Altenburg & Wymenga
ECOLOGISCH ONDERZOEK

# Risk assessment of the Black swan (*Cygnus atratus*) in the Netherlands

A&W-report 1978

Commissioned by

Nederlandse Voedsel- en Warenautoriteit
*Ministerie van Economische Zaken, Landbouw en Innovatie*

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**A&W-report 1978**

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E. Klop

**Front page**
Black swan, drawing from J. Gould (1848) Birds of Australia

**N. Beemster, E. Klop**
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# Contents

# Samenvatting

De Zwarte zwaan *Cygnus atratus* is een van oorsprong in Australië voorkomende zwanensoort. Aan het eind van de 18e eeuw werden de eerste exemplaren naar Europa gebracht, waar de soort erg populair werd als parkvogel en in watervogelcollecties. Ontsnapte exemplaren hebben in verschillende Europese landen geleid tot kleine, in het wild broedende populaties. In Nederland wordt de huidige broedpopulatie ingeschat op circa 60-70 broedparen, en vormt daarmee de grootste populatie van Zwarte zwanen in Europa.

De eerste voortplanting van de Zwarte zwaan in Nederland dateert van 1978. Met name in de jaren ’90 is de populatie aanzienlijk gegroeid, waarna de aantallen zich min of meer hebben gestabiliseerd. Hoewel de soort in het gehele land wordt waargenomen, zijn de hoogste aantallen te vinden in het zuidwesten van het land en langs de grote rivieren. De presentie van Zwarte zwaan vertoont een negatief verband met de strengheid van het winterseizoen, wat erop duidt dat koude winters tot aanzienlijke mortaliteit kunnen leiden. Dit is mogelijk één van de redenen waarom de populaties in noordwest Europa relatief beperkt blijven. Ook is mogelijk het broedsucces relatief laag. Harde cijfers met betrekking tot overleving en broedsucces ontbreken echter.

Veel invasieve exoten – d.w.z. soorten die door menselijk handelen in een nieuw gebied terecht komen en zich daar weten te vestigen en te verspreiden – kunnen negatieve effecten hebben op de inheemse fauna. Daarnaast kunnen ze economische schade veroorzaken en een risico vormen voor de volksgezondheid en veiligheid. De impact van de vestiging van de Zwarte zwaan in Nederland is nader onderzocht aan de hand van het *Invasive Species Environmental Impact Assessment* (ISEIA) protocol. Bij deze methode wordt het risico van een soort beoordeeld aan de hand van vier factoren: het dispersievermogen, de potentiële kolonisatie van waardevolle habitats, de nadelige gevolgen op inheemse soorten en het effect op ecosystemen.

Zwarte zwanen bezitten een hoog dispersievermogen en zijn in staat waardevolle habitats te koloniseren. Hoewel de populatie verder kan groeien, is het niet waarschijnlijk dat de Zwarte zwaan zeer hoge dichtheden bereikt in Nederland vanwege suboptimale klimatologische en ecologische omstandigheden. De ecologische effecten worden als laag ingeschat. Hoewel het dieet en habitat van de Zwarte zwaan overlapt met dat van enkele andere watervogels, zijn effecten op populatieniveau op de nauw verwante Knobbelzwaan of andere watervogels onwaarschijnlijk. Andere negatieve ecologische effecten, zoals een aantasting van de onderwatervegetatie of depositie van stikstof in waardevolle habitats, zijn verwaarloosbaar. De totale ISEIA score bedraagt 7, waarmee de risico’s als gevolg van de vestiging en verspreiding van de Zwarte zwaan als laag worden geclassificeerd.

Potentiële economische effecten door de Zwarte zwaan hebben voornamelijk betrekking op graasschade. Op dit moment is de populatie Zwarte zwanen echter zeer klein en eventuele graasschade waarschijnlijk marginaal. Mogelijk kunnen hogere aantallen wel plaatselijk tot meetbare schade leiden. Sociale effecten kunnen betrekking hebben op de verspreiding van ziektes, zoals vogelgriep. De Zwarte zwaan is zeer gevoelig voor het H5N1 virus. Doordat geïnfecteerde vogels zeer snel ziek worden en sterven, is het risico op geografische verspreiding van vogelgriep door Zwarte zwanen gering.

# Summary

The Black swan *Cygnus atratus* is native to Australia, where it is the only swan species. It was introduced in Europe in the late 18th century, and is a very popular species in waterfowl collections. Escaped individuals have established feral populations in several European countries, including the Netherlands. The Dutch population is currently estimated at roughly 60-70 breeding pairs, making it the largest feral population of Black swans in Europe.

The first breeding record of Black swans in the Netherlands dates back to 1978. The population grew rapidly in the 1990s, but seems to have stabilized in the last 10-15 years. Although Black swans are reported from the entire country, the highest numbers are found in the southwest and along the main rivers. The number of atlas grid squares where the species is reported shows a negative correlation with winter temperatures, suggesting that cold winters can lead to substantial mortality. High winter mortality and relatively low breeding success may be the main factors that limit population growth in European Black swan populations. Empirical data on breeding success and mortality rates are lacking, however.

Invasive species – i.e. species that have arrived with human assistance outside their native range and subsequently established self-sustaining populations – can have major impacts on local biodiversity, for example through competition with native species, predation, or habitat modification. In addition, there may be important economic or social impacts, such as damage to agricultural crops or the introduction of parasites or pathogens. The impact of the Black swan in the Netherlands has been assessed using the *Invasive Species Environmental Impact Assessment* (ISEIA) protocol. In this methodology, the risk of a species is judged on the basis of four factors: dispersal potential, colonization of natural habitats, impact on native species and impact on ecosystems.

Black swans are capable of travelling substantial distances, and may colonize valuable habitats or protected areas in the Netherlands. However, high population densities are unlikely because of climatic and ecological conditions, and the ecological impacts are probably low. Although Black swans share food and habitat with Mute swans and various other species of waterfowl, negative effects on the population of the more dominant Mute swan are not expected. Ecological impacts on ecosystems, such as nitrogen deposition in valuable habitats or the reduction of submerged vegetation biomass, are probably negligible. The overall ISEIA score for Black swan is 7, which means that the overall risk is qualified as low.

Besides ecological effects, the establishment of a feral Black swan population may have some economic or social impacts. Agricultural damage may occur as a result of grazing activity on pastures during the moulting period and winter season. At present this impact is probably minimal, but damage may increase in case of substantial population growth. Social impacts can refer to the spread of diseases, such as avian influenza. The species appears to be highly susceptible to the highly pathogenic H5N1 virus. Because of the rapid illness and death following infection, geographic spread of the virus by Black swans is unlikely.

# Acknowledgements

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This assessment benefitted greatly from the input of many people in the Netherlands and abroad. Jan Beekman and Jeroen Nagtegaal provided valuable information on the Dutch population, and Menno Hornman helped us with the SOVON winter counts. Pierreco Eyma of Aviornis International kindly provided us with data on Black swans in Dutch waterfowl collections. We are also very grateful to Mark Holling of the Rare Breeding Birds Panel in the UK for sharing detailed information on the British population of Black swans. Guy Anderson (Royal Society for the Protection of Birds), Chas Holt (British Trust for Ornithology / UK Wetland Bird Survey), Richard Hearn and Debbie Pain (Wildfowl & Wetlands Trust) also provided much help by sharing information or pointing us to the right people.

# 1 Introduction

The Black swan *Cygnus atratus* is native to Australia, where it is a common and widespread species in various wetland habitats. Black swans have been brought to Europe in the late 18th century, where they still are very popular in waterfowl collections and as an ornamental species in parks and estates. Escaped individuals have established feral populations in several European countries, including the Netherlands. Invasive species – i.e. species that have arrived with human assistance outside their native range and subsequently established self-sustaining populations – can have major impacts on local biodiversity, for example through competition with native species, predation, or habitat modification (Simberloff 2013). In addition, there may be important economic or social impacts, such as damage to agricultural crops or the introduction of parasites or pathogens.

The potential ecological, economic and social impacts of the establishment of the Black swan in the Netherlands are currently unknown. Therefore, the Team Invasive Species of the Netherlands Food and Consumer Product Safety Authority (VWA) has asked Altenburg & Wymenga Ecological Consultants to carry out a risk assessment of the Black swan in the Netherlands.

This report aims to provide an independent impact assessment of the Dutch population of Black swans. First, the general biology of the species is discussed (chapter 2). The actual risk assessment is described in chapter 3, after which the options for risk management are briefly described in chapter 4.

# 2 Ecology and distribution

## 2.1 Introduction

The Black swan *Cygnus atratus* is native to Australia, where it is the only swan species (Marchant & Higgins 1990). Distinct (sub)species of the Black swan occurred in New Zealand and the Chatham Islands, but went extinct before European arrival (Worthy & Holdaway 2002, Hume & Walters 2012). The Black swan seems to be most closely related to the Mute swan *C. olor* from Eurasia and the Black-necked swan *C. melanocoryphus* from South America (Del Hoyo *et al*. 1992). As the name implies, the species has an all-black plumage except for the white primaries. The species is considerably smaller than the Mute swan, having a male body mass of approximately 3800-8750 g (Del Hoyo *et al*. 1992).

## 2.2 Distribution

The current distribution of the Black swan is shown in figure 2.1. The species is widespread and locally very common in eastern Australia and Tasmania; in northern and central parts of Australia the species is much rarer (Madge & Burn 1988, Del Hoyo *et al*. 1992). Vagrant Black swans have been recorded in New-Guinea.

In the 1860s the species was re-introduced in New Zealand, where about 100 birds were released in several parts of the Southern Island. By 1900 the species was widespread and common on both the Northern and the Southern island, and within a century the population had grown to roughly 100,000 birds (Heather & Robertson 2005, Lever 2005). In the 1960s over 60,000 Black swans were counted at Lake Ellesmere alone, after which numbers dropped due to storm damage which caused food shortages and breeding failure (Madge & Burn 1988, Del Hoyo *et al*. 1992). This rapid increase has been attributed to the presence of an ecological niche that was left vacant after the extinction of the New Zealand Black swan (Lever 2005). In addition, birds may also have arrived naturally from Australia (Williams 1981, Del Hoyo *et al*. 1992). The population in New Zealand is currently estimated at 50,000 individuals (Williams 2013).

The Black swan has been introduced to Europe in the late 18$^{th}$ century, when the first birds were brought to the United Kingdom in 1791 (Banks *et al*. 2008). The first breeding in the wild was recorded in 1902, and only in recent years a small but increasing breeding population has become established (see chapter 3.2). Small feral populations now exist in various European countries (figure 2.2), including the Netherlands, all of which are of captive origin (Banks *et al.* 2008). Contrary to the situation in New Zealand, numbers in Europe have remained low.

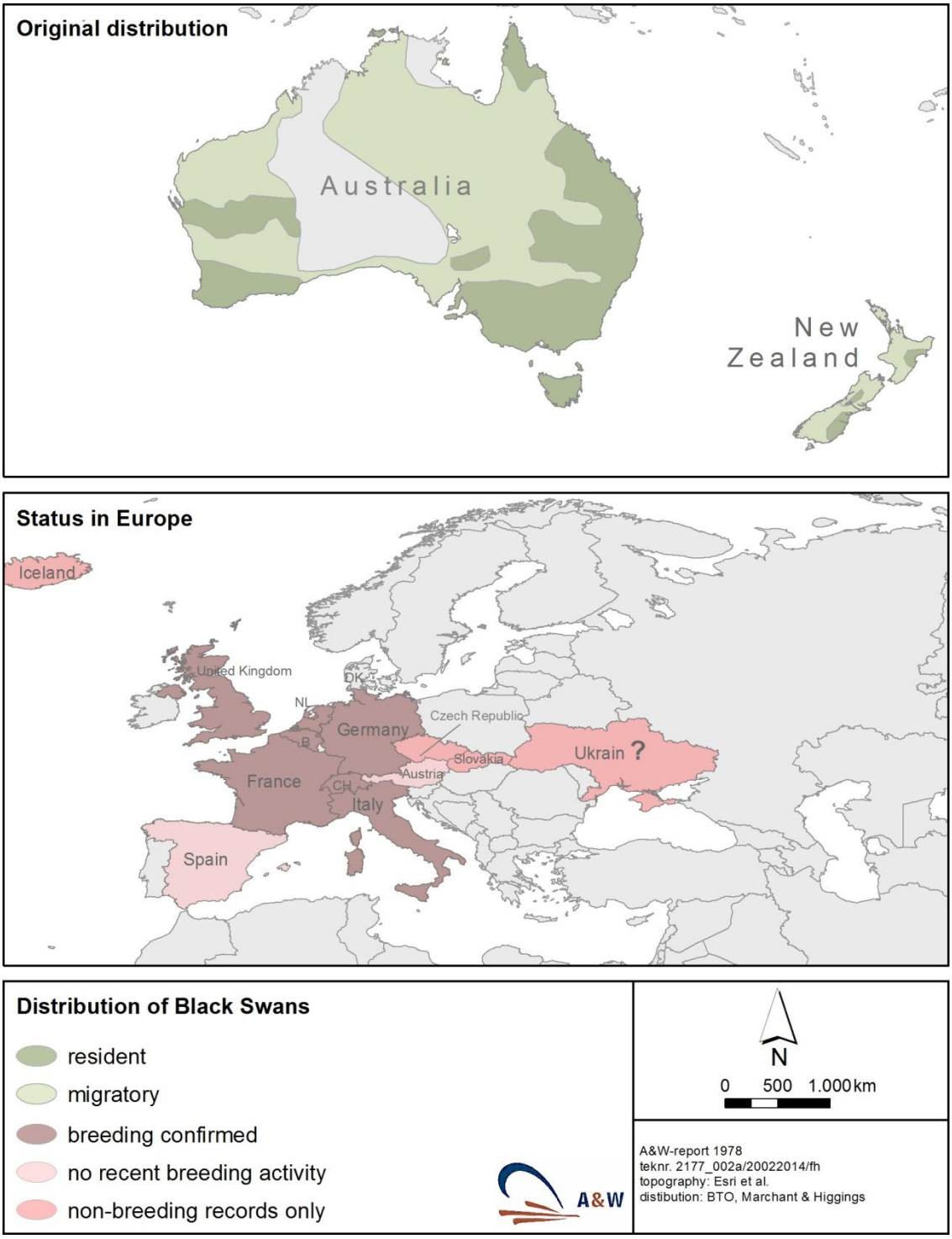



*Figure 2.1 Native distribution of the Black swan in Australia and New Zealand, and the distribution of feral populations in Europe (based on Marchant & Higgins 1990 and the sources listed in table 3.2). The current status in the Ukraine is uncertain.*

## 2.3 Habitat

In Australia the Black swan is widespread in a variety of wetland habitats, including lakes, marshes, coastal lagoons and estuaries (Madge & Burns 1988, Marchant & Higgins 1990, Kear 2005). Black swans breed in both fresh and brackish wetlands with sufficient vegetation for nest-building and shelter (Marchant & Higgins 1990). During widespread floods, birds may nest near any shallow pool that is available (Frith 1982).

Adults are sedentary in permanently suitable habitat, but young and adult birds from ephemeral habitat may disperse widely (Del Hoyo *et al*. 1992). In southwest Australia the species is mainly a migrant breeder, with its arrival closely governed by rainfall (Del Hoyo *et al*. 1992). After breeding, Black swans congregate in large flocks on open water during the moulting period or winter season (Madge & Burns 1988).

## 2.4 Food

Black swans are almost entirely herbivorous, and feed mainly on leaves and shoots of submerged aquatic plants (Marchant & Higgins 1990). When aquatic plants are not available, pastures are used for grazing (Sagar *et al.* 1995). Food is taken mainly while swimming, and the birds can reach depths down to 1 m (Marchant & Higgins 1990). High grazing pressure can affect vegetation biomass, which may facilitate other waterbirds that require open water (Smith *et al.* 2012).

## 2.5 Reproduction and survival

Black swans start breeding at the age of 2-4 years. In Australia breeding has been recorded throughout the year and the timing is highly dependent on local water levels. Birds nest in territorial pairs or in colonies, depending on habitat (Williams 1981). Breeding colonies can contain huge numbers of nests; the famous colony at Lake Ellesmere (New Zealand) in the 1960s counted over 5,000 nests that were spaced only 2-3 m apart (Miers & Williams 1969, Adams 1971). Nests are normally found within 100 m of the water (Heather & Robertson 2005).

According to Bart *et al*. (1992), the percentage of adults that breed is no more than one third of the total adult population (>4 years). This low percentage is comparable to other swan species, although breeding participation may increase with age (Perrins & Reynolds 1967, Bart *et al*. 1992). The average clutch size is four to six eggs (table 2.1). Incubation is done by both parents, which makes the Black swan the only swan species in which the male actively incubates (Kear 2005). The incubation time usually lasts 36-40 days (Del Hoyo *et al*. 1992).

Data on breeding success of the Black swan are scarce. In New South Wales, average clutch size was 5,5 eggs, of which on average 4,1 cygnets hatched and 2,7 cygnets survived to fledging (Frith 1982). At Lake Ellesmere, with an average clutch size of 5,4 eggs, on average 3,6 cygnets hatched per breeding attempt (Miers & Williams 1969) (table 2.2). Data on productivity of the closely related Mute swan are comparable, with figures of 1,6 – 2,6 cygnets fledged per breeding pair (Brown & Brown 2002).

The annual survival of adult Black swans in New Zealand is about 85% (table 2.3), which is comparable to that of other *Cygnus* species (e.g. Haapanen 1991, Bart *et al*. 1992, Brown 1997). Survival rates of immature swans are likely to be lower (Williams 1973, Bart *et al*. 1992).

*Table 2.1 Average clutch size of Black swans at different localities in Australia and New Zealand. The range refers to the minimum and maximum values, n refers to the sample size.*

| Locality | Average clutch size | range | n | Reference |
|---|---|---|---|---|
| Ne. Qld (Austr.) | 4,5 | 1-8 | 187 | Lavery in Frith 1982 |
| New South Wales (Austr.) | 5,5 | 4-10 | 407 | Frith 1982 |
| Lakes George, Bathurst (Austr.) | 5,32 | 3-9 | 403 | Braithwate 1977 |
| Tasmania (Austr.) | 4,46 | / | 10.365 | Guiler 1966 |
| Various colonies (New Zealand) | 4,9-5,7 | 3-14 | 70-1000 | Miers &Williams 1969 |

*Table 2.2 Average number of cygnets of Black swans hatched and raised per breeding attempt in Australia and New Zealand.*

| Locality | Average (number of) clutch size | Cygnets hatched | Cygnets surviving till fledging | Reference |
|---|---|---|---|---|
| New South Wales (Australia) | 5,5 | 4,1 | 2,7 | Frith 1982 |
| Lake Ellesmere (New Zealand) | 5,4 | 3,62 | No data | Miers & Williams 1969 |

*Table 2.3 Average survival of adult Black swans at two localities in New Zealand.*

| Locality | Period | Annual survival (%) | Reference |
|---|---|---|---|
| Lake Wairarapa | unknown (15 years) | 84 | Barker & Buchannan 1993 |
| Lake Ellesmere | 1956-1967 | 87,8 | Williams 1979 |
| Lake Ellesmere | 1956-1974 | 83,6 | Williams 1979 |

# 3 Risk assessment

## 3.1 Probability of entry

All Black swan populations in Europe originate from captivity or deliberate introductions into parks and estates, as natural migration between Australia and Europe can be ruled out. Black swans have been introduced to several countries in Europe, primarily as an ornamental species (Banks *et al.* 2008). The species is very popular in parks and waterfowl collections, which will continue to form a large source pool of potential escapes. The exact number of captive birds in the Netherlands or in surrounding countries is unknown. A survey in 2008 by Aviornis International, the main organization for waterfowl keepers, indicated a number of 245 Black swans present in the collections of Dutch members (P. Eyma *in litt*.). Due to an unknown response rate, true numbers are estimated to be at least 2-3 times higher (P. Eyma *in litt*.). In addition, there may be many Black swans in other collections or in parks who are not a member of Aviornis, so the total captive population of Black swans in the Netherlands is probably in the range of 750 – 1,000 birds.

Escapes from waterfowl collections are probably incidental events. The wings of captive waterfowl are usually clipped, and escape rates of these birds are probably low. However, semi-captive birds in parks may be less restricted and possibly more prone to escape or to contribute to the 'wild' breeding pool. In any case, it is likely that the main current source of population growth is reproduction by feral birds rather than escapes from captivity. The Black swan is not listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), so the trade in Black swans is not subject to regulation. Numbers of Black swans imported or exported are unknown.

***Summary***

The Black swan remains a very popular species in private collections and parks, with a total (semi-)captive population in the Netherlands that may reach 750 – 1,000 birds.

## 3.2 Probability of establishment

### *3.2.1 Present status in The Netherlands*

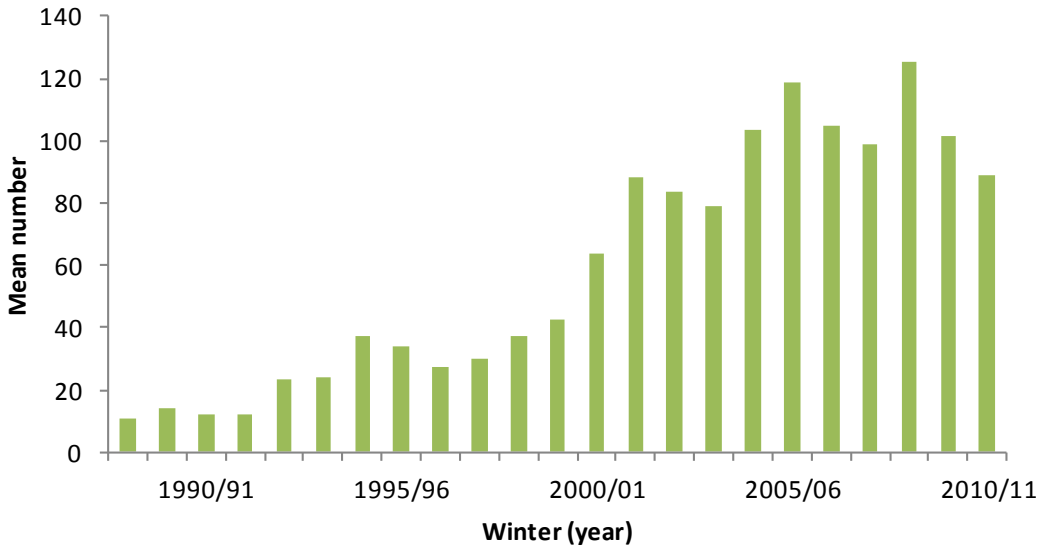
The first published breeding record in the Netherlands dates from 1978 (Lensink *et al.* 2013). In the late 1980s and early 1990s Black swans started to breed in small numbers along the great rivers (7 pairs in 1994), small fens in Brabant (4 pairs), several lakes in The Delta (13 pairs), Zuid-Holland (3 pairs) and Noord-Holland (1-2 pairs). The total population in the Netherlands in 1994 was estimated at 25-30 pairs (Lensink 1996). In 1998-2000 the breeding population had increased to 60-70 pairs (van Dijk 2002), after which the numbers seem to have stabilized. In 2008-2010 the breeding population was again estimated at 60-70 pairs (Lensink *et al.* 2013).

Breeding areas normally consist of a mixture of shallow open water, grassland and a vegetation of helophytes (Lensink 1996). In Limburg most of the pairs breed along the Maasplassen, which are very deep (up to 30 meters) lakes along the river Maas. In these deep lakes submerged aquatic plants are absent and birds feed mainly on grass in meadows along the river (J. Nagtegaal, pers. comm.).

*Table 3.1 Estimated breeding population of the Black swan in the Netherlands after its settlement in 1978.*

| Period | Estimated number of breeding pairs | Reference |
|---|---|---|
| 1985 | 1 | Vergeer & van Zuilen 1994 |
| 1994 | 25-30 | Lensink 1996 |
| 1998-2000 | 60-70 | van Dijk 2002 |
| 2008-2010 | 60-70 | Lensink *et al.* 2013 |

Outside the breeding season, groups of Black swans congregate on open water, where they feed on submerged aquatic plants, often together with Mute swans *Cygnus olor*. The largest flocks of Black swans have been observed on the Volkerak (55 birds in July 2012) and the IJsselmeer along the Friesian coast (29 birds in August 2012; Hornman *et al.* 2013). These summer concentrations consist mainly of moulting birds (van Dijk 1998). Waterfowl counts outside the breeding season by SOVON show a gradual increase in the number of Black swans to approximately 100-150 birds in recent years (figure 3.1; Hornman *et al.* 2013). The maximum number of birds counted in all monitoring areas was 225 (Lensink *et al.* 2013).




*Figuur 3.1 Mean numbers of Black swans in monthly counted areas in the Netherlands in 1975/76 - 2010/11. Source: Hornman et al. 2013.*

### *3.2.2 Present status in neighbouring countries*

Breeding populations in surrounding countries are still relatively low (table 3.2). The largest populations outside the Netherlands are found in Belgium, France, and the United Kingdom. The populations in Belgium, France and the United Kingdom are increasing, in Germany the population is stable (Lensink *et al.* 2013). Very small populations are present in Spain and Switzerland. In Austria, a population of around 30 breeding pairs in Vienna was controlled during the 1990s, and currently the species no longer breeds in Austria (Banks *et al.* 2008).

*Table 3.2 Estimates of the annual number of breeding pairs of the Black swan in European countries other than the Netherlands.*

| State | Annual number of breeding pairs | Source |
|---|---|---|
| Belgium | 40-45 (2000-2002) | Vermeersch & Anselin 2009 |
| Germany | 11-18 (2005) | Bauer & Woog 2008 |
| France | 6-26 (2000-2006) | Dubois 2007 |
| United Kingdom | Average 25 (2007-2011) | M. Holling in litt. / RBBP 2011 |
| Italy | 5-10 (2004-2007) | Banks *et al.* 2008 |
| Spain | Occasional (2004-2007) | Banks *et al.* 2008 |
| Switzerland | Maximum 2 (2004-2007) | Kerstenholz *et al*. 2005 |
| Austria | 0 (2004-2007) | Banks *et al.* 2008 |

Data on the development of the breeding population are only available for the United Kingdom. The number of breeding pairs in the UK is being monitored by the Rare Breeding Birds Panel (RBBP). Between 1996 and 2000, no more than a handful of breeding pairs were present (figure 3.2). Since the year 2000 numbers have increased into double figures, with a maximum of 34 breeding pairs (of which 25 confirmed) in 2010 (M. Holling *in litt*., RBBP 2011).

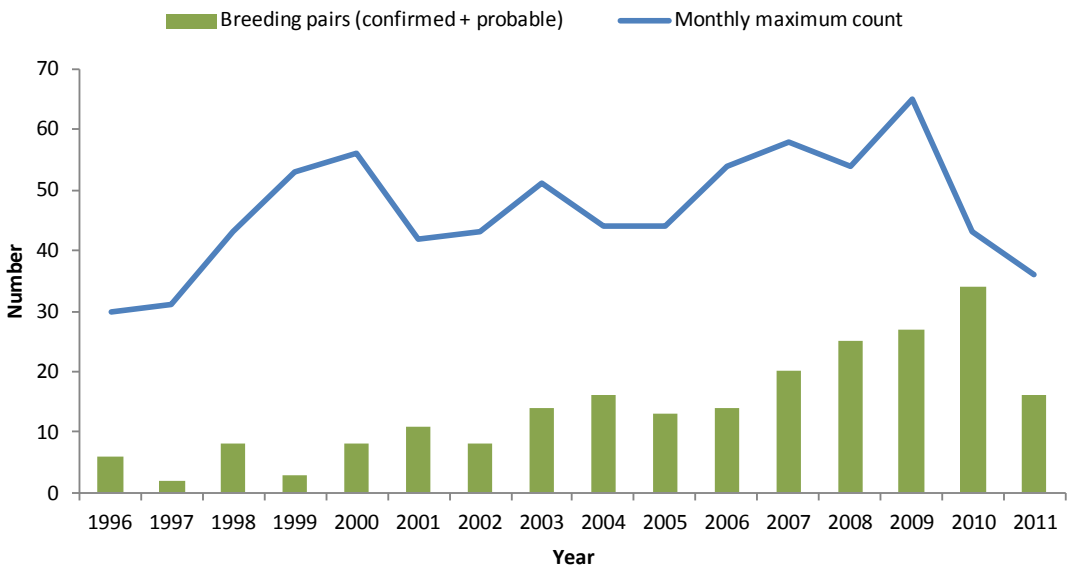



*Figure 3.2 Number of confirmed and probable breeding pairs, and the maximum monthly counts of Black swan in the United Kingdom. Source: Rare Breeding Birds Panel (M. Holling in litt.) / Wetland Bird Survey (C. Holt in litt.).*

### *3.2.3 Establishment capacity in The Netherlands*

Roughly 30 years after the first breeding record, the Black swan has established a feral population of 60-70 breeding pairs in the Netherlands (Lensink *et al.* 2013). Although numbers increased rapidly in the 1990s, the population seems to have stabilized in the last 10-15 years. The rate of increase of the population is relatively low, which may be caused by low breeding

success and survival in temperate Europe compared to the species' mostly subtropical native range.

Another factor that may impede population growth by Black swans in western Europe is the presence of competitors such as the much more numerous Mute swan. Several studies demonstrated that invasive species are more likely to colonize new areas when related species – who occupy similar niches – are absent (Strauss *et al*. 2006, Davies *et al*. 2010). Although such mechanisms are hard to demonstrate in the field, the rapid expansion of Black swans in New Zealand has been explained by the presence of a 'vacant niche' and the absence of competitors (Lever 2005). Interestingly, the Mute swan was introduced to New Zealand at around the same time the Black swan was re-introduced; 150 years later, the population of Black swans has grown to 50,000 birds whereas the population of Mute swans is still below 200 birds (Del Hoyo *et al*. 1992).

**Breeding success**

Data on breeding success in the Netherlands are scarce. Jeroen Nagtegaal (pers. comm.) estimated that 15 breeding pairs in Limburg in 2013 produced about 20 fledged cygnets, which is equal to 1,3 fledged cygnets per breeding pair. In a study by Lensink (1996), 39 of 73 breeding attempts led to hatched cygnets (54%). On average 3,5 cygnets hatched per successful nest, resulting in an average number of 1,9 hatched cygnets per breeding attempt. As can be seen in table 2.2, this value is much lower than in Australia (4,1) and New Zealand (3,6). A study in France indicated a breeding success of 3,25 young per successful breeding pair (Dubois 2007).

European Black swans are frequently reported to breed outside the 'regular' breeding season of the northern hemisphere, and there are many breeding records from the winter season. The small population in Vienna, Austria, had a nesting peak in the months of January and February (Brugger & Taborsky 1994). This aberrant timing may contribute to nest failure and high mortality because of cold or food shortage (Blair *et al*. 2000, Vermeersch & Anselin 2009). However, in Lensink's study (1996) the majority of young cygnets (n=15) appeared on open water in May-July and only a few (n=2) in August-September. These records suggest that the timing of breeding was well adapted to the northern hemisphere.

When looking at data from www.waarneming.nl, the far majority of reported breeding records fall inside the regular breeding season (figure 3.3). Around 10% of occupied nests were reported in the months of September – November. However, it should be noted that these data were not systematically recorded and may be biased. In the province of Limburg some (successful) breeding attempts have also been observed in December-January (J. Nagtegaal, pers. comm.).

**Mortality**

Mortality rates of juvenile and adult Black swans in the Netherlands are unknown. However, analysis of the number of occupied atlas grid squares (as reported by www.waarneming.nl) suggests that the population is affected by the severity of the winter season. The severity of the winter weather is expressed here by the IJnsen index, which is based on the minimum and maximum temperatures and returns a number between 0 and 100 (IJnsen 1981). The higher the IJnsen index, the colder the weather. Cold winters occurred in the periods 1991, 1996-1997, 2003 and 2010-2012. As can be seen in figure 3.4 and 3.5, cold periods (with a severity index higher than 10-15) correspond well with a fall in the number of occupied grid squares. Very mild winters, with a severity index below 10, generally have no negative effect (figure 3.5).

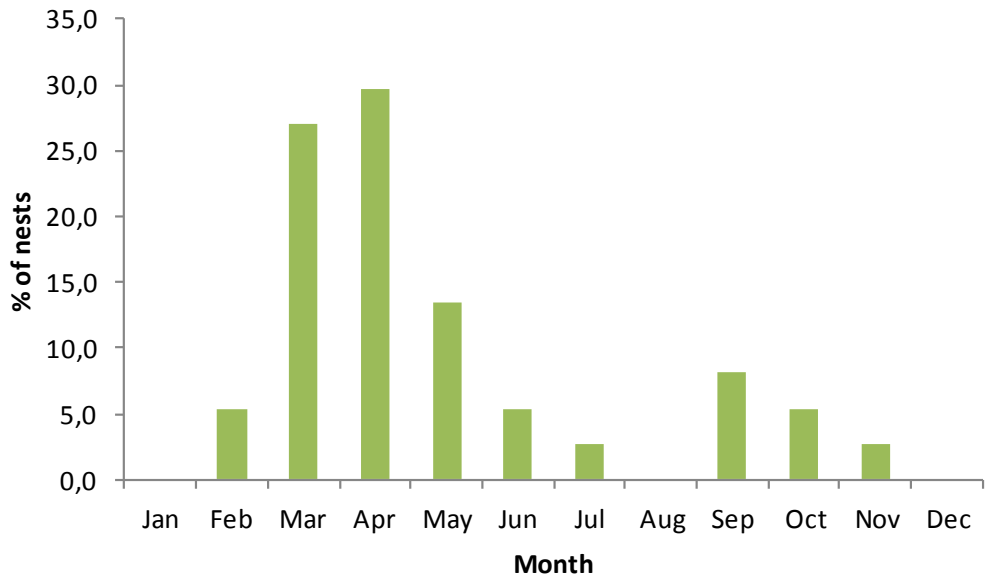



*Figure 3.3 Monthly distribution of occupied nests of Black swans (n=39) in the Netherlands in 2009-2013 according to www.waarneming.nl. Ten nests are observed in two months; in that case only the first month is taken into account.*

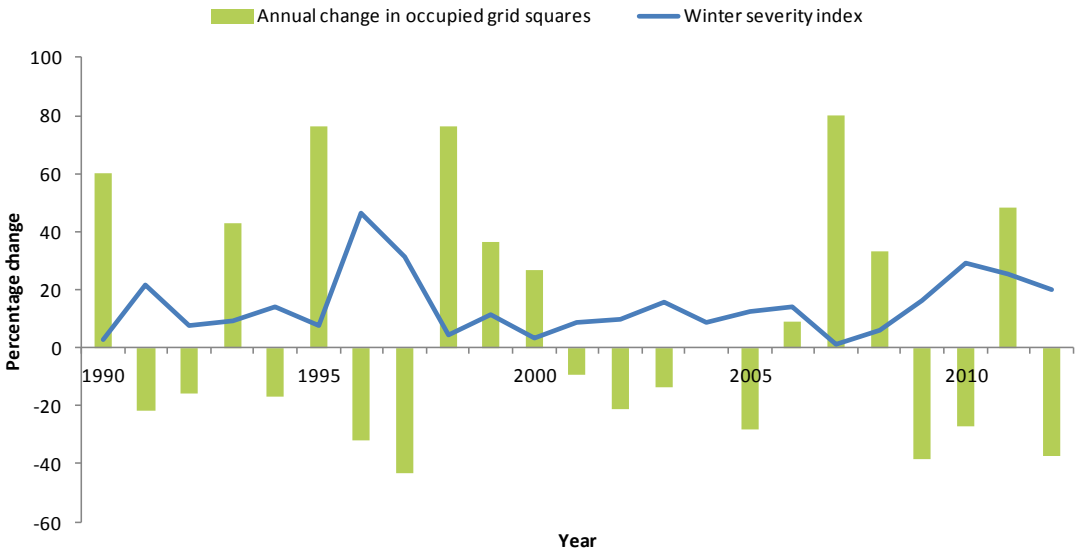



*Figure 3.4 Annual change (%) in occupied atlas grid squares (5x5 km) where Black swan have been observed in the Netherlands in 1990-2012 in relation to winter severity (index value of IJnsen). Source: www.waarneming.nl (grid square data).*

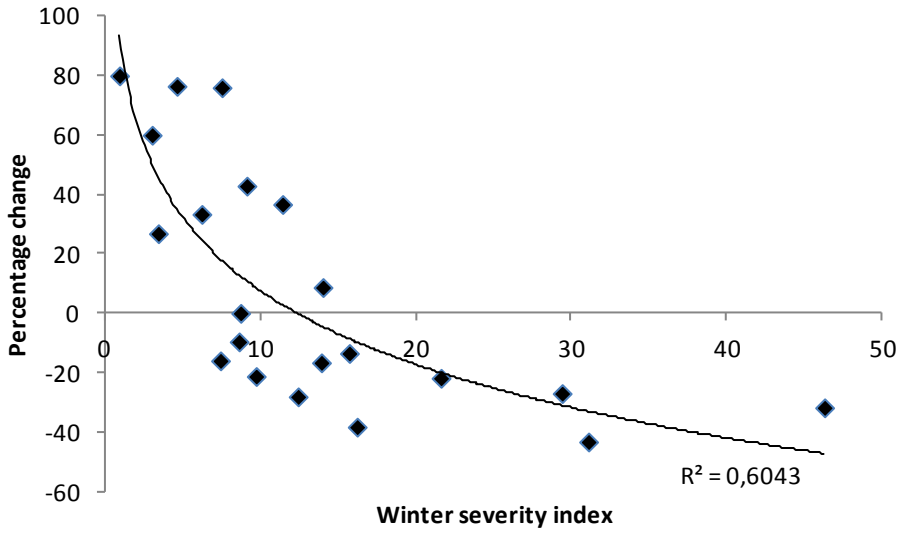
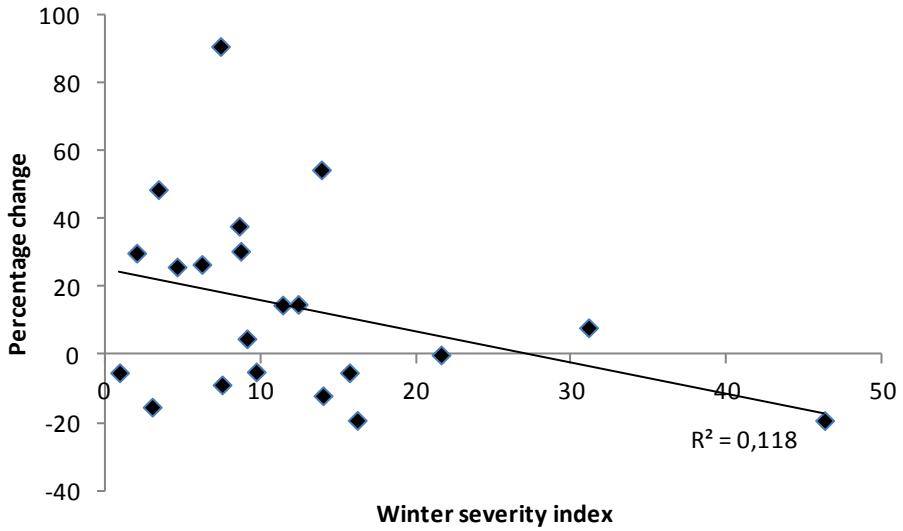



*Figure 3.5 Annual change (%) in number of grid squares where Black swans have been observed as a function of winter severity (index of IJnsen) in 1990-2010. Source: www.waarneming.nl (grid square data).*




*Figuur 3.6 Annual change (%) in average winter counts of Black swans in the SOVON monitoring areas, as a function of winter severity (index of IJnsen). Source: Hornman et al. 2013.*

The negative relationship between the IJnsen index and Black swan distribution may point to increased mortality during cold winters. Another explanation may be that Black swans are more prone to congregate in their wintering areas during cold weather. However, analysis of the winter counts carried out in the SOVON monitoring areas (Hornman *et al*. 2013) do not show higher numbers in the main wintering areas during cold winters (figure 3.6). In fact a slightly negative trend is shown (fig. 3.6), suggesting that cold winter weather indeed results in increased mortality of the Dutch population of Black swans. Similar effects of cold winters on

survival and reproductive output are also seen in other swan species, including Mute swan (e.g. Esselink & Beekman 1991).

Data from the United Kingdom also show a sudden decrease in both the number of breeding pairs and the monthly maximum counts in the period 2010-2011 (see figure 3.2), which may be caused by the cold winters in these years (M. Holling *in litt*.). More research is needed on the relationship between climatic conditions and population limitation (i.e. survival and breeding success) in feral Black swans in the Netherlands and other European countries.

***Summary***

The current population of Black swans in the Netherlands consists of around 60-70 breeding pairs. This makes the Dutch feral population the largest in Europe, although there has been no increase in numbers in the last 10-15 years. The relatively low densities in Europe may be due to unfavourable climatic conditions and the presence of potential competitors, including good numbers of Mute swan.

The feral population of Black swans in Europe may benefit from climate change, leading to increased survival rates and reproductive output. A further increase in numbers can therefore not be ruled out. However, high densities comparable to those in New Zealand are highly unlikely because of major differences in ecological conditions, including the composition of the waterfowl community. In any case, the chances of permanent establishment are high.

## 3.3 Range expansion capacity

The expansion of Black swans from the 1980s until 2012 is illustrated in figure 3.7, which shows the atlas grid squares (5x5 km) where Black swans have been observed (source: www.waarneming.nl). The number of atlas grid squares where Black swans have been observed increased from 95 in the period 1982-1992, to 221 in 1993-2002 and to 455 in 2003-2014. Lensink *et al.* (2013) have measured the velocity of range expansion by Black swan in 1985-2010 at 0,4 km per year.

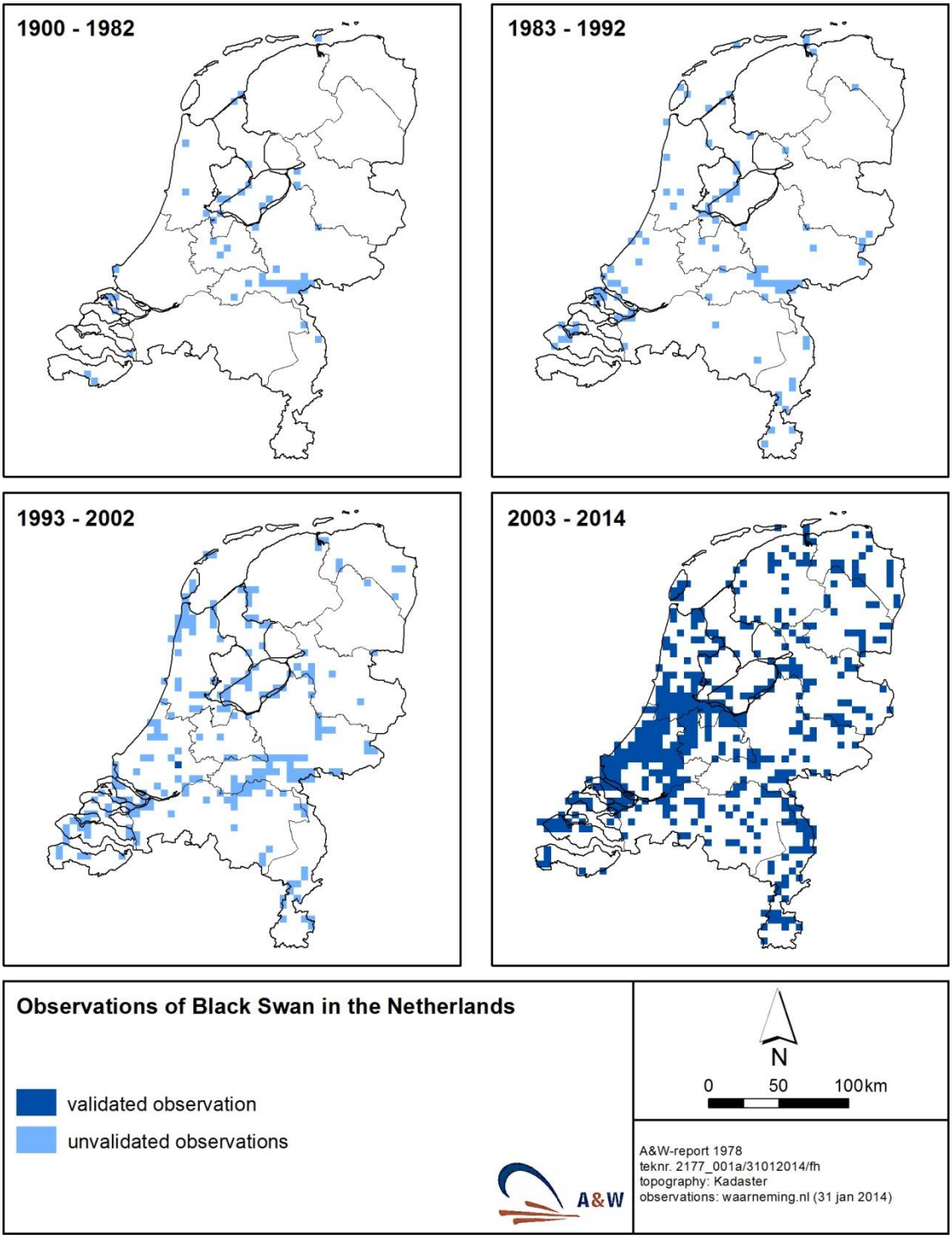
Range expansion of Black swans may to some extent be facilitated by humans due to the distribution of birds over captive collections. However, natural dispersal of Black swans can be high and the species is capable of travelling substantial distances. The expansion of its feral range is therefore more likely to be governed by environmental factors, such as climate, the availability of suitable habitat, or chances of finding a mate.

***Summary of range expansion capacity***

In three decades, Black swans have shown a five-fold increase in occupied grid squares. The main concentrations are found in the southwest of the country and along the main rivers. Given the high dispersal capacity, chances of further range expansion are high.

## 3.4 Protected areas

Black swans are often found on shallow lakes with a rich vegetation of submerged aquatic plant species. Such areas often include protected areas in the Natura 2000 network, such as Krammer-Volkerak, (parts of) IJsselmeer, Lauwersmeer and Veluwemeer. The species may spread to other protected areas with a well-developed submerged vegetation.




*Figuur 3.7 Grid squares occupied by Black swans, based on both validated and unvalidated records. Source: www.waarneming.nl*

## 3.5 Effects of establishment

The establishment of non-native species can have many negative impacts, including the displacement of native fauna, habitat modification and the spread of diseases or parasites (Simberloff 2013). The environmental, economic and social effects of the establishment of Black swans in the Netherlands are described below.

### *3.5.1 Environmental effects*

Environmental effects can refer to interactions with native fauna (e.g. competition for resources or aggressive interactions), or negative effects on ecosystems (e.g. habitat damage or eutrophication). The concern has been raised that in case Black swans become widely established in Europe, they could displace native waterfowl species (Blair *et al*. 2000, Lever 2005). High population levels of Black swan could, in theory, lead to competition for food or habitat with other species of waterfowl. Typical species of waterfowl foraging on submerged aquatic plant species are Mute swan *Cygnus olor*, Bewick's swan *Cygnus columbianus*, Whooper swan *Cygnus cygnus*, Wigeon *Anas penelope*, Gadwall *Anas strepera,* Pintail *Anas acuta*, Shoveler *Anas clypeata*, Red-crested Pochard *Netta rufina*, Pochard *Aythya ferina* and Coot *Fulica atra.* At high densities, waterfowl can reduce the availability of submerged vegetation biomass (Søndergaard *et al*. 1996, Marklund *et al*. 2002). For example, summer grazing by large numbers of Mute swans and various other species of waterfowl has been shown to reduce the biomass of pondweed (*Potamogeton*), thereby affecting food availability to Bewick's swan (Hidding *et al*. 2009). Several studies in New Zealand have raised concern about the impact of Black swan grazing on vegetation biomass (Mc Kinnon & Mitchell 1994, Sagar *et al.* 1995, Dos Santos *et al*. 2012). However, such effects occur only at high waterfowl densities (Marklund *et al*. 2002). Population densities and grazing pressure in the New Zealand studies are far higher than in the Netherlands, and the relative impact of Black swans within the entire Dutch waterfowl community is considered to be minimal.

Black swans and other waterfowl can contribute to nitrogen loads in lakes and on pastures because of the nitrogen content of their faeces (Coleman 2006). However, this nitrogen input is likely to be negligible compared to the high nitrogen loads in Dutch agricultural areas and lakes. Even at high densities in New Zealand, nutrient input by Black swans in lakes is minimal (Mitchell & Wass 1996).

***Summary of environmental effects***
At present there is no evidence of negative environmental effects caused by Black swans in the Netherlands.

### *3.5.2 Economic effects*

Black swans may graze on agricultural pastures, in particular during the moulting period and winter season, when submerged vegetation is not available and the swans congregate in groups to forage on grasslands. Average grass intake in adult birds (weighing 4-5 kg) is approximately 1-1,25 kg per day, or 0,1 kg/day dry weight (Coleman 2008).

Grazing by the much more numerous Mute swan can result in agricultural damage eligible for monetary compensation by the Dutch Faunafonds. In the period 2007-2012 an average annual amount of roughly €73,000 was paid by the Faunafonds to compensate for Mute swan

damage[1] (Faunafonds 2012). Although Black swans may also cause damage by grazing activities, the Dutch population of feral Black swans is currently too small to cause substantial economic damage. Damage resulting from Black swan grazing is currently not eligible for compensation. Although further population growth cannot be ruled out, numbers in the same order of magnitude as Mute swan are not credible.

***Summary of economic effects***
At present the population of Black swan in the Nederlands is considered to be too small to give substantial economic effects. Agricultural damage is probably minimal, but may increase in case of further population growth. However, damage in the same order of magnitude as caused by Mute swan, is unlikely.

### *3.5.3 Social effects*

Black swans and other species of waterfowl are able to carry a wide range of bacterial, fungal and viral diseases (Wobeser 1981). Waterfowl are a well-known reservoir for avian influenza, including the highly pathogenic H5N1 virus. This virus was found on a captive Black swan in Germany in 2006 (Klenk *et al*. 2008). Black swans appear to be highly susceptible to H5N1, with a 100% death rate among infected birds (Brown *et al*. 2008). Because of the rapid illness and death following infection, geographic spread of the virus by Black swans does not seem likely (Brown *et al*. 2008).

***Summary of social effects***
Black swans are able to carry a number of diseases, including the highly pathogenic H5N1 virus. We are not aware of any documented records of disease transmission by Black swans to other species of waterfowl or humans.

### *3.5.4 Positive effects*

Black swans are popular ornamental birds that provide aesthetic value to many people. From an ecological point of view, in marsh vegetations in New Zealand grazing by Black swans can help to retain a variety of other waterbirds that require open water (Smith *et al.* 2012).

## 3.6 ISEIA scoring

The Invasive Species Environmental Impact Assessment (ISEA) methodology has been used to assess the risk for the Black swan in the Netherlands. ISEIA is an initiative of the Belgium Forum on Invasive Species (Branquart 2009). It refers to a protocol in which the risk of a species is judged on the basis of four factors: dispersal potential, colonization of natural habitats, impact on native species and impact on ecosystems.

These four factors will be assessed and judged as a low, medium or high risk (score 1, 2 en 3). The sum of these scores is the global ISEIA score, which can range from 4 to 12. The ISEIA score can be classified into three categories. A score of 4-8 is considered a low risk. A score of 9-10 refers to a medium risk, in which it is advised to place the species on a *watch list*. A score of 11-12 means a high risk, in which the species may be placed on a *black list*.

[1] This amounts to roughly €3,- per Dutch Mute swan

**Dispersal potential: score 3**
All bird species fall into this category. Lensink *et al.* (2013) report an average expansion rate of 0,4 km per year since the Black swan's settlement in 1978. This rate is relatively low. The observation of a collared bird that was marked in the province of Limburg and subsequently observed in the German Waddensea (J. Nagtegaal, pers. comm.) shows that the species can travel substantial distances. Even longer distances are shown by the vagrant Black swans recorded in Iceland, or by the presumed natural migration between Australia and New Zealand (Del Hoyo *et al*. 1992, Kear 2005), which would involve a distance of over 1500 km.

**Colonization of natural habitats: score 2**
Populations of Black swan are usually confined to habitats with a low or medium conservation value, but may occasionally colonize habitats with a high conservation value. Habitats with a high conservation value mainly concern shallow lakes with a rich vegetation of submerged aquatic plant species. Examples of such areas are Krammer-Volkerak, parts of the IJsselmeer, Lauwersmeer and Veluwemeer.

**Impact on native species: score 1**
At present the negative impact of Black swan on native species is probably negligible. The feral population in the Netherlands is still relatively small and more or less stable since about 2005 (Hornman *et al.* 2013). Although the population might still grow, there are strong indications that numbers are reduced during harsh winters (see chapter 3.3).

High numbers of Black swan could lead to competition for food or habitat with other species. Similar concerns have been raised for the feral population of Mute swans in North America (e.g. Reese 1975, Hindman & Harvey 2004; but see Conover & Kania 1994). Black swans share food and habitat with Mute swans and various other species of waterfowl, but this does not necessarily imply competition unless these resources are limited. Given the abundance of pasture in the Netherlands, competition for grass is not likely to occur. High grazing pressure can reduce pondweed biomass, but the impact from Black swan grazing will be negligible compared to the combined effect of other, more numerous species. A negative impact on the population of Mute swan or other waterfowl is therefore not expected. Although Black swans and Mute swans often mingle, aggressive interactions seem to be rare (J. Beekman *in litt*.).

Hybridization with Mute swan has been observed in captivity and in the wild, including in the Netherlands (Vergoossen *et al.* 2011, J. Beekman pers. comm.). Apparently the offspring is infertile (Del Hoyo *et al*. 1992).

**Impact on ecosystems: score 1**
Grazing by waterfowl may have an impact on submerged macrophyte biomass and therefore indirectly also on water quality (Søndergaard *et al*. 1996). However, reduction of submerged vegetation biomass normally only occurs at high waterfowl densities (Marklund *et al*. 2002). This was also the case in the New Zealand studies on Black swan grazing, where hundreds of Black swans were foraging on a single meadow (Dos Santos *et al*. 2012). These densities are unlikely in the Netherlands, and the relative impact of Black swan within the entire waterfowl community is considered to be minimal. The impact on ecosystem processes and structures is classified as low.

**Global ISEIA score**
The global ISEIA score for Black swan is 7 (table 3.3), which means that the overall risk is qualified as low.

The ISEIA score given here is lower than for the feral population in Belgium, where Black swans are considered a *medium risk species* with an ISEIA score of 10 (Anselin *et al*. 2011). In the Belgian assessment, impacts on species and ecosystems are considered 'likely', based on the argument that "dense colonies may impair the development of submerged vegetation and outcompete native water birds from nesting sites. They are also likely to affect ecosystem functions" (Anselin *et al*. 2011). These arguments seem to be drawn directly from the studies in New Zealand, where Black swan densities are far higher and climatic conditions, food resources and the composition of the waterfowl community uncomparable to those in Europe.

*Table 3.3 ISEIA score of the Black swan.*

| Category | Estimate | Score |
|---|---|---|
| Dispersal potential | High | 3 |
| Colonization of natural habitats | Medium | 2 |
| Impact on native species | Low | 1 |
| Impact on ecosystems | Low | 1 |
| List / total score | Low | 7 |

## 3.7 Summary of the different sections of the risk assesment

The feral population of Black swans in the Netherlands has grown substantially since the first known breeding record 30 years ago. However, in the last decade the population seems to have stabilized at around 60-70 breeding pairs. Low breeding success and high mortality rates during harsh winters may limit the expansion of feral Black swans. In addition, the presence of potential competitors such as the more dominant Mute swan may impede substantial population growth. High population growth rates as observed in New Zealand are therefore not expected, even in the absence of cold winters.

All in all, the Dutch population of Black swans is currently very small and although numbers may still rise, major environmental, economic or social impacts are unlikely. This results in an overall ISEIA score of 7 and the classification of the Black swan as a low risk species.

# 4 Risk management

## 4.1 Elimination

One of the main dilemmas in the management of invasive species is whether and when to consider elimination (Bauer & Woog 2011). As pointed out by Simberloff (2013), elimination of a non-native species is far more likely to succeed early in the colonization process. However, at this stage the magnitude of potential impacts is often unclear. The debate is centered around the question whether elimination should be considered *before* (when elimination is still feasible) or *after* such impacts have been studied in detail (Bauer & Woog 2011, Edelaar & Tella 2012).

Given the low numbers and conspicuous habits of Black swans, elimination is probably feasible. Elimination can be done by catching birds when they are flightless in the moulting period, or by shooting. The small population in Austria has ceased to breed following egg treatment (Banks *et al*. 2008).

## 4.2 Control

Options for population control of the Black swan are similar to those for Mute swan and other large waterfowl species (see e.g. Ebbinge *et al*. 1998, Schekkerman *et al*. 2000, Perry 2004, Van der Hut 2013). The two main options are a) reducing the population growth rate by affecting reproductive output, and b) removal of adult birds from the population.

Reduction of the population growth rate can be achieved by removing eggs or treating the eggs so that they will not hatch. This will result in decreased (local) breeding success and a demographic shift towards older birds in the population, who contribute less to the breeding pool (Ebbinge *et al*. 1998). In a study on Greylag geese, Schekkerman *et al*. (2000) recommended that not all eggs are removed from the nest, to prevent the parent birds starting a second nest. Egg removal has some important drawbacks: it requires substantial, long-term effort (particularly in long-living birds such as swans), it can result in disturbance of other species, it may increase survival of juveniles that do hatch, and is only successful at the local level (see e.g. Voslamber *et al*. 2004, Van der Hut 2013).

Reducing the survival of adult birds can be achieved by shooting birds, or by catching birds during the moulting period. Model studies indicate that Mute swan populations are much more sensitive to changes in adult survival than to changes in breeding success (Hindman & Harvey 2004). Shooting or catching birds is therefore likely to have a stronger effect than egg treatment, in particular when the population is still growing (see Schekkerman *et al*. 2000). However, such measures can be highly controversial and may not be acceptable to the public.

It should be noted that empirical data on breeding success and mortality rates in European populations of Black swan are extremely scarce. Since population growth is primarily governed by these two factors, further research on these parameters and their role in population limitation in feral Black swans is recommended.

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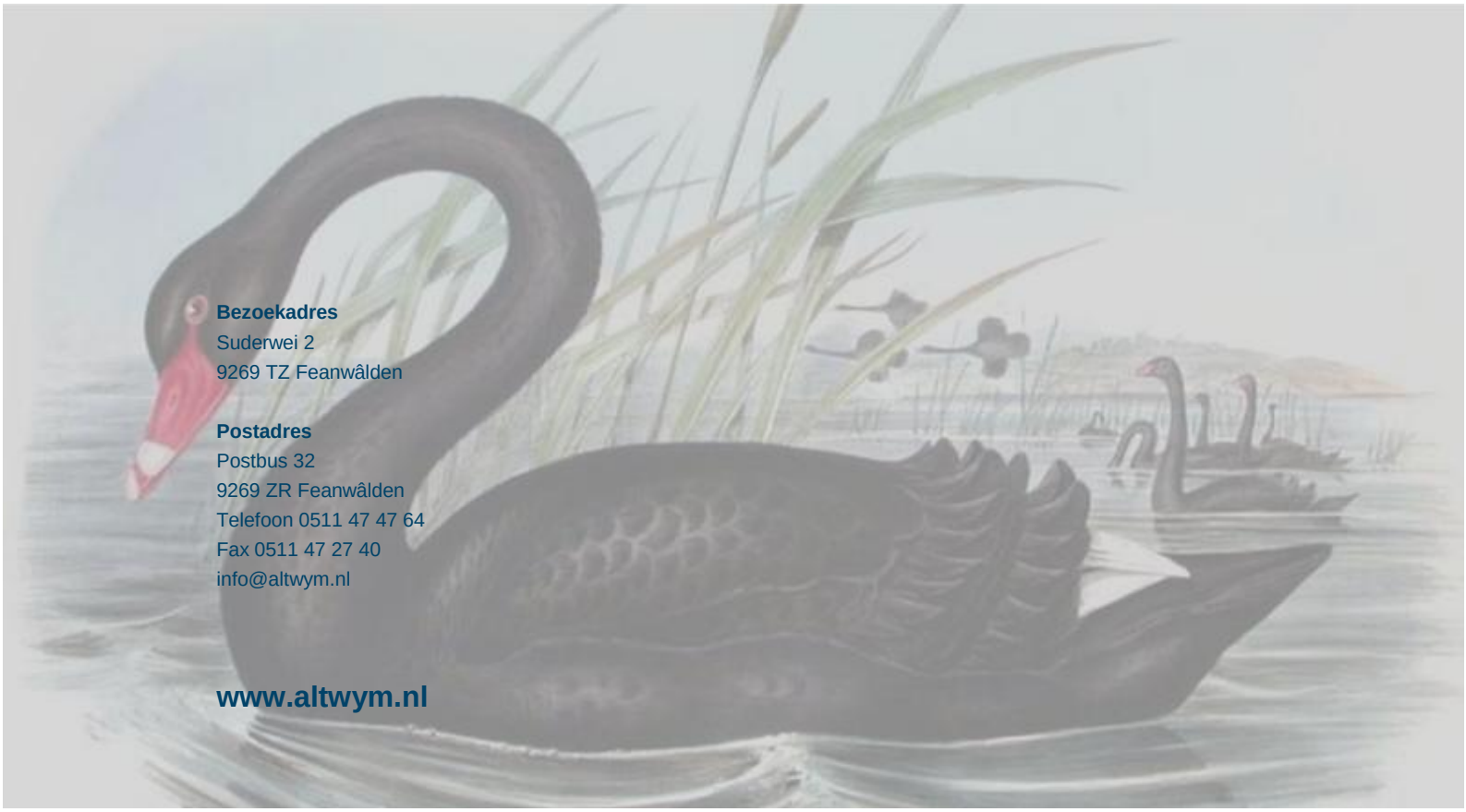

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