer et al, 1978-1994
Bohemen, Slovakia	?	?	?	0.2	"
"	?	?	?	0.45	"
"	?	?	?	0.61	"
Slovakia	?	?	?	0.93	"
Scotland	?	?	?	0.3-3	"
Eastern Germany	?	?	?	0.5-1	"
Latvia	?	?	?	0.01-0.94	"
Karelia, Russia	?	?	?	0.23-0.4	"
"	?	?	?	0.01-0.23	"
Bulgaria	?	?	?	0.4	"
Bucin Forest, Slovakia	Forest area	?	?	0.42	in Homolka and Mrlik, 1989
Germany	Forest area	-	General estimate	0.3	Schröpfer, 1997

3.10.4 Baseline densities

The densities that were found in literature mostly range between 0 and 1 individual per sq. km., with a median value of 0.42. Densities of Pine Marten are very difficult to measure, because it is a shy and nocturnal animal and our knowledge of its behaviour and ecology is still very limited. The densities found in literature and proposed below seem to be fairly low and could well be higher in reality. The following, average, long-term densities are proposed, based on the median value and species ecology:

Table 36. Baseline densities for the Pine Marten. Density is given in the number of adult Pine martens per square kilometre.

Nature type	Baseline density (No. km.$^{-2}$)
Forest on higher sandy soils	0.4
Forest in riverine area	0.3
Forest on marine clay	0.3
Forest in peat area	0.3
Forest in hilly area	0.4
Dune forest	0.4

As mentioned, the densities are very low. The strong solitary and territorial behaviour of the Pine Marten is probably an important reason for these low densities. The density of the Pine Marten in the forest in riverine areas, on marine clay and in peat area will probably be lower than on the higher sandy soils, because of its preference for dryer areas (Tamis et al, 1998). This is, however, very preliminary. As already mentioned, our knowledge on the ecology of this species is very limited. This certainly counts for the difference between forest types.

3.10.5 Actual numbers in the 1950s and currently

Data for the present number of Pine marten have been obtained from the VZZ. Currently the Pine Marten is only found in the forests of the higher sandy soils of Gelderland, Utrecht, Drenthe and Friesland (Drents/Friese Woud). The number, presented in the table below, is a rough estimate, derived from the found number of traffic victims and nesting sites. It is an estimate for the total number of Pine Marten in 2001 (VZZ, personal communication). The number in the 1950s is unknown. Table 37 summarises the data on the number of Pine Marten currently and in the 1950s.

Table 37. The number of Pine Marten in the 1950s and currently (2001) for different nature types.

Nature type	Actual number 1950	Actual number currently
Forest on higher sandy soils	No data	300
Forest in riverine area	No data	0
Forest on marine clay	No data	0
Forest in peat area	No data	0
Forest in hilly area	No data	0
Dune forest	No data	0

3.10.6 Quality values

The quality values are calculated on the basis of the actual numbers of table 37 and the baseline numbers (calculated from the area sizes in table 1 and the baseline densities of table 36). The results are presented in table 38.

Table 38. Quality values for the Pine Marten for the different nature types in 1950 and currently. The baseline and actual numbers, on which the quality values are based, are also presented in the table.

Nature type	Baseline number 1950 area	Baseline number current area	Actual number 1950	Actual number currently	Quality value 1950	Quality value currently
Forest on higher sandy soils	841	1054	No data	300	No data	27
Forest in riverine area	49	41	No data	0	No data	0
Forest on marine clay	17	86	No data	0	No data	0
Forest in peat area	9	21	No data	0	No data	0
Forest in hilly area	16	20	No data	0	No data	0
Dune forest	27	47	No data	0	No data	0

The quality values show that the distribution of the Pine Marten is still very limited in the Netherlands. For most nature types the quality value is 0. It is only found on the higher sandy soils and the quality value for the forests on the higher sandy soils is more or less the same as for the Red Squirrel. For this species, maybe even more as for the Red Squirrel, accounts that it needs old, extensive forests. These are very rare in the Netherlands and are only found to some extent on the higher sandy soils.

Unfortunately, no data were available on the situation in the 1950s.

3.10.7 Monitoring

At the moment there is no structural monitoring of the number of Pine Marten in the Netherlands. Monitoring of this species is difficult because it lives in very low densities and has an elusive life style. Since a couple of years traffic victims are structurally gathered and these give a reasonable overview of the distribution of the species. These data, together with territory estimates, have resulted in the number estimate of 3.10.5.

Monitoring of the number of Pine Marten would be possible by counting the number of occupied nests in spring. However, to get an idea of the real number of Pine Marten more knowledge is necessary on the species ecology, like the percentage of breeding females. Kleef (1998) describes the potential monitoring of the number of Pine Marten. First, the potential nesting trees in the forest area have to be surveyed. This is a labour intensive process, but it has to happen only once in several years because the stock of potential nesting trees changes very gradually. Based on this map of potential nesting trees, the trees can be checked yearly on the presence of Pine Marten. Combined with increased knowledge on the species ecology this would give reasonable estimates of the number of Pine Marten. In larger forest areas, counting areas should be chosen to monitor the Pine Marten, as was mentioned for the Red Squirrel.

To be more efficient, the monitoring of Pine Marten and Red Squirrel should occur simultaneously and in the same areas, as the monitoring methods and habitats for both species are comparable.

3.11 The Badger

3.11.1 General description

The Badger (*Meles meles*, L., 1758) is a large-sized member of the marten family. The species is present throughout the Eurasian continent from Ireland to Siberia and from northern Finland to Israel and China. It is quite common in this range, though it is fairly rare in some parts of its range due to the introduction of intensive agriculture (mainly western Europe). The Badger, on average, weighs 10-20 KGs., with a body length varying between 61-72 cm.. The shoulder height averages 30 cm.. (Mitchell-Jones et al, 1999; Van den Brink, 1978).

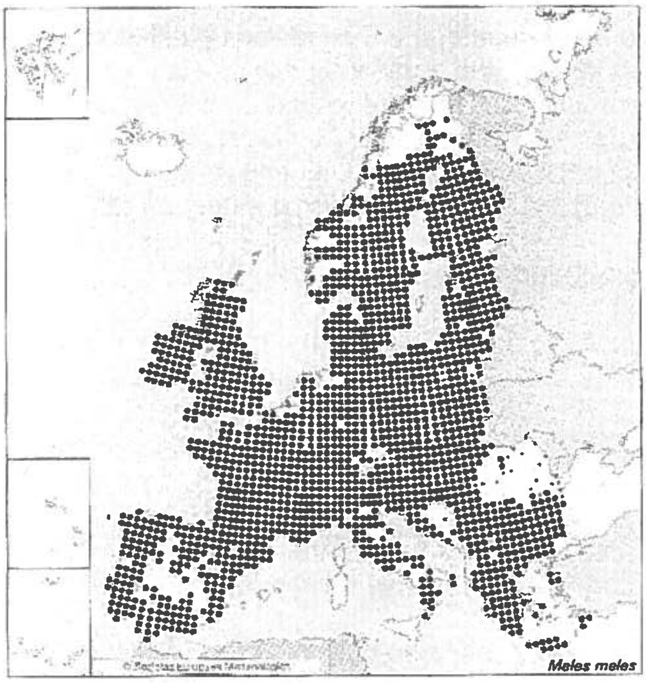

Figure 01. Distribution of the Badger (*Meles meles*) in western and central Europe (© Societas Europaea Mammalogica).

The original distribution area of the Badger in the Netherlands was mainly restricted to the region of the higher sandy soils in the east and south-eastern parts of the country (especially along the edges of these higher sandy soils) and the hilly area in the most southern part of the country. Nowadays, its range is very much restricted and the Badger has disappeared from much of its range due to habitat destruction by intensified agriculture. It is mainly found in the Veluwe area, north-eastern Noord-Brabant, Rijk van Nijmegen and in the hilly area of Zuid-Limburg. (Broekhuizen et al, 1992).

3.11.2 Species ecology

The Badger can be found in a wide variety of habitats. From deciduous forests to prevailing agricultural land and in some cases even urban parks. Its optimal habitat exists of a varied landscape with open areas, forests and scrubby areas, resulting in a varied number of food sources. Furthermore, the area must be suitable for digging a set. In this respect, the Badger prefers dryer sandy soils with a deep ground water level. (Mitchell-Jones et al, 1999; Heptner and Naumov, 1974).

The Badger has a highly diverse diet, ranging from mice and young birds to frogs, invertebrates and plant material (Heptner and Naumov, 1974). In western Europe (United Kingdom, the Netherlands) its diet mainly consists of earthworms. The density of Badgers is strongly correlated to the availability of food (if the possibility for set digging is not limited), in western Europe mainly the biomass of earthworms (Kruuk, personal communication).

As shown above, the Badger is a very adaptable species. It has a strong social structure and is highly territorial. Badgers live in and near complex set systems with several adults in one clan (on average 3-6 in Scotland; Kruuk, 1989). The number of adults per clan has been correlated to the availability of earthworms (Kruuk, 1989). On average a Badger female produces two cubs per litter (Heptner and Naumov, 1974). The Badger is not necessarily very susceptible to human disturbance. In the contrary, Badgers reach very high densities in human made extensive agricultural areas with a varied landscape of grasslands, small forests and hedgerows (e.g. in southern England). These areas represent their optimal habitat. On the other hand, however, Badger populations have severely suffered from the intensification of agriculture, resulting in poor, monotone habitats and habitat fragmentation due the creation of infrastructure (roads, railways etc.).

3.11.3 Densities found in the literature

Table 39. Population densities (No. km.$^{-2}$) for the Badger as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant.

Area	Habitat Type	Census Period	Census Method	Density (No. km^{-2})	Reference
N Ireland	Good habitat	Adult density	Bait-marking and live trapping	11.9	Feore & Montgomery, 1999
"	Moderate habitat	"	"	1.6	"
"	Bad habitat	"	"	0.86	"
United Kingdom	forest interspersed with good agricultural land	"	"	21.1	"
"	Pastoral farmland with limited forest	"	"	5.2	"
"	Upland vegetation	"	"	0.8	"
United Kingdom	Pastoral land, 20% forested	Autumn density	Line-transect (sighting data)	2.35, 2.51	Heydon et al, 2000
"	Pastoral land, 5% forested	"	"	1.45, 1.16	"
SW England	Optimal habitat	Highest density	-	20-30	Kruuk, personal communication
Scotland	"	"	-	8	"

SW England	Pastoral land, 20% forested, no real human impact	Adult density	Capture-recapture	12.5, 17.2	Tuyttens et al, 1999
"	Pastoral land, heavy population persecution	"	"	1.4	"
S England	Pastoral land, 20% forest	Adult density	Total capture	19.5	Cheeseman et al, 1981
"	Pastoral land, 7% forest	"	"	4.9	"
"	Pastoral land, 6% forest	"	"	4.7	"
SW Spain	Mediterranean scrubland	Average annual density	Radio-tracking	0.23, 0.67	Revilla et al, 1999
Scotland	Pastoral land, forest in various quality and quantity	Average annual density	Radio-tracking (territory size) + faeces count (group size)	1-8	Kruuk, 1989
Czechoslovakia	?	Adult density	?	<0.1-0.6	Anderson & Trewhella, 1985
Ukraine	?	"	?	0.5-1.8	"
France	?	"	?	<1.0, 1.6	"
The Netherlands	?	"	?	1.0	"
E Germany	?	"	?	2.0-4.0	"
Scotland	?	"	?	1.5-2.7, 1.1-3.2, 5.7-6.2	"
England	?	"	?	5.8, 5.2-8.4, 6.2, 10.6	"
Sweden	?	"	?	2.4-3.2	"
Germany	Forest area	?	?	0.5-2.9	Niethammer and Krapp, 1974-1994
C Ireland	Agricultural land, <10% forest	Adult density	Catch-effort analysis	3.24-5.86	Hayden, 1993
-	Undisturbed and optimal habitat	-	General estimate	>10	Niethammer and Krapp, 1974-1994

3.11.4 Baseline densities

The densities, found in literature, range from 0.1-30 No. km^{-2}.. 67% of these figures, however, range between 1 and 10 No. km^{-2}.. Table 39 shows the extremely high densities of the Badger in the extensive agricultural areas of southern England (Feore and Montgomery, 1999; Cheeseman et al, 1981; Kruuk, personal communication). Furthermore, it is clear that the density of Badgers is higher when the percentage of forest in agricultural areas is higher (Heydon et al, 2000; Cheeseman et al, 1981). Densities on mainland Europe range from 0.1-4.0 No. km^{-2}..

However, all the densities, that were found in literature, come from study areas in agricultural landscapes. For the data of Anderson and Trewhella (1985) the habitat type of the study area is unclear. As already mentioned, the Badger typically reaches its highest densities in diverse, human made, agricultural landscapes. Therefore, the density values are not very representative for a natural situation. Dirkmaat (personal communication) suggests, that Badgers in the original western European forest systems had a much more nomadic existence, with much smaller families per set (2 adults and cubs). Densities would be much lower than in the current cultural landscapes. He mentions unpublished data from Bialowieza forest in Poland of 1 Badger per 700 ha. (0.14 No. km^{-2}.). It has to be noted, however, that this extremely low density represents a closed forest system. The structure-rich, open forest type, as described by Vera (1999), probably sustains higher densities.

We did not find additional information on the density of the Badger in its natural habitat, except for the personal comments of Dirkmaat. Based on the note that Badger densities in natural systems are probably lower, the median value of the densities found in literature (2.8 No. km^{-2}.) and the species ecology we suggest the following long-term baseline densities for the different nature types:

Table 40. Baseline densities for the Badger. Density is given in adult individuals per square kilometre in winter.

Nature type	Baseline density
Forest on higher sandy soils	2
Forest in riverine area	2
Forest on marine clay	0
Forest in peat area	0
Forest in hilly area	2
Dune forest	2
Heath on higher sandy soils	1
Open dune	0

As already mentioned, the Badger's optimal habitat lies at the edge of the higher soils and the lower grounds. Here it profits from a high availability of food sources in the riverine areas and the high suitability of the higher sandy soils for digging its set. The density of 2 No. km^{-2}. for the forest on higher sandy soils and in riverine areas, therefore, must be seen as the density at the transition area of these two regions. The density of Badgers towards the centre of the higher sandy soil areas will probably be much lower due to lower availability of food (Dirkmaat, personal communication). Furthermore, for the proposed densities we assume that the natural forest is structure-rich, with many open spaces.

The forest on marine clay and in peat area is unsuitable as a Badger habitat, because of the high level of ground water, which makes it impossible to dig a set. The heath on higher sandy soils is moderately suitable as a habitat. The lack of cover makes it relatively unsuitable for creating a set. As part of a forest system, however, heath can increase the food availability for the Badger. We, therefore, choose for an intermediate baseline density. The dunes are also moderately suitable as a habitat. In the dunes the Badger needs forested parts, where it can dig a set, because the loose dune sand is being fastened by tree roots. Where these forest patches are available, the dunes can be suitable as a Badger habitat. The dune forest, therefore, is comparable to the forest on higher sandy soils. The open dune, however, is unsuitable as a Badger habitat.

3.11.5 Actual numbers in the 1950s and currently

No data are available on the actual number or density of Badgers at present or any time in the past. The most detailed study on the status of the Badger in the Netherlands is the report by Van Moll (1996). This report is the result of the last national Badger census, which is executed once every 5 years. He describes the status of the Badger per province expressed in the number of inhabited kilometre squares. He gives these numbers for the end of the 1950s (1958-1959) and for 1995. We used these numbers to estimate the actual number of Badgers in the 1950s and currently. The first assumption we have to make is that the number of inhabited kilometre squares equals the number of inhabited dens. This will underestimate the actual number of inhabited dens. Secondly, we had to convert the number of inhabited dens into the number of Badgers. For this purpose, we use an average of 3.7 Badgers per inhabited den (as has also been proposed by Hollander (2000)). Obviously, this number fluctuates strongly between dens and nature types.

The above-mentioned assumptions and the data from Van Moll (1996) lead to the actual number of Badgers for the different nature types (table 31) in the 1950s (1958-1959) and currently (1995). Forest and heath on higher sandy soils and forest in riverine area have been combined, because the actual numbers were not available for these nature types separately.

Table 41. The number of Badgers in the 1950s (N_{1950}) and currently ($N_{currently}$) for different nature types. Between brackets the number of inhabited kilometre squares is given, as mentioned by Van Moll (1996).

Nature type	Actual number 1950	Actual number currently
Forest and heath on higher sandy soils, and forest in riverine area	892 (241)	1980 (535)
Forest on marine clay	0	0
Forest in peat area	0	0
Forest in hilly area	522 (141)	729 (197)
Dune forest	0	0
Open dune	0	0

3.11.6 Quality values

The quality values are calculated on the basis of the actual numbers of table 41 and the baseline numbers (calculated from the area sizes in table 1 and the baseline densities of table 40). The results are presented in table 42.

Table 42. Quality values for the Badger for the different nature types in 1950 and currently. Nature types have been combined because the species uses them as one habitat. The baseline and actual numbers, on which the quality values are based, are also presented in the table.

Nature type	Baseline number 1950 area	Baseline number current area	Actual number 1950	Actual number currently	Quality value 1950	Quality value currently
Forest and heath on higher sandy soils and forest in riverine area	5947	5982	892	1980	15	33
Forest on marine clay	0	0	0	0	-	-
Forest in peat area	0	0	0	0	-	-
Forest in hilly area	78	98	522	729	669	744
Dune forest and open dune	137	237	0	0	0	0

First of all the quality values for the Badger show that the situation for this species has strongly improved since the 1950s. Quality values are clearly higher currently. This improvement is caused by specific conservation actions during the last decades, like the construction of special Badger tunnels under roads and protection against extermination.

As mentioned in the species ecology section the marine clay regions and peat areas are unsuitable as Badger habitat. No dens have been found in these areas. Furthermore, Badgers are absent in the dunes. It is, however, unclear whether the dunes have been a part of the Badger habitat in the past. When Badgers have never been present in the dunes, it is not relevant to calculate a quality value for this nature type. In this case the 0 value in appendix III has to be replaced by a -.

The low quality value for the forest and heath on the higher sandy soils and the forest in riverine area are mainly caused by the limited distribution of Badgers in these areas. Especially in the provinces of Overijssel, Drente and Noord-Brabant the distribution of occupied dens is very minimal compared with the amount of suitable areas. This is to a large extent caused by the severe fragmentation of the habitat, which makes it difficult for Badgers to disperse to new areas.

The population in the hilly area has an extremely high quality value. This is caused by the fact that the Badgers in this region have adapted very well to the extensive agricultural landscape. This agricultural landscape exists of small highly diverse grasslands alternated with shrubs and other woody elements. The amount of cover and food is very high in this landscape. As explained in the species ecology section such a landscape represents the optimal habitat for the Badger. Because the quality value of the hilly area is only based on the small forest patches (while the Badger uses the whole landscape), it reaches a very high value.

3.11.7 Monitoring

Badgers have been intensively monitored for quite some time now. The monitoring is mainly focusing on the distribution of the Badger, not so much the actual numbers. The last intensive survey was done in 1995 by 'Vereniging Das & Boom'. The data on the actual number at present in table 31 are based on this survey. Their method is described here (Van Moll, 1998).

The survey existed of an intensive investigation of Badger dens. Existing databases were used with information on the position of Badger dens. In preparation of the field-survey all known Badger dens (from the 1960s) were mapped. This map was used as the basis of the survey. In the field areas were surveyed per kilometre square. It was recorded whether a kilometre square contained an occupied den or not, using all possible tracks and signs of Badger presence. In the field the surveyors also looked for new, unknown dens. Through this intensive method a reliable map has been created which shows the presence of occupied Badger dens for the whole Badger distribution range in the Netherlands. This method is a reliable, but very intensive method to monitor Badger distribution.

The crucial point is to translate the distribution of occupied dens in Badger numbers. We assumed that each occupied square kilometre contained only one Badger colony. This seems to be valid (Van Moll, 1998), but should be investigated. Furthermore, we assumed an average number of 3.7 Badgers per colony. This figure was used by other authors, but it is unclear whether this figure is realistic for the Dutch situation. To allow a more reliable estimate of the number of Badgers a study should be executed to estimate the average number of Badgers per colony for the Dutch situation next to the monitoring of occupied dens.

3.12 The Eurasian Otter

3.12.1 General description

The Eurasian Otter (*Lutra lutra*, L., 1758) is an aquatic member of the marten family. It used to be widely distributed throughout Eurasia, found everywhere where water was abundant. The canalisation of rivers and the reclamation of marshes and other water surfaces, heavy persecution and pollution of the water with especially PCBs have strongly influenced the Otter population in Europe. It has disappeared from large parts of its original range, especially in north-western and central Europe (Mitchell-Jones et al, 1999). It is still very common in Scotland and Ireland. The Otter weighs 6-16.5 KGs, with a body-length of 62-93 cm. (Van den Brink, 1978).

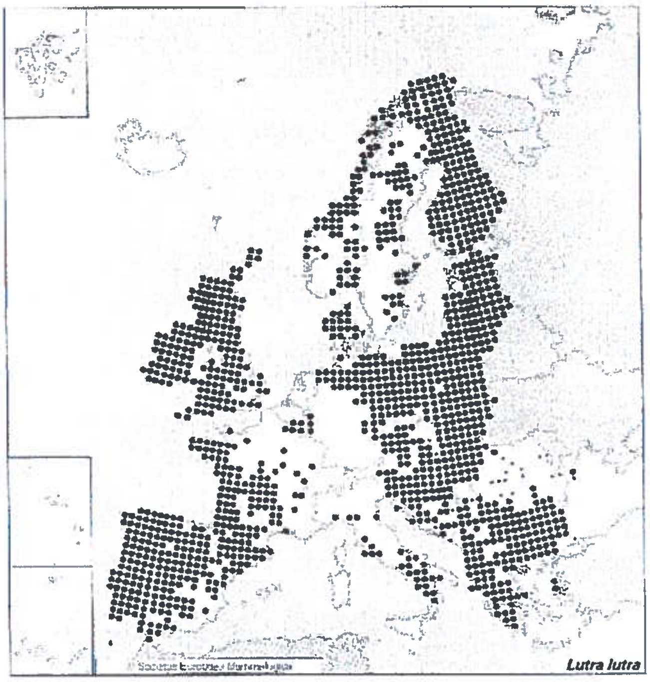

Figure 12. Distribution of the Eurasian Otter (*Lutra lutra*) in western and central Europe (© Societas Europaea Mammalogica).

The Otter used to be distributed throughout the Netherlands. It was found near all fish-rich water surfaces around 1900. In the 1940s and 1950s, however, it was already very rare due to heavy hunting. After protection in the 1950s it increased in numbers, but in the middle of the 1960s the species declined again due to habitat destruction and contamination of water and food with PCBs. Nowadays, the species is assumed to be extinct. The last evidence of occurrence in the Netherlands has been an animal, overridden by a car in 1988. (Broekhuizen et al, 1992). At the moment plans are being made for reintroduction of the species (www.terugkeer.nl).

3.12.2 Species ecology

The Otter is found in a wide variety of water-rich habitats, from fast streaming rivers in the mountains to the seacoast. Broekhuizen et al (1992) describe the most important habitats in the Netherlands: the small rivers and fens in the region of the higher sandy soils, the large rivers with dead branches, the bog areas with its ponds and lakes and the lakes of the sea-clay area. Most important aspects of the Otter habitat are the food availability (fish-richness), a thick cover along the waterside and the extent to which the water becomes frozen during winter. Furthermore, as a top-predator, the Otter is very susceptible to contamination of the water with toxic substances. For a healthy Otter population the water has to be free of such contaminants. Furthermore, the water has to be clear, because the Otter hunts by sight. Unclear water, e.g. due to nutrient enrichment, has a negative impact on Otter populations.

The Otter mainly feeds on fish. Depending on the season, the diet of the Otter is supplemented with frogs, birds and small mammals (Heptner and Naumov, 1974). The density of the Otter is directly correlated to the biomass of fish (Kruuk, personal communication). In Scotland some Otter populations live along the seacoast and besides fish also eat crabs and other invertebrates. These sea populations reach relatively high densities (Kruuk, personal communication).

Otters, generally, have linear home ranges and are rarely found far from water. They are highly territorial against individuals of the same sex. They live a solitary life, though adult females associate with one another. Otters, usually, have one litter per year, existing of, on average, 2-3 cubs. (Hayden & Harrington, 2000). Otters have been very susceptible to human interference. This is mainly due to contamination of the water, extensive hunting and canalisation of rivers. Except for this habitat destruction and hunting, Otters can stand slight human disturbance fairly well, as proved by Otters living near large cities in Ireland. The situation in Ireland also shows that Otters can live in populated areas, as long as the water is clean and there is no direct interference (like hunting).

3.12.3 Densities found in the literature

Table 43. Population densities for the Eurasian Otter as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant.

Area	Habitat Type	Census Period	Census Method	Density (No. km^{-1})[1]	Reference
Slovakia	Main river	?	?	0.04-0.08	Reuther, 1977
"	Side river	?	?	0.018-0.024	"
"	River	?	?	0.08, 0.125, 0.2, 0.24, 1.3	"
S Sweden	Lake shore	?	Track census	0.4-0.6	Erlinge, 1968
"	River	?	"	0.2-0.3	"
France	River	?	?	0.2	Van Wijngaarden & Peppel, 1964
England	"	?	?	0.1	"
Shetland	Sea coast	?	Holt census, reliable census	0.5-0.7	Kruuk et al, 1989
Bialowieza, Poland	Medium - sized forest rivers (width 11-15 m.)	Winter	Track census	0.3	Sidorovich et al, 1996
"	Small forest	"	"	0.17	"

	rivers (width 6-10 m.)				
"	Very small forest rivers (width 1-5 m.)	"	"	0.1	"
NE Belarus	Large forest river (width 20-40 m.)	?	?	0.43-0.55	"
"	Small forest rivers (width 1-8 m.)	?	?	0.13-0.3	"
Naliboki forest, NE Poland	medium and small-sized forest rivers	?	?	0.17-0.4	"
Petschora, Russia	Taiga rivers	Multiple years average	?	0.17	Heptner and Naumov, 1974
Ireland	Lake shore	-	General estimate	0.25	Hayden & Harrington, 2000
"	Sea coast	-	"	1	"
Shetland	Sea coast	-	Max. density	0.8	Hans Kruuk, Pers. comm.
Scotland	River	-	"	0.07	"

3.12.4 Baseline densities

As mentioned already, Otters generally have linear home ranges along a water surface. Therefore, the most suitable density figure for this species is the number per kilometre of shore. Most densities in the literature were given in this dimension and the baseline density is also expressed in this density dimension.

The found densities range from 0.018 to 1 No. km^{-1}.. These densities, however, can be divided in to three habitat types: rivers, lakes and seacoast. The found densities for rivers range from 0.018-0.55 No. km^{-1}., for lakes from 0.07-0.92 No. km^{-1}. and for sea coast from 0.5-1 No. km^{-1}.. The Otter density for the seacoast is clearly higher than for the other two habitats. This habitat, however, is not regarded in this study, because for as far as we know Otters did not use this habitat in the Netherlands. This brings us to the following long-term baseline densities for the Otter for the different nature types:

Table 44. Baseline densities for the Eurasian Otter. Density is given as number of adults per kilometre of shore length (one shore side only).

Nature type	Baseline density
Rivers and streams	0.2
Lakes	0.3
Marshes	0.3

The baseline density for the rivers is based on the mean density of 0.20 No. km^{-1}. and the median value of 0.17 No. km^{-1}. for the data in table 43, which regard river habitat. It has to be noted that broader rivers will, generally, have a higher Otter density than smaller rivers and brooks, because the amount of water (and, therefore, fish) per kilometre of river is higher. This effect is clearly shown by the data from Slovakia (Reuther, 1977) and Poland (Sidorovich et al, 1996). At this moment, however, not enough knowledge is available to link Otter density to river width in a quantitative way. We, therefore, cannot give baseline densities, specified per river width. For this reason table 44 gives a mean baseline density for the rivers. Generally, from the found data, the density in lake habitats seems to be higher than in river habitats (with a mean density of 0.29 No. km^{-1}. and a median of 0.25 No. km^{-1}.). This is explained by the fact that lakes contain more water per kilometre of shore and in this way more fish per kilometre of shore. The baseline density has been based on the mean density and median of the data from table 43, which regard lake habitat. No data were found for marshes. We assumed that this nature type can support at least as high densities as the lake area, looking at the large amount of water of which marshes generally exist. We, therefore, suggest the same baseline density for this nature type as for the lake areas.

3.12.5 Actual numbers in the 1950s and currently

As explained in the species description the Otter has been extinct in the Netherlands since 1989. Plans have been made for reintroductions, but so far no reintroduction has occurred and the number of Otters, and consequently the density, in the Netherlands is still 0.

Data for the 1950s were obtained from Hollander (2000). He gives a total number of 144 Otters in the Netherlands. More specified data was not found.

3.12.6 Quality values

The quality values are calculated on the basis of the actual densities and the baseline densities of table 44. The results are presented in table 45.

Table 45. Quality values for the Eurasian Otter for the different nature types in 1950 and currently. The baseline and actual densities, on which the quality values are based, are also presented in the table.

Nature type	Baseline density	Actual density 1950	Actual density currently	Quality value 1950	Quality value currently
Rivers and streams	0.2	No data	0	No data	0
Lakes	0.3	No data	0	No data	0
Marshes	0.3	No data	0	No data	0

Obviously, the quality value for the Eurasian Otter for all nature types is 0 for the present situation, because the species is extinct. The pollution of the water and traffic victims have been the main causes for this extinction. Currently, the quality of the water has strongly improved and reintroductions of the Otter in its original habitat will probably start in the first half of 2002 (www.vzz.nl).

3.12.7 Monitoring

Obviously, there is no monitoring of the Otter in the Netherlands at present, because it is extinct. Within short terms, however, the species will be re-introduced. Therefore, below, a short description is given on how Otter monitoring is generally executed.

Conroy and Kruuk (1995) describe the monitoring of the Otter. According to them most studies have been based on the use of otter signs, mainly faeces. This methodology, however, has a lot of problems and is not useful to evaluate numerical changes of the population. They, therefore, used a different method. The otters were monitored on the basis of a census of dens. In this method surveyors walked along the shore counting all dens, which were regularly visited (using evidence like spraints and tracks). Further, they found a strong correlation between the number of occupied dens and the number of adult females. Together with data on the ratio of males to females they were able to estimate the number of otters. Obviously, the described method is very labour intensive. Furthermore, studies on the correlation between dens and adult females and on the ratio of males to females have to be done in the Netherlands again, when a monitoring programme is set up in future.

At the moment in the Netherlands a new monitoring method is being developed. This method recognises individual Otters from DNA samples from their excrements. The method is developed to follow Otters, which are re-introduced. The method may prove to be valuable for the monitoring of the Otter in future.

3.13 The Red Fox

3.13.1 General description

The Red Fox (*Vulpes vulpes*, L., 1758) is a member of the dog family (Canidae). It is a reddish-brown medium-sized carnivore. The body length ranges between 0.58 and 0.85 m., weighing 4-10 KGs.. The species is distributed throughout the northern hemisphere, from North America to Siberia. (Van den Brink, 1978).

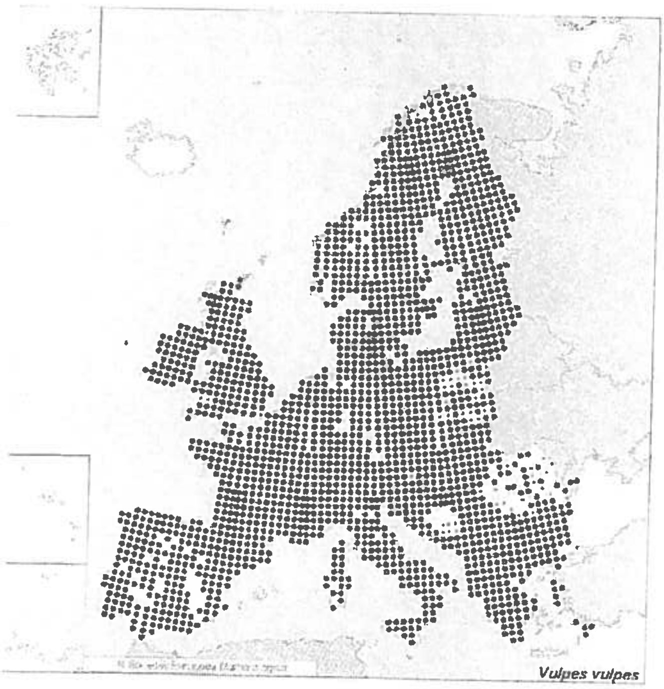

Figure 03. Distribution of the Red Fox (*Vulpes vulpes*) in western and central Europe (© Societas Europaea Mammalogica).

The Red Fox can be found throughout the Netherlands, but especially on the higher sandy soils and in the dunes. (Broekhuizen et al, 1992).

3.13.2 Species ecology

The Red Fox is a highly adaptable species. It can be found in a wide variety of habitats, including urban centres. Its optimal habitat exists of varied, half-open landscapes with sufficient cover and possibilities to dig a den. In this respect, sandy soils are preferred. Deciduous forests are preferred over coniferous forests. Very high densities are reached on the forest steppes and steppes of Russia (Heptner and Naumov, 1974).

The Fox is a generalist. Its diet contains a large variety of food items, from fruits and mushrooms to birds and small mammals. This varied diet enables the Fox to inhabit many different habitats. For this reason, it prefers a diverse habitat with many different food sources.

In general, the Red Fox is a solitary animal. Often an adult male and female take care of the young together. The young are brought up in a den, which the foxes dig in loose soil. On average, a Fox female gets 4-6 young per year.

3.13.3 Densities found in the literature

Table 46. Population densities (No. km.$^{-2}$) for the Red Fox as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant. The word 'in' before a reference means that the density figure is mentioned in the reference, but originates from a different reference.

Area	Habitat type	Census Period	Census Method	Density (No. km^{-2})	Reference
Slovakia	Agricultural area	?	Based on culling data	0.4	Homolka and Mrlik, 1989
Bucin Forest, Slovakia	Forest area	?	?	0.42	"
Poland	Agricultural area with 24% forest	Prebreeding	Based on No. of occupied dens	1.08 (4.52 in forested area)	Goszczynski, 1999
Scotland	Various habitats	?	?	0.08-0.27	in Heydon et al, 2000
mid-Wales, east Midlands, East Anglia, United Kingdom	Agricultural area	Prebreeding	Line transect count	0.49-1.12	Heydon et al, 2000
"	"	Postbreeding	"	1.30-2.95	"
Bulgaria	Various habitats	Spring	?	0.523	Grigorov, 1992
Sweden	?	Spring	?	0.8	in Palomares and Ruiz-Martinez, 1994
"	?	"	?	0.2-0.4	"
Spain	?	"	?	1.2	"
Germany	?	"	?	1.2-1.5	"
Spain	?	Spring	Faecal pellet count	1.6	Palomares and Ruiz-Martinez, 1994
Amsterdamse Waterleiding duinen, The Netherlands	Coastal sand dunes	-	Based on number of occupied dens	2.8	Baeyens et al, 2000
The Netherlands	Various habitats	?	?	0.1-2.5	in Broekhuizen et al, 1992
Russia	Forest areas	-	General estimate	0.02-0.3	Heptner and Naumov, 1974
"	Forest-steppe and steppes	-	"	0.09-3.3	"

-	Optimal habitat	-	General estimate	1-2	Nowak, 1999
Noord-hollands Duinreservaat, The Netherlands	Dunes	Spring	?	1.9	in Van der Niet, 2000
Meijendel, The Netherlands	"	"	?	6	"
Central Europe	Various habitats	Spring	General estimate	0.4-1.8	in Niethammer et al, 1978-1994

3.13.4 Baseline densities

Most of the densities found in literature ranged between 0 and 2 foxes per sq. km. (86%), with a median density of 1 animal per sq. km.. Based on the median density and the species ecology, the following average spring densities are proposed:

Table 47. Baseline densities for the Red Fox. Density is given in No. km.$^{-2}$ in spring.

Nature type	Baseline density (No. km.$^{-2}$)
Forest on higher sandy soils	1.5
Forest in riverine area	1
Forest on marine clay	0.5
Forest in peat area	0.5
Forest in hilly area	1.5
Dune forest	1.5
Heath on higher sandy soils	1.5
Open dune	1.5

The forest on higher soils, in the hilly area and the dune forest will have a high density, because the soil is most suitable for digging a den. The density in the forest on higher sandy soils and the hilly area will be highest in the forest areas with an open structure, where vegetation and resulting food sources are diverse.

Though cover may be scarcely available on the heath and open dune areas, food is varied and often abundant in these areas (mice and rabbits). Therefore, we propose the same densities as for the dune forest and forest on higher sandy soils and in the hilly area.

The forest on marine clay and in the peat area is relatively unsuitable for the Red Fox. The clay soil and the relatively high level of surface water are unsuitable for digging a den. The same accounts, to some extent, for forest in riverine areas. However, when possibilities for digging a den are available close to these riverine areas (e.g. on sand dunes), these areas can have a positive effect on Fox density because of the high food availability. The riverine area, therefore, has an intermediate density.

Finally, it has to be noted that most Fox populations in Europe are under a regime of population control. The densities in table 34 are, therefore, probably quite conservative. Population densities from unhunted populations in the Dutch dunes (Baeyens et al, 2000; Van der Niet, 2000) show much higher values. The values of the proposed densities in table 47, therefore, could well be too low. However, not enough is known about long-term unhunted populations to be sure about this.

3.13.5 Actual densities in the 1950s and currently

Data on the present densities of Red Fox for the different nature types were obtained from the VZZ. These data result from the breeding-bird monitoring network of SOVON, as explained in section 3.13.7. The data are the average over the period from 1994 to 1998 (VZZ, unpublished results). No data were available on the situation in the 1950s. Table 36 summarises the densities of Red Fox for different nature types in the 1950s and currently.

Table 48. The density of the Red Fox in the 1950s and currently (1994-1998) for different nature types. Density is given in number of Red Fox per square kilometre.

Nature type	Actual density 1950 (No. km-2.)	Actual density currently (No. km-2.)
Forest on higher sandy soils	No data	0.5
Forest in riverine area	No data	0.5
Forest on marine clay	No data	0.6
Forest in peat area	No data	No data
Forest in hilly area	No data	No data
Dune forest	No data	2.5
Heath on higher sandy soils	No data	0.5
Open dune	No data	2.5

3.13.6 Quality values

The quality values are calculated on the basis of the actual densities of table 48 and the baseline densities of table 47. The results are presented in table 49.

Table 49. Quality values for the Red Fox for the different nature types in 1950 and currently. The baseline and actual densities, on which the quality values are based, are also presented in the table.

Nature type	Baseline density	Actual density 1950	Actual density currently	Quality value 1950	Quality value currently
Forest and heath on higher sandy soils	1.5	No data	0.5	No data	33
Forest in riverine area	1	No data	0.5	No data	50
Forest on marine clay	0.5	No data	0.6	No data	120
Forest in peat area	0.5	No data	No data	No data	No data
Forest in hilly area	1.5	No data	No data	No data	No data
Dune forest and open dune	1.5	No data	2.5	No data	167

The quality values of the Red Fox populations on the higher sandy soils and in the riverine area are low. This may be due to an underestimate of the actual densities. The data for the Red Fox came from the same monitoring method as for the Brown Hare and European Rabbit. As already mentioned, for these species the actual densities were also extremely low. Using a different monitoring method probably gives a more useable estimate for the calculation of quality values (see next section).

The forest on marine clay and the dunes seem to have optimal Red Fox populations. The quality values are high. Especially for the dunes this value is clearly above 100%. This indicates that the number of Red Fox in this nature type is on a fairly natural level. It is clear that the Red Fox is not so much affected by habitat fragmentation, as for example the Roe Deer. Important in this respect is that the Fox is a highly mobile species, travelling considerable distances per day. Furthermore, the Red Fox has adapted very well to cultural landscapes. It also intensively uses agricultural landscapes, which are not taken into account in this study.

3.13.7 Monitoring

As for the Brown Hare and the European Rabbit, there is no monitoring of the numbers of Red Fox specifically. It is only monitored to some extent by the breeding-bird monitoring network of SOVON. The same remarks are valid for the Red Fox, as have been mentioned for the Brown Hare in section 3.6.7.

Again, to get a more realistic idea of the abundance of the Red Fox in the different nature types other monitoring methods should be applied. Below such a method is described.

In a fixed counting area the number of occupied dens is surveyed. This occurs in spring when the dens are occupied for breeding. In this way data are gathered on the number of territorial males and females and the number of young. The only problem is that the non-territorial animals are not counted. Further research is necessary to estimate the fraction of non-territorial animals. (Baeyens et al., 2000).

As for the Brown Hare and the Rabbit, a network of counting areas should be set up, distributed over different nature types to get estimates of the present abundance of the Red Fox in these nature types.

3.14 The Lynx

3.14.1 General description

The Eurasian Lynx (*Lynx lynx*, L., 1758) is the third largest predator of Europe. It used to be widely distributed throughout the Eurasian continent. It existed in the whole of Europe, except for the Iberian Peninsula (where the closely related species, the Pardel Lynx (*Lynx pardinus*) is found), most islands, unforested coastal regions and the north-western part of northern Europe. Nowadays, after severe human persecution and habitat destruction, the species is restricted to large populations in the Scandinavian countries, Baltic countries and the Carpathian Mountains. Furthermore, reintroduced populations exist in the Alps, Jura, Vosges, Bohemian-Bavarian region and the Dinaric Alps. It is a large cat species, with a typical spotted coat and black tufts on the ears. It shows a high phenotypic variation throughout its range. The size, however, is very similar for all Eurasian Lynx, weighing 12-35 KGs. with a total body length of 70-130 cm.. The shoulder height averages 65 cm.. (Breitenmoser et al, 2000).

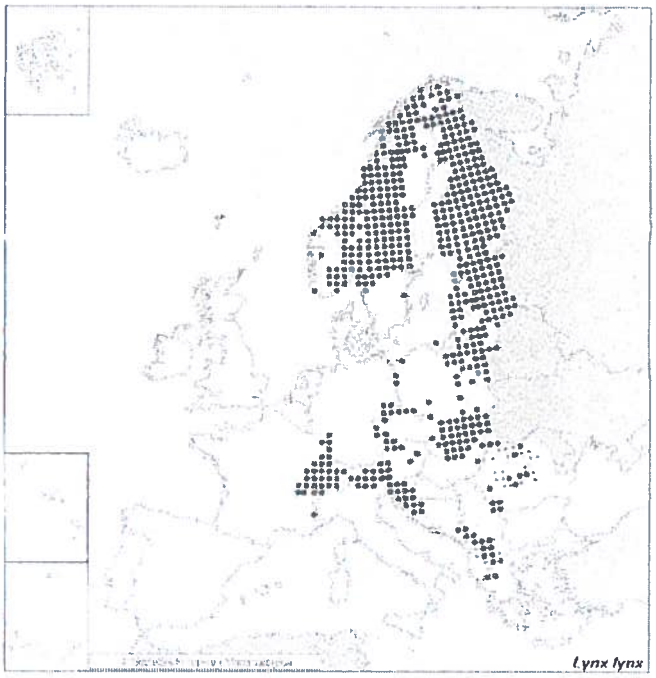

Figure 14. Distribution of the Lynx (*Lynx lynx*) in western and central Europe (© Societas Europaea Mammalogica).

There is no hard evidence for the historical occurrence of the Lynx in the Netherlands. Based on its ecology (see 3.1.2), there seems no reason for the species not to be part of the original fauna. The presence of the Lynx in the Netherlands, however, probably dates back a very long time (> 1,000 years), because no historic accounts on the presence of the species in the Netherlands are available. (Mulder, 1992). Looking at the species ecology and at the importance of the species, as a top-predator, for the completeness of the nature types, it was decided to include the Lynx in this report as one of the mammals in the nature types, described in 2.2.

3.14.2 Species ecology

In Europe and northern Russia the Lynx is an inhabitant of large, extensive forests. In central Asia, however, they also inhabit sparsely wooded areas, e.g. in semi-deserts. Therefore, it seems to be a species, which can adapt to many different habitats.

The diet of the Lynx exists of a wide range of species. Its main prey, however, exists of ungulate species. From these ungulate species the smaller species form its staple food. Depending on the area, these species are Roe Deer, Chamois and Musk Deer. In the western European lowland situation, the Roe Deer is the most important food source. In this respect, the Lynx prefers deciduous forest and density of Lynx are highest where Roe Deer are abundant. Lynxes seem to be able to have a considerable influence on the population dynamics of their prey species, especially Roe Deer populations. At the time being, however, there are not enough long-term studies to support general ideas on these predator-prey interactions. (Breitenmoser et al, 2000).

The Lynx is a solitary, highly territorial species, with estimates for home range sizes in Europe ranging from 98-2780 km^2.. The size of the home range relates to the habitat type and density and composition of the prey species. Generally, males share their home range with one or two females and females sometimes with their daughters. Next to prey density, the territorial behaviour plays an important role in determining the population density. The Lynx seems to be a very shy animal, which is susceptible to human disturbance. The damage of the Lynx to livestock seems to be relatively low, compared to other predators. Furthermore, this damage is especially low in areas with autochthonous Lynx populations. The damage is highest where the Lynx has been re-introduced. Its litter size varies from 1-5 young, but most often exists of 2-3 cubs. (Breitenmoser et al, 2000).

3.14.3 Densities found in the literature

Table 50. Population densities (No. $km.^{-2}$) for the Eurasian Lynx as found in literature. Next to the literature reference, where possible census area, habitat type, census period and census method are given for each density. ?: no information on this fact, -: information is not relevant.

Area	Habitat Type	Census Period	Census Method	Density (No. km^{-2})	Reference
Bialowieza, Poland	Mixed deciduous forest	Winter, 1991-'94	Snow tracking	0.028-0.032	Jedrzejewski et al, 1996
"	"	Winter, 1950s	"	0.06	"
Bialowieza, Poland	Mixed deciduous forest	Winter, 1995-'96	Snow tracking	0.024	Okarma et al., 1997
Alps and Jura mountains, Switzerland	Mixed deciduous forest	?	Radio-telemetry	0.0094-0.0143	Breitenmoser et al, 2000
Sweden	?	Winter	Snow tracking	0.0034-0.0074	Anonymous
Ru ssia	?	?	?	<0.04	Anonymous
S Norway	?	?	?	0.0025	Breitenmoser et al, 2000
SC Sweden	?	?	?	0.01	"
Transbaikalia, Russia	Taiga forest	1950s-60s	?	0.1-0.2	Heptner and Sludskij, 1980

Komi Republic, NC Russia	?	1960s	?	0.018	"
NW Russia	Protected forest area	1930s	?	0.03-0.053	"
Bialowieza, Belarus	Mixed deciduous forest	1940s-50s	?	0.1	"
Carpathians, W Russia, Yugoslavia	?	?	?	0.025-0.1	Niethammer and Krapp, 1978-1994
Maximum density	-	-	General estimate	0.1	"
Medium density	-	-	"	0.01-0.05	"

3.14.4 Baseline densities

Densities found in literature range from 0.0025 to 0.2 No. km^{-2}.. Around 70% of the density figures, however, range between 0 and 0.05 No. km^{-2}.. The higher densities, that were found, ranging from 0.06-0.2 No. km^{-2}., all date from the first half of the 20th century (Jedrzejewski et al, 1996; Heptner and Sludskij, 1980). Furthermore, Breitenmoser et al (2000) emphasise that the only reliable current population density estimates for the Eurasian Lynx are those in Switzerland and Poland. These range from 0.0094-0.032 No. km^{-2}..

For the Canadian Lynx (*Lynx canadensis*) densities have been found up to 0.3 and 0.45 No. km^{-2}. (Slough & Mowat, 1996; Poole, 1994). This species, however, is smaller and may, therefore, reach somewhat higher densities.

Based on the reliable current estimates and the value of the median for the literature densities (0.029) we suggest a minimal long-term natural winter density of 0.03 No. km^{-2}. for the Eurasian Lynx in the described forest types.

Table 51. Baseline densities for the Eurasian Lynx. Density is given in adult individuals per square kilometre in winter.

Nature type	Baseline density
Forest on higher sandy soils	0.03
Forest in riverine area	>= 0.03
Forest on marine clay	>= 0.03
Forest in peat area	>= 0.03
Forest in hilly area	0.03
Dune forest	0.03
Heath on higher sandy soils	0
Open dune	0

Table 51 shows the suggested baseline densities for the Lynx in the different nature types. Lynx are absent in unforested regions, at least in Europe (Breitenmoser et al, 2000). Baseline densities for Heath and Dunes are, therefore, set at 0. These systems, however, can sometimes form a part of the extensive territory of a Lynx.

In an extensive, ungulate rich forest, with low human disturbance, Lynx can possibly reach a higher density than the proposed baseline density, of up to 0.1 No. km^{-2}. or even higher. This is shown by the density data from Russia and the 1950s in Bialowieza, Poland and also suggested by Niethammer and Krapp (1978-1994). It is unclear, however, whether these figures are very reliable and whether they represent temporal high densities or long-term natural densities.

The density of the Lynx will be higher in the ungulate rich forests in riverine areas and on marine clay. The density of the Roe Deer, the main prey of the Lynx in lowland deciduous forests, is at its highest in these forest types. Because no data were found, upon which densities for each separate forest type could be based, a minimal baseline density of 0.03 number of adult lynxes in winter per square km. should be used for the three types, with the note that the potential density will probably be higher in the forest on marine clay and in riverine areas.

3.14.5 Actual numbers in the 1950s and currently

As mentioned, the Lynx has been extinct in the Netherlands since long. Lately, some signs have been found that the Lynx visits the forests of the hilly area. The question is whether these signs are reliable. However, there is no evidence that the Lynx permanently remains in the Netherlands. The number of Lynx in the 1950s and currently in the Netherlands is 0 for all nature types.

3.14.6 Quality values

The quality values are calculated on the basis of the actual numbers and the baseline numbers (calculated from the area sizes in table 1 and the baseline densities of table 51). The results are presented in table 52.

Table 52. Quality values for the Lynx for the different nature types in 1950 and currently. Nature types have been combined because the species uses them as one habitat. The baseline and actual numbers, on which the quality values are based, are also presented in the table.

Nature type	Baseline number 1950 area	Baseline number current area	Actual number 1950	Actual number currently	Quality value 1950	Quality value currently
Forest and heath on higher sandy soils	63	79	0	0	0	0
Forest in riverine area	5	4	0	0	0	0
Forest on marine clay	2	9	0	0	0	0
Forest in peat area	1	2	0	0	0	0
Forest in hilly area	1	1	0	0	0	0
Dune forest and open dune	2	4	0	0	0	0

As for the Eurasian Otter the quality values for the Lynx are all 0 due to its absence in the Netherlands. During the last few years speculation is increasing about its presence in the most southern parts of the country. There is, however, much discussion on whether the Dutch nature areas are suitable for a resident population of Lynx. Looking at the proposed baseline numbers the situation seems to have improved since the 1950s, especially the amount of forest. These baseline numbers are still much too low to present a viable population. Perhaps as part of a larger population over the borders of Germany or Belgium the Lynx could become part of the Dutch ecosystems in future.

3.14.7 Monitoring

Below a short description is given on the monitoring of the Lynx. As explained the Lynx is absent in the Netherlands and no monitoring takes place currently.

Lynx are monitored in two different ways (Jędrzejewski et al, 1996):

1) Radio-tracking. In this method several lynxes from an area are captured and radio-collared. Next, these individuals are intensively followed and their position is recorded daily for a considerable period of time. With this information the home range of each individual Lynx is determined. Then, together with data on the surface of suitable habitat the number and density if Lynx can be estimated. This implies the assumption that all suitable habitat is occupied. This method is fairly expensive.
2) Snow-tracking. This method is nowadays often used as a supplementary method, but in the past it was the most common method. In this method the home range of individual lynxes is determined by mapping found tracks of individuals. Obvious difficulties are the lack of snow and difficulties with identifying tracks from different individuals.

4. Monitoring mammals

Next to the species-specific information and discussion on monitoring, which has been given in the former chapter, we would like to give some general and summarising recommendations on the monitoring of mammals in the Netherlands. These recommendations are discussed here.

The main recommendation we want to make is that there is a need for central co-ordination of all the data regarding monitoring of mammals. For most species monitoring programmes are in practice, but often the monitoring is done by different organisations. This has the consequence that data are sometimes difficult to find and are often stored in all different kinds of formats. It would make the situation of the Dutch mammals much more clear and work, like the work presented in this report, much more efficient, when these data are centralised. In this respect the Vereniging voor Zoogdierkunde en Zoogdierbescherming already organises and coordinates the monitoring of many of the mammal species. This monitoring is centralised in the Network Ecological Monitoring (NEM). The NEM would be a logical choice, when looking for a central co-ordination point. The government could play a facilitating role in accomplishing this. Organisations like, for example, Das & Boom (for the Badger), Vereniging Wildbeheer Veluwe (for Wild Boar and Red Deer), the different WBE's (for the Roe Deer) and Alterra (for different species) should be involved in this process.

A second important recommendation is the creation of monitoring programmes for the species, which lack reliable monitoring of abundance. As mentioned in the former chapter, this mainly accounts for the Brown Hare, the European Rabbit, the Pine Marten, the Red Fox and to some extent the Roe Deer. When these species have to be regarded in the calculation of quality values in the future it is very important that monitoring is set up, which focuses more on species abundance than on trends. In the different species sections possible monitoring methods have been described for these species. For the other species the monitoring seems to function fairly well. For the Roe Deer it is important to get more insight in the monitoring methods of the different WBE's. Monitoring of this species should be standardised. Furthermore, when possible the data of the WBE's should be summed up per nature type instead of province. For another species, the Red Squirrel, additional counting areas should be monitored, especially in the forest dune and the forest of the higher sandy soils, to come to more reliable average densities for these nature types.

A third general recommendation is that where possible monitoring programmes should be supplemented with research on the species ecology, specifically focusing on aspects that are important for reliable monitoring. For example, knowledge on the number of nests per territorial male Red Squirrel, the number of Badgers per set, the number of nests per female Pine Marten and male-female ratio of the Pine Marten are some aspects that would make monitoring more reliable and easier to exercise.

A final recommendation regards a general idea on the monitoring of mammals for the purpose of the Natural Capital Index. Monitoring all the species of mammals for the purpose of the NCI (so more than determination of trends) is a very intensive and time-consuming practice. Instead of monitoring all mammal species it would be more efficient to look for indicator species per nature type. An indicator species is a species that is typical for a certain nature type. These species should be part of a species package existing of indicator species from different species groups. In this way you get for example a species package for forest on higher sandy soils, existing of plants, insects, birds and mammals (in the case of forest on higher sandy soils e.g. the Pine Marten). Each of these species groups serves as an indicator for processes on different scales. For example, plants for soil quality and water availability and mammals for processes on much larger scale, like fragmentation and forest structure. By choosing only a couple of indicator species from the whole set of mammal species, these species could be more intensively monitored than is the case when all the species have to be regarded. The Dutch breeding-bird monitoring network could in this respect serve as an example of a well-functioning monitoring network. A system of counting areas should be set up, divided over the different nature types (minimally 25 plots per nature type from a statistical perspective). These counting areas should be monitored every year by a fixed group of experienced surveyors. For these plots the density of the species is determined. It is important that plots are chosen randomly to avoid that only plots with optimal habitat are investigated. The data for all these species should be gathered at a central point. From this central point, regular results, like for the Nature Outlook could then be relatively easily produced. This network can be based to some extent on existing monitoring plots and surveyors. It first of all needs co-ordination, as was already mentioned in the first paragraph of this discussion. Furthermore it needs new plots to increase the statistical reliance of observed changes. It is not exactly clear how many plots are needed for mammal species. This should be further investigated to make more reliable estimates possible in the future.

5. General Discussion

There remains a lot to be discussed regarding the estimation of quality values of mammal populations. The quality values exist of two components, the actual abundance and the baseline abundance. Issues regarding the reliability of the actual abundance have been discussed in the monitoring sections. In this discussion problems are discussed surrounding the estimation of the baseline abundance or density. A short overview will be given on important density-determining factors, which makes the estimation of natural, baseline densities difficult.

First of all there, often, is a considerable amount of temporal fluctuation in densities. Densities fluctuate through the season. Densities, for example, are highest just after the young are born and lowest in late winter, just before the breeding season. Furthermore, large differences in density can occur between years. These differences are especially typical for the highly reproductive species, like the European Rabbit and the Wild Boar. As already has been mentioned, main reasons for these year-to-year variations are outbreak of diseases and changes in weather condition, which influence food availability. Temporal fluctuations are a natural part of the species population dynamics and have to be part of the baseline numbers. Therefore baselines and present numbers should be expressed in long-term averages.

Besides temporal differences in densities, there are also substantial spatial differences in densities. First of all, not all habitats will be an optimal habitat for a certain species. However, this does not mean that the species only lives in optimal habitats. Younger and/or weaker animals will be forced to move into less optimal habitats, especially when the density increases. The density will be higher in an optimal habitat than in a sub-optimal habitat, though both are natural densities.

Furthermore, there are also spatial differences linked to the behaviour of the animal. Often, species have a different habitat preference, depending on the type of behaviour. The Pine Marten, for example, prefers forest patches with wealthy undergrowth during its hunts for food. During its 16 hours of sleep, however, it prefers dark, dense coniferous forests. Finally, during the breeding period, the Pine Marten preferably lives in a hole in an old tree, especially Beech (Müskens, pers. comm.). So, clearly, densities can change spatially during the day or the season.

Another spatial change in a species density due to seasonality is shown by the already mentioned case of the Red Deer. As described in chapter 3.2.2, Red Deer populations often migrate between summer and winter habitats. The animals will stay in riverine areas during summer and move to the areas of the higher sandy soils during winter. Clearly, in this case, the density of a species in a certain nature type changes per season.

A third factor that is important, when discussing natural densities, is natural predation. It is, however, still fairly uncertain what the exact impact of predation can be. One theory could be that an herbivore population has different stable points. One stable point, where the population density is controlled by carnivores and a higher stable point, where it is controlled by the vegetation. When, for example due to diseases, the carnivore density is temporarily low, the herbivores can escape the carnivore pressure and grow to the vegetation-determined density. This seems to be likely, especially for highly reproductive species like the European Rabbit and Wild Boar (Van Wieren, unpubl. res.). Other species, with a lower reproductive capacity (e.g. Red Deer), have more difficulties with 'escaping' the carnivores and their population density will be more controlled by these carnivore species.

A different theory, however, suggests that carnivores only predate on the surplus of an herbivore population, especially the old and weak individuals. In this case they do not influence the population density significantly. When this theory is closer to reality, population control (hunting) that takes place throughout Europe does not seem to fulfil the role of the disappeared predators. However, most densities that were found in literature are based on populations that are under some regime of population control. All the proposed densities would then be on the conservative side. However, as mentioned, the discussion on the role of predation is still going on and this makes the assumptions above conservative. The role of predation (or hunting) is, however, a very important aspect in determining baselines for natural densities.

The overall structure of the forest is another factor that plays a role in the discussion about natural densities. Generally, there are two theories in this respect. The oldest and most widely accepted theory states that the influence of large grazers on the forest structure is minimal and that the forest principally will be a closed forest. The theory described by Vera (1997), however, describes the European forest as a shifting mosaic of different stages of succession next to each other; parts of closed forest alternated by open places, with shrubs, heath and herb vegetation's. The important steering factor behind this mosaic landscape is the presence of large herbivores (like Wisent, Aurochs substitute and Wild Horse substitute). They form an essential part of the forest ecosystem and are responsible for the fact that the forest has a diverse, open, park-like landscape structure.

At present, most European forests are closed systems (heavily influenced by forestry practices). Most of the densities that were found in literature come from these closed forests. If, however, the theory of Vera were true, the densities probably would be different. Regarding the fact that all species (except perhaps the Pine Marten) prefer diverse, half-open landscapes (see species ecology chapters) densities in the forest systems, as Vera describes them, could well be higher than the proposed densities.

A final ecological discussion point is the possible interactions between species. These interactions can have a positive or negative impact on the density of the species. The Brown Hare, for example, seems to have a lower population density when the European Rabbit is present (Van Wieren, unpubl. res.). The same could be the case for the Roe Deer with respect to the presence of the Red Deer. An example of positive interaction is the presence of large herbivores, like Heck Cattle or Wild Horse, on the density of Lagomorph and possibly other smaller herbivore species (Van Wieren, unpubl. res.).

However, often interactions are not studied thoroughly enough to be useful for the prediction of natural densities. Especially interactions under natural circumstances are very hard to study. It is clear, though, that this point can have a significant effect on the proposed densities.

The method, used in this study, can be used for any other mammal species, though the quality of the analysis obviously depends on the amount of literature that is available on the density of the species. All the mentioned discussion points make it difficult to come to good baselines. Therefore, in this study we used precautious estimates as baselines. More thorough and species specific research is needed, going into the ecology discussed above, to get better founded baselines. This report is part of the process to come to these better-founded baselines.

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Appendix I. Description of the vegetation for the various forest types, as described in chapter 2.5.

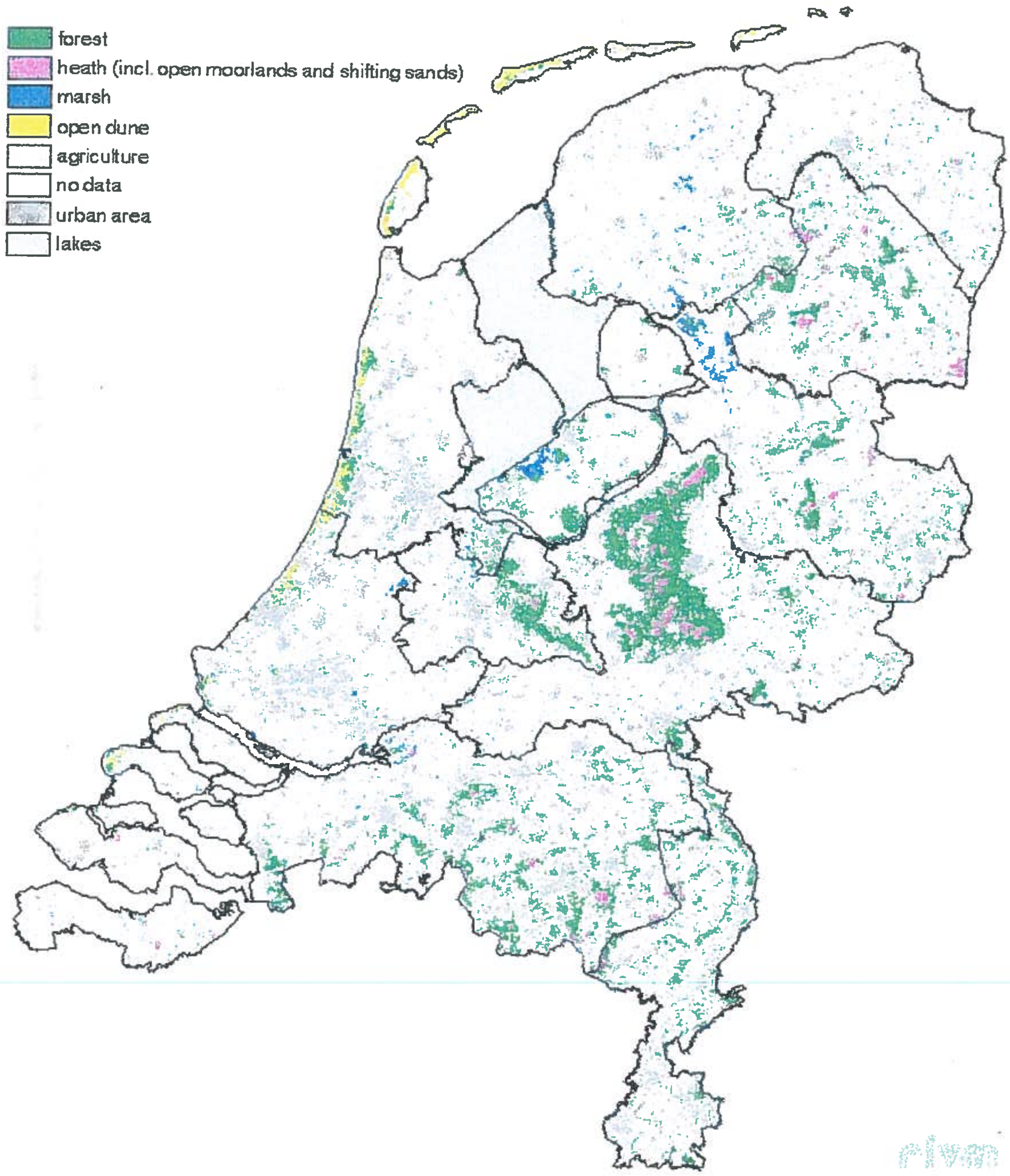
Forest associations	Shrub layer	Herb layer	Availability of mast
Birch-Pedunculate Oak forests (Betulo-Quercetum roboris)	Sparsely developed, e.g. Wild Mountain-ash (*Sorbus aucuparia*) and Alder Buck-thorn (*Rhamnus frangula*)	Common Hairgrass (*Deschampsia flexuosa*) or Purple Moor Grass (*Molinia caerulea*) under moist circumstances, Bilberry (*Vaccinium myrtillus*) and Heather (*Calluna vulgaris* and *Erica tetralix*)	Acorns
Sessile Oak-Beech forests (Fago-Quercetum petraeae)	Wild Mountain-ash (*Sorbus aucuparia*) and Alder Buck-thorn (*Rhamnus frangula*), also Holly (*Ilex aquifolium*) and *Rubus* species	Typical is Bracken (*Pteridium aquilinum*) and, under moist circumstances, Purple Moor Grass (*Molinia caerulea*) with some additional herb-, grass- and sedge species	Acorn and Beech nuts
Alder forests (Chrysoplenio oppositifolii-Alnetum)	Sparsely developed, e.g. Blackcurrant (*Ribes nigrum*) and Grey Willow (*Salix cinerea*)	Richly developed, many different species of sedge, grasses and herbs	-
Ash forests (Carici remotae-Fraxinetum)	Hazel (*Corylus avellana*) and also a/o. Guelder Rose (*Viburnum opulus*) and Wild Mountain-ash (*Sorbus aucuparia*)	Richly developed, many different species of sedge, grasses and herbs	-
Alder-Oak forest (Lysimachio-Quercetum)	Sparsely developed, mainly Alder Buck-thorn (*Rhamnus frangula*) and European Aspen (*Populus tremula*) and Wild Mountain-ash (*Sorbus aucuparia*)	Several grass- and sedge species	Acorns
Birch marsh forest (Periclymeno-Betuletum pubescehtis)	Minimal	Poor herb layer of Bilberry (*Vaccinium myrtillus*) and some grass and sedge species	-
Common Alder marsh forest (Carici elongatae-Alnetum)	Mainly Blackcurrant (*Ribes nigrum*) and Grey Willow (*Salix cinerea*)	Richly developed, many different species of sedge, grasses and herbs	-
Mesoneutophilous and acidicline beech groves (Milio-Fagetum)	Minimal, occurring species are Hazel (*Corylus avellana*) and Hawthorn (*Crataegus monogyna*)	Minimal	Beech nuts
White Willow forest (Salicetum albae)	Richly developed, different Willow species (*Salix* spp.)	Several annual herb species	-
Alder-rich Ash-Elm forest (Fraxino-	Mainly Hawthorn (*Crataegus*	Very richly developed, many different moist-loving	-

Ulmetum alnetosum)	*monogyna*), Blackthorn (*Prunus spinosa*) and Dewberry (*Rubus caesius*)	species	
Dry Ash-Elm forest (Fraxino-Ulmetum)	Richly developed, mainly Hawthorn (*Crataegus monogyna*), Spindle (*Euonymus europaeus*) and Hazel (*Corylus avellana*)	Richly developed, many different species of sedge, grasses and herbs	-
Abele-Elm forest (Violo odoratae-Ulmetum)	Hawthorn (*Crataegus monogyna*), Elder (*Sambucus nigra*) and Spindle (*Euonymus europaeus*)	Reasonably developed, different species of sedge, grasses and herbs	-
Common Oak-Hornbeam forest (Stellario-Carpinetum)	Mainly Hazel (*Corylus avellana*) and Hawthorn (*Crataegus monogyna*)	Richly developed, many different species of sedge, grasses and herbs	Acorns
Bird cherry-Ash forest (Pruno-Fraxinetum)	Richly developed, Bird-cherry (*Prunus padus*) and e.g. Red Current (*Ribes rubrum*), Spindle (*Euonymus europaeus*) and Hazel (*Corylus avellana*)	Richly developed, many different species of sedge, grasses and herbs	-
Alder Carr (Carici laevigatae-Alnetum)	Willow species (*Salix* spp.) and Alder Buck-thorn (*Rhamnus frangula*)	Different species of sedge, grasses and herbs	-
Melico-Fagetum	Beech forest with very poor shrub layer, with typical species like Mezereon (*Daphne mezereum*)	Richly developed, with the typical species, Wood Melick (*Melica uniflora*) and Woodruff (*Galium odoratum*)	Beech nuts
Carici-Fagetum	Beech forest with shrub species like Field Rose (*Rosa arvensis*), Hazel (*Corylus avellana*) and Mezereon (*Daphne mezereum*)	Richly developed, with many orchid species, like Helleborine (*Cephalanthera* spp.) and Birdsnest Orchid (*Neottia nidus-avis*)	Beech nuts
Luzulo-Fagetum	Beech forest with poorly developed shrub layer of Wild Mountain-ash (*Sorbus aucuparia*), Alder Buck-thorn (*Rhamnus frangula*) and Holly (*Ilex aquifolium*)	Different species of sedge, grasses and herbs with the typical species, Wood Rush (*Luzula luzuloides*) and Wood Ragwort (*Senecio nemorensis fuchsii*)	Beech nuts
Marsh Fern-Alder marsh forest (Thelypterido-Alnetum)	Salix species and Wild Mountain-ash (*Sorbus aucuparia*), Alder Buck-thorn (*Rhamnus frangula*)	Many species of sedges and other typical marsh species, typical is the Marsh Fern (*Thelypteris palustris*)	-
Brush-Alder forest (Filipendulo-Alnetum)	Species like Hawthorn (*Crataegus*	Richly developed with many moist-loving species	-

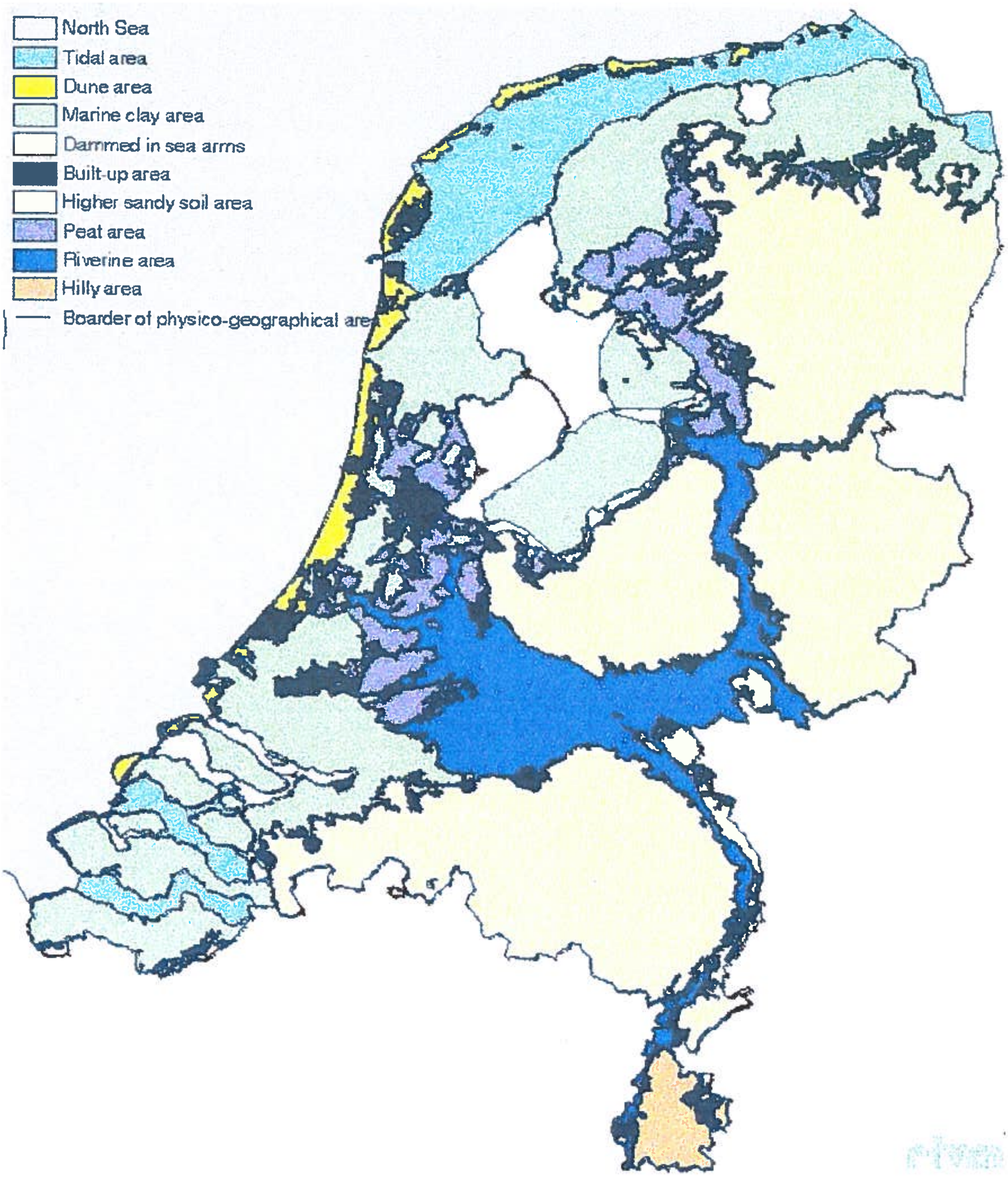
	monogyna), Grey Willow (*Salix cinerea*) and *Rubus* species		
Birch-Alder marsh forest (Alno-Betuletum pubescentis)	Many Alder Buck-thorn (*Rhamnus frangula*), furthermore Wild Mountain-ash (*Sorbus aucuparia*) and different *Salix* species	Several grass and sedge species, often quite open herb layer, most abundant is Purple Moor Grass (*Molinia caerulea*)	-

Appendix II. Maps showing the position of the nature types (A) and the physico-geographic regions (B).

A



B


North Sea
Tidal area
Dune area
Marine clay area
Dammed in sea arms
Built-up area
Higher sandy soil area
Peat area
Riverine area
Hilly area
Boarder of physico-geographical are

Appendix III. Summary of the quality values for all species.

The table below shows the quality values for the 14 mammal species for different nature types in 1950 and currently. Nature types have been combined because the mammal species use them as one habitat. The quality value for 1950 has been based on the baseline number in 1950 and the actual number in 1950, as explained in the methods section (chapter 2). The quality value for the present situation has been based on the baseline number present and the actual number currently. The baseline and actual numbers are also given in the table below. For the Hare, Rabbit, Beaver, Squirrel, Otter and Fox no data were found on actual numbers of individuals, only densities. For these species the quality values have been based on the baseline densities. Therefore, for these species the table below gives the baseline densities. For the other species the baseline densities can be found in chapter 3.

Species	Nature type	Baseline density	Baseline number 1950	Baseline number currently	Actual abundance 1950	Actual abundance currently	Quality Value 1950	Quality Value currently
Wild Boar	Forest and heath on higher sandy soils	-	7724	8344	2118[1]	2118[1]	27	25
	Forest and marsh in riverine area	-	1021	882	0	0	0	0
	Forest and marsh on marine clay	-	138	456	0	0	0	0
	Forest and marsh in peat area	-	278	276	0	0	0	0
	Forest in hilly area	-	116	147	0	0	0	0
	Dune forest and open dune	-	565	650	0	0	0	0
Red Deer	Forest and heath on higher sandy soils	-	18280	17570	2050[1]	1607[1]	11	9
	Forest and marsh in riverine area	-	1633	1411	0	0	0	0
	Forest and marsh on marine clay	-	1103	3648	0	450[1]	0	12
	Forest and marsh in peat area	-	2226	2210	0	0	0	0
	Forest in hilly area	-	233	295	0	0	0	0
	Dune forest and open dune	-	1849	1889	0	0	0	0
Roe Deer	Forest and heath on higher sandy soils	-	38622	-	16500[1]	-	43	-
	Forest and marsh in riverine area	-	5103	-	0	-	0	-
	Forest and marsh on marine clay	-	3448	-	0	-	0	-
	Forest and marsh in peat area	-	6955	-	0	-	0	-
	Forest in hilly area	-	582	-	0	-	0	-
	Dune forest and open dune	-	8556	-	0	-	0	-
Brown Hare	Heath on higher sandy soils	15	-	-	28.1[2]	2.2[2]	187	15
	Open dune	25	-	-	28.5[2]	0.8[2]	114	3
European Rabbit	Heath on higher sandy soils	1000	-	-	ND	11.2[2]	ND	1
	Open dune	1500	-	-	ND	26.2[2]	ND	2
European Beaver	Marshes	0.8	-	-	0	0	0	0
	Lakes	0.8	-	-	0	0.17[3]	0	21
	Rivers and streams	0.8	-	-	0	0.2[3]	0	25

Red Squirrel	Forest on higher sandy soils	65	-	-	ND	18[2]	ND	28
	Forest in riverine area	30	-	-	ND	ND	ND	ND
	Forest on marine clay	0	-	-	ND	ND	ND	ND
	Forest in peat area	0	-	-	ND	ND	ND	ND
	Forest in hilly area	65	-	-	ND	25[2]	ND	25
	Dune forest	50	-	-	ND	6[2]	ND	12
Pine Marten	Forest on higher sandy soils	-	841	1054	ND	300[1]	ND	27
	Forest in riverine area	-	49	41	ND	0	ND	0
	Forest on marine clay	-	17	86	ND	0	ND	0
	Forest in peat area	-	9	21	ND	0	ND	0
	Forest in hilly area	-	16	20	ND	0	ND	0
	Dune forest	-	27	47	ND	0	ND	0
Badger	Forest and heath on higher sandy soils and forest in riverine area	-	5947	5982	892[1]	1980[1]	15	33
	Forest on marine clay	-	0	0	0	0	-	-
	Forest in peat area	-	0	0	0	0	-	-
	Forest in hilly area	-	78	98	522[1]	729[1]	669	744
	Dune forest and open dune	-	137	237	0	0	0	0
Eurasian Otter	Marshes	0.3	-	-	ND	0	ND	0
	Lakes	0.3	-	-	ND	0	ND	0
	Rivers and streams	0.2	-	-	ND	0	ND	0
Red Fox	Forest and heath on higher sandy soils	1.5	-	-	ND	0.5[2]	ND	33
	Forest in riverine area	1	-	-	ND	0.5[2]	ND	50
	Forest on marine clay	0.5	-	-	ND	0.6[2]	ND	120
	Forest in peat area	0.5	-	-	ND	ND	ND	ND
	Forest in hilly area	1.5	-	-	ND	ND	ND	ND
	Dune forest and open dune	1.5	-	-	ND	2.5[2]	ND	167
Lynx	Forest and heath on higher sandy soils	-	63	79	0	0	0	0
	Forest in riverine area	-	5	4	0	0	0	0
	Forest on marine clay	-	2	9	0	0	0	0
	Forest in peat area	-	1	2	0	0	0	0
	Forest in hilly area	-	1	1	0	0	0	0
	Dune forest and open dune	-	2	4	0	0	0	0

[1] Abundance is given in number of animals.
[2] Abundance is given in density, number of animals per square kilometre.
[3] Abundance is given in density, number of animals per kilometre.
ND = No Data

Appendix IV. Summary of the quality values for the Roe Deer currently.

The table below gives the quality values for the Roe Deer currently. Because data on the number of Roe Deer at present were only available on the level of the provinces, the quality values were calculated differently than for the other species. The present quality values ($QV_{present}$) were calculated for each province separately. The present baseline numbers are calculated on the basis of the baseline densities for each nature type and the total surface of each nature type per province (obtained from RIVM). In this way the total baseline number of Roe Deer per nature type per province was calculated. Summing up the numbers for the different nature types gave the baseline number per province. The quality values represent the ratio between the actual number currently and the baseline number currently for all provinces separately.

Provinces	Actual number currently	Baseline number currently	$QV_{currently}$ (%)
Groningen	3082	937	329
Friesland	2803	4521	62
Drente	8376	5007	167
Overijssel	9432	6705	141
Flevoland	2270	5159	44
Gelderland	9441	15285	62
Utrecht	1802	3128	58
N-Holland	444	5373	8
Z-Holland	470	2842	17
Zeeland	177	1036	17
N-Brabant	7385	10957	67
Limburg	3247	4856	67