Effectivity of Dutch Goose management during the breeding season

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Abstract

The change in agricultural regimes and thereby the increased grass growth, combined with the demise in goose and fox hunting have caused the Netherlands to become a prime goose paradise. By extending their arctic breeding locations to more temperate latitudes such as the Dutch Delta the geese have increased their summer staging and breeding areas. Nowadays the Dutch goose population is the largest growing breeding bird population in Western Europe. As all growing wildlife populations the geese population causes conflicts with farmers who see their crop being consumed by all these geese. Crop damage is compensated by the government through the taxpayers. In this article we focus on the methods which can be used in goose management and their efficiency in population control. We provide different methods which can be used to control goose populations. Scaring techniques and biotope management are described. We show that goose reduction at the egg and juvenile stages has no impact on the population growth. Hunting is observed as a partly effective method but only when certain individuals are targeted. We perceive gassing to be efficient but only when the right portion to the population is culled. Finally we conclude that culling incubating females in the breeding colonies has an impact to retard the growth of the Dutch goose population.

Introduction

Most of the Dutch Delta landscape is characterized by vast meadows of heavy intensified dairy and cattle farms. The fluctuating water levels of the rivers and the tidal influence of the sea together with the creeks, gullies and the extensive pastureland make the Dutch Delta a heterogenic safe haven for waterfowl and meadow birds in this highly intensified farming landscape.

Historically, growing populations of wildlife gave rise to conflicting interests with farmers in densely populated areas with highly intensified farming landscapes such as Western Europe. Nowadays the fast growing portion of non migratory summer-staging and breeding geese in the Netherlands are a topic of debate because of the financial damage they cause to farmers which is compensated by the government through the taxpayers (Ouweneel, 2001; Voslamber *et al.*, 2007; Voslamber & Turnhout, 2004).

The shift from extensive to intensive farming (Van Eerden *et al.*, 2005) , global warming (Hoglind *et al.*, 2013), a reduction of hunting pressure by man (Ebbinge, 1991) and the intense eradication of foxes (Van der Jeugd *et al.*, 2009; Voslamber *et al.*, 2007) are main factors to the growing Dutch goose population. In 2005 there were 38.500 breeding pairs or 155.000 geese divided over 13 species (Van der Jeugd *et al.*, 2006). Model predictions show that the greylag goose population will rise to 70.000 breeding pairs in 2017, the ceiling with 90.00 pairs will be reached around 2040 when all potential breeding grounds are colonized (Van der Jeugd *et al.*, 2006). The canada goose and barnacle goose populations are rising quickly as well and will reach levels of 10.000 and 15.000-20.000 breeding pairs, but these levels are highly dependant on fox predation (Van der Jeugd *et al.*, 2006).

Managing goose populations has proved to be quite difficult (Mooij, 1991) and populations are still expanding, both in number as in area of exploited farmland (Ebbinge *et al.*, 2003; Voslamber & Turnhout, 2004). Wintering geese which still migrate to the arctic breeding grounds are not seen as a problem by farmers because damage is small or non-existent (Van der Jeugd *et al.*, 2009; Voslamber *et al.*, 2007).

In this article I give an overview of the methods used in Dutch goose management and the effects they might have on the summer staging non- migrating goose population. Summer staging geese are defined as wild geese, of any species, being present in the Netherlands in the period 1st April – 1st October (Faunafonds, 2008).

Density dependence

Density dependent effects are potential forces that can affect recruitment rate and population growth of nesting birds (Morrissette *et al.* 2010), their reproductive success appears strongly affected by food and nest site availability (Madsen *et al.*, 2007)

Habitat quality (McNab, 1963; Schoener, 1981; Ford, 1983; Mace *et al.*, 1983) is a determining factor for home range size (Kilpatrick *et al.*, 2001). The lower the competition within a group of organisms, and the better the habitat quality, the smaller the home range will be (Kilpatrick *et al.*, 2001). Higher population densities assume better habitat quality (VanHorne, 1983) and animals living in better quality habitat need to travel less to obtain life requisites (Kilpatrick *et al.*, 2001). Creating protected areas is an important part of the strategies for the conservation of species (Higgs, 1981; Margules & Pressey, 2000). However, in many animals, home range size exceeds protected area size (Kramer & Chapman, 1999; Woodroffe & Ginsberg, 1999). In barnacle geese (*Branta* leucopsis) density dependent processes lead to carrying capacity, the competition for food on the breeding grounds causes gosling growth rate to be lower and gosling mortality to be higher (Loonen *et al.*, 1997; Larsson & Forslund, 1994). Even final adult body size was smaller when the adult was exposed to density dependant effects such as food competition as a gosling (Loonen *et al.*, 1997; Larsson & Forslund, 1991).

In theory, when a habitat of good quality is exploited by many individuals of a particular species, and the saturation point of the carrying capacity is reached, intraspecific competition (Burt, 1943; Sanderson, 1966; Mace *et al.*, 1983; Gese *et al.*, 1989) will be strong and the area will "overflow" causing emigration to other, mostly lower quality, feeding areas (Cope *et al.*, 2003). This is known as the buffer effect (Brown, 1969; Gill *et al.*, 2001). As populations grow, an increasing portion of animals is displaced into poorer quality areas leading to reduced fecundity and survivorship (Gill *et al.*, 2001).

Grazing by cattle causes sward canopy height to be lower and facilitates for the geese (Van der Graaf *et al*. 2002). Grazed areas are more preferred by the geese than the ungrazed nature reserves where the grass grows taller over the season (Van der Graaf *et al*. 2002). Goose grazing pressure is negatively correlated to canopy height which could be beneficial, by forcing geese into nomadic behaviour. This preference towards grazed pastures unfortunately increases the grazing damage inflicted to farmers. Contradictory, philopatry displayed by geese may cause them to stage in unsuitable habitats longer then one would expect (Rockwell *et al.*, 1993), leaving the geese to breed in a slightly degraded habitat (Black & Owen, 1995).

When individuals are removed or culled from a population, intraspecific competition can be lower and therefore the production of offspring in next years can be larger. In fisheries biology, Maximum Sustainable Yield (MSY) is calculated annually, to optimize the harvest of pelagic fish stocks and to leave the remaining population in such a state that intra specific competition is quite low and next years recruitment will be optimal (Holmgren *et al.*, 2012).

Another good example for the importance of the concept of density dependence in wildlife management are red deer (*Cervus elaphus*) on hunting estates in Scotland.
When culled under 50 % of carrying capacity female red deer will give birth to male offspring more frequently (Clutton-Brock *et al.*, 2002). Male deer are usually culled by fee-paying hunters making them beneficiary to the estates exchequer. By reducing female deer numbers Scottish deer managers also increase the food abundance for male deer making their antlers grow larger and making them an even more desirable trophy for hunters. This increases the managers annual take-off of mature males, and net income from deer management by the sale of female venison. Reduction of female deer numbers is likely to have benefits for tree regeneration which in turn will have further benefits to the deer population by an increase in forage and shelter (Clutton-Brock *et al.*, 2002).

Inclusive fitness

Among species with overlapping generations, life- history theory predicts that survival and reproductive success are selected to maximize lifetime reproductive performance, thus fitness (Rockwell & Cooch, 1993). Inclusive fitness is basically the spread of genes of one female through a population. It can be true that as a breeding female from a long lived species, the female breeding next to you in a colony is your relative and holds the same genes as you do. Altruism is encouraged in high genetic closeness and it would be better to slacken competition slightly in favour of your own offspring when it is breeding next to you (Taylor, 1992). As fitness is defined by a count of breeding offspring it seems reasonable for a mother or even grandmother not to compete with her daughter or granddaughter (Taylor, 1992).

When there is declining dispersal the relatedness of surrounding individuals rises and the more altruistic behaviour should be (Taylor, 1992). Limited dispersal leads to a correlation between maternal and offspring environments, which favours plastic adjustment of offspring size in response to local survival (Kuijper & Johnstone, 2013). In group-structured populations, altruistic acts can be selectively favoured only to the extent that an altruistic group is able to export a fraction of the benefits it generates (Grafen, 1983). Meaning that some of the additional offspring produced by this altruistic behaviour have to compete with individuals of relatively low relatedness (Taylor, 1992).

What counts is that the offspring can be accommodated by the environment in such a way that the offspring they would normally compete with do not feel the full effects of their presence. This environmental elasticity is the only force which can mitigate the damping effect of local competition on the selective advantage of altruism toward relatives (Taylor, 1992). When the environment has no capacity for local expansion (inelastic), then selection pays attention to the direct effect of the actor on her own fitness, but not to her direct effects on any other individual, no matter how closely related that individual is (Taylor, 1992).

In semi structured populations, such as goose flocks, where family bonds can be observed, kin selection gives rise to more altruistic behaviour, such as lowering aggression towards kin and sounding alarm cries in a earlier stage to protect kin from approaching danger and predators (Van der Jeugd *et al.*, 2002; Trivers, 1971). Settling close to kin with more altruistic behaviour can facilitate nest site acquisition and breeding success and herby raise inclusive fitness (Watson *et al.*, 1994; Van der Jeugd *et al.,* 2002). Geese tent to quite frequently adopt young goslings from neighbouring broods which may result in parental resources being provided to non-kin and can have major effects on the cost and benefits of parental care and individual strategies (Choudhury *et al.*, 1993). Settling close to kin lowers the risk of adopting non-kin goslings.

Geese are highly philopatric, meaning that they return to the same nesting locations year after year (Loonen *et al.*, 1997) giving them knowledge about local conditions (Rockwell *et al.*, 1993) and as their offspring is philopatric as well they increase relatedness and thereby kin selection and inclusive fitness.

Geese form lifetime pair bonds and the females' success is attributable to the males' qualities enabling the acquisition of good territories (Black, 2001; Black & Owen, 1995). Loss of this pair bond by decease of a partner means a loss of knowledge and teamwork (Black, 2001). Females generally grow older than males, because males participate in fights, protect the nest against other males and fend off predators. The female then has to resort in choosing another male from a much younger cohort which are mostly inexperienced resulting in loss of the nest site and higher chick mortality (Black, 2001; Rockwell & Cooch, 1993).

In colonial animals the individuals with the best physical condition and best advantages through kin selection probable have the best territories which give them the highest direct and inclusive fitness producing most offspring (Watson *et al.*, 1994; Van der Jeugd *et al.*, 2002). The best territories are usually in the centre of the breeding colony because the individuals with a lower physical condition will breed further of the centre (Gill *et al.*, 2001). On the outskirts of a colony, where predation is highest and nest failure is most likely to occur are the animals which are least favoured by kin selection and with the lowest physical condition.

On the other hand, it could also be true that birds breeding on the outskirts of the colony do this as a planned move (Ens, 1994). Assuming that foraging area's are adjacent to the colony, then breeding on the outskirts gives your chicks direct access to forage from hatching day onwards, while birds breeding on the centre of the colony have to traverse their offspring through the already established feeding spots of their outskirt-inhabiting neighbours. The outskirt neighbour males will defend their territories and peck at the young of the centre birds, which might have not enough time to forage and may starve, or even get separated from their parents and perish (Ens, 1994). In this way it might be more beneficial to breed at the outskirts of the colony, especially in situations, such as the Netherlands, where foxes are nearly absent and predation is relatively low compared to the arctic breeding sites (Van der Jeugd *et al.*, 2006).

When we look at fast growing populations, we find that only a small percentage of very fit adults with high inclusive fitness produce most of the offspring (Black & Owen, 1995; Kuijper & Johnstone, 2013) it is these individuals which form the crux to goose managers. Culling this portion of the breeding population has the greatest impact in deterring population growth (Kleijn *et al.*, 2012). The majority of a goose population will have failed breeding attempts, loss of juveniles through predation, or do not even initiate breeding through a lack of suitable nest sites (Voslamber *et al.*, 2007).

Goose population development

Historically being regarded as an obligate arctic breeder, a portion of barnacle geese in the flyway have started a breeding colony in the Dutch Delta since 1982 (Van der Jeugd *et al.*, 2009; Voslamber *et al.*, 2007). These geese have stopped migrating, stage in the Netherlands year round and breed and raise their goslings. Limited dispersal increases the populations' viscosity and hereby the probability that parents care for related as opposed to unrelated offspring (Lion & van Baalen, 2007), making the Dutch population more viscous than the still migrating part of the goose populations (Kuijper & Johnstone, 2013). Furthermore, the smaller the average radius of dispersal, the higher the average relatedness between neighbours will be. The more likely a goose is to breed next to kin (Van der Jeugd *et al.*, 2002), with more local altruistic interactions to obtain maximum inclusive fitness and produce more offspring (Taylor, 1992). In this way the non migrating portion of geese might experience a faster growth than their migratory counterparts.

Before 1980 all barnacle geese used to follow the so called "green wave" of spring from their Dutch wintering grounds and travel north along the climatic gradient, through the Baltic to the Russian tundra's, taking advantage of the high quality spring growth in forage plants at each stopover site along the gradient (Drent *et al,.* 1978). The "green wave" hypothesis has explained the northerly migration of geese from temperate latitudes and states that while travelling to their arctic breeding grounds on the Russian tundra the geese take advantage of the best forage in each stopover location (Graaf *et al.,* 2006).

Barnacle geese are specialized herbivores depending on forage of high nutritional quality (Prop en Vulink, 1992), which is mainly found in monocotyledons (grasses). On the intensely farmed meadows in the Netherlands the grass is mowed 3-5 times per annum and highly fertilized, making the short fast growing grass rich in nutrients and a feast to barnacle geese (Van Eerden *et al.*, 2005*)*. Due to global warming the growing season of the grass is intensified and prolonged, this combined with the acid rain which fertilizes the grass even more, accelerated the growth (Hoglind *et al.*, 2013). The increase in forage quality and production has had positive effects on gosling survival in summer and adult survival in winter and thereby population growth (Voslamber *et al.*, 2007; Voslamber & Turnhout, 2004). Nowadays, the Dutch barnacle goose population is the fastest growing goose population found in the world, with a breeding population of 6000 pairs and 25000 individuals (2005 census). The population's centre of gravity lies around South-Holland's Delta region (Van der Jeugd *et al.*, 2009; Voslamber *et al.*, 2007) and recent shifts in land use from farmland to nature reserve have been debit to this explosive colonisation (Voslamber *et al.*, 2007).

The very successful project "Delta nature" aims on re-wilding sections of farmland and floodplains by the rivers Meuse and Rhine in order to link small nature reserves and restore the Delta's natural beauty which was affected by the build of the Haringvliet sluices in 1970 (Schmit, 2003). The closure of the sluices caused a decline in salinity of the estuary's water and turned the Haringvliet estuary into a freshwater lake which was beneficial to the grass growth on the adjacent farming meadows (Van Meerkerk *et al.,* 2013). The prospect is that in 2018 the sluices will be set ajar in order to let diadromous fish pass on their migrations and to restore estuarine functions of the Delta (Schultz van Haegen, 2013). All nature reserves incorporated in the "Delta nature" project are, protected under the 1971 "Convention on

Wetlands of International Importance especially as Waterfowl Habitat", Signed in the city of Ramsar, Iran (Davis, 1994). This recent enlargement of new linked nature makes suitable habitat for geese to breed (Van der Jeugd *et al.*, 2009; Voslamber *et al.*, 2007) and provides shelter to individual geese and goslings (Ouweneel, 2001). Unfortunately the boundaries of these nature reserves are very sharply defined. On one side of the fence nature reserve on the other vast meadows of heavy intensified dairy and cattle farms.

Greylag geese (*Anser anser*) are the only historically breeding and summer staging geese in The Netherlands (Voslamber *et al.*, 2007). Greylag geese have been hunted to extinction but have been re-colonizing the Netherlands since the 70's and have made a major comeback which is seen as a success to conservationists (Voslamber *et al.*, 2007). Nowadays the greylag goose is the fastest growing breeding bird species in terms of population growth, in the Netherlands, (Faunafonds, 2012). In 2009 the population summer staging greylag geese in the Netherlands was estimated at 190.000 individuals (Faunafonds, 2009). Unlike barnacle geese and white-fronted geese (*Anser albifrons*) which only forage on grass, greylag geese feed on crop such as cereals, beets and lettuce (Kleijn *et al.*,2012). And thereby create more damage to agriculture (Faunafonds 2012). Unlike barnacle geese they do not breed in colonies but more solitary.

In the lifecycle of the goose, the egg and juvenile stage are most crucial to lifetime survival (Voslamber & Turnhout, 2004). On average, the goslings of only about 15% of potential breeding pairs survive to 4 months (Pettifor *et al.*, 1998). During its lifecycle a barnacle goose may experience several breeding seasons with total nest failure due to predation (Tombre, 1995). Foxes can have devastating effects by eradicating all laid clutches in a colony (Tombre *et al.*, 1998), foxes can deplete a whole area for eggs and thereby prevent the production of recruits that year (Tombre *et al.*, 1998). In areas where foxes appear the geese will only breed in locations inaccessible to foxes (Voslamber & Turnhout, 2004). By decreasing survival and forcing entire populations into refuges, foxes are able to keep goose populations in check and under control (Voslamber & Turnhout, 2004). The intense hunting pressure on foxes to protect meadow birds has led to a very low fox population in the Dutch Delta (Van der Jeugd *et al.*, 2009; Voslamber *et al.*, 2007) and the fox is the only predator of importance in the urbanized Netherlands (Voslamber & Turnhout, 2004). The foxhunt combined with the decrease in goose hunting all over Europe, are major contributing factors to the explosive increase in goose numbers (Ebbinge, 1991).

After surviving the egg and juvenile stages, the adult geese can potentially reach high ages. Adult geese of over 20 years of age are no exception (Voslamber & Turnhout, 2004), with an average lifespan of 9 years (Owen & Black, 1989), this gives rises to a long reproductive period during the goose's life. In principle, one successful breeding attempt in which only 2 goslings reach maturation and reproduce is enough to secure the survival of the species. Most goose species are monogamous and have only one mate during their lifetime, although many have the opportunity to re-pair after death of the initial partner (Black, 2001). When a female goose loses her male lifetime companion she can search for a new mate and mostly recruit one of the younger males (Black & Owen, 1995). This will decrease her lifetime reproductive success drastically because younger males are far more inexperienced in obtaining a suitable nest site and females though philopatric have to start exploring the new breeding location (Black & Owen, 1995).

The average goose produces 2.2 young during its lifetime (Owen & Black, 1989). However the best geese produce 14 young. Recent analyses of long-term reproductive success in barnacle geese has indicated that gosling recruitment increases in the early years, peaks between 7 and 9 years, and then declines in the later years of life (Black & Owen, 1995). As the average lifespan of these geese is about 9 years reproductive performance of these individuals can improve throughout their lives (Black & Owen, 1995).
Roughly about 10% of the adults produce 50% of juveniles and 50% of the adults, produce no offspring at all (Owen & Black 1989) due to predation of eggs and juveniles or failed breeding through intraspecific competition for nest sites (Voslamber *et al.*, 2007; Voslamber & Turnhout, 2004). In locations where goslings have the opportunity to forage on mowed well fertilized grassland breeding pairs will raise mostly more than 5 juveniles. In breeding areas with more natural rough vegetation breeding pairs will only raise 2-3 juveniles (Voslamber & Turnhout, 2004).
In winter flocks, pairs without offspring account for 70-99% of the adult population (Pettifor *et al.*, 1998). Because non-breeders do not have to take care of a nest nor rear gosling, they are much more flexible towards the habitat and can appear on any location where forage is suitable (Voslamber & Turnhout, 2004). This means that geese without offspring can exploit the ideal free distribution more optimal (Fretwell and Lucas, 1970) and will forage on farm land much more often. These cause the bulk of the financial damage inflicted to farmers than do breeding geese which have to account for gosling safety and will stick to the nature reserves.

In large herbivores adult female survival shows little year to year variations as does fecundity of prime-aged females and yearling survival. Herbivores are strongly iteroparous (Gaillard *et al.,* 1989; 2000), females generally reproduce over 5 times (Berger, 1986; Berger & Cunningham, 1994; Byers, 1997; Clutton-Brock *et al.*, 1982) and a few individuals may reproduce 15 times during a lifetime (Gaillard *et al.,* 1998; 2000). After first reproduction in most species, females attempt to reproduce every year (Gaillard *et al.,* 2000). In particular, male survival is typically lower than female survival at all ages (Clutton-Brock *et al.*, 1982).

The same holds true for geese. In geese some of the best adults produce most of the juveniles while others have failed breeding attempt (Voslamber *et al.*, 2010). We have seen that the best individuals breed in the centre of the colony and that the best animals occupy the best territories giving them highest inclusive fitness. When a population needs to be reduced we can best target these best reproducing geese (Black & Owen, 1995) instead of the whole population, to be (financially) effective and to reduce disturbance of other biota by unnecessary shooting (Voslamber & Turnhout, 2004).
In circumstances, such as the Netherlands where geese graze on farmland and interact negatively with human interests, conservation initiatives may only succeed where the requirements of both the animals and humans are considered (Nepal & Weber, 1995; Cope *et al.,* 2003). Ensuring that local people benefit from conservation initiatives is vital to the success of these initiatives (Fiallo & Jacobson, 1995; Fortin & Gagnon, 1999; O'Connell-Rodwell *et al.,* 2000; Cope *et al.,* 2003). This was illustrated by the enthusiasm shown by both farmers and conservationists after a test in which geese where lured to designated meadows and scared from farm land. The 641 farmers owning these meadows where financially compensated by the Dutch government (Ebbinge *et al.*, 2003).

Options for goose management

Whilst the increase in goose population from very low levels is a success for conservation (Cope *et al.*, 2003; Ebbinge *et al.*, 2003, Voslamber *et al.*, 2007), increased goose grazing of summer staging geese on pasture and cropland in the Netherlands, causes a direct conflict with farmers who rely on these resources for stock grazing and harvest (Owen, 1990), during the spring and summer season (Ebbinge *et al.*, 2003).

In Nordrhein-Westfalen, Germany, the compensation paid per hectare for goose damage, is up to 4.5 times higher for crops then for pastures (Ernst, 1991). In normal winters, more than 85% of the geese feed on pastures (Mooij, 1991). In cold winters the number of geese feeding on crop can reach more than 20%, which increases the total sum of goose damage compensation (Ernst & Mooij, 1988; Mooij, 1984; Van der Jeugd *et al.*, 2006).
In the UK, reserve areas have been considered beneficial in reducing this human wildlife conflict by concentrating geese away from farm land (Owen, 1973; 1990) but geese still forage outside the reserves. With the growing population the buffer effect (Brown, 1969; Gill *et al.*, 2001) is reached more often. In the Netherlands reserves in lowland agricultural areas are mostly designed to protect meadow birds and shorebirds (Beintema, 1986). In many cases the mowing regime of these reserves is not beneficial to geese and they will forage outside of the reserves. An experimental design in which 641 farmers combined their lands as a goose refuge has let to enthusiastic reactions of both farmers and conservationists but with the ever growing goose population these reserves are already overflowing in their capacity (Ebbinge *et al.*, 2003). Outside the reserves the farmers are paid compensation fees (Ebbinge *et al.*, 2003; Voslamber & Turnhout, 2004).

In the Netherlands a goose agreement "G7" was signed in December 2012. In this agreement the state provinces combined with the agriculture and farming organisations and the larger nature organisations work together and give guidelines for the goose management. The aim of the agreement is to limit goose numbers and goose initiated damage up till a "acceptable" level like it was in 2005 (G7, 2012). Within the framework of this agreement the Dutch government can still reach their international guidelines concerning migratory birds. Only Summer staging geese will be limited and the farmers who suffer from crop damage will be compensated (G7, 2012).

Especially where breeding reserves are adjacent to farmland a potential risk for goose initiated damage exists. Especially if there are meadows adjacent to water, with short grass close to the breeding reserves the geese rearing goslings will lead there offspring there to forage. This is in the season when grass and crop growth is strongest and these non-breeding geese cause most of the damage, before during and after moult in the months March till mid-July (Voslamber & Turnhout, 2004). Reduction of goose numbers to reduce goose damage only makes sense, when there is a direct relation between goose numbers and the occurrence or the extent of goose damage (Mooij, 1991).

Management of existing goose populations can roughly be divided in four stages:

1) Interfering in adult goose survival by: shooting or gassing
2) Indirect by: scaring and disturbing
3) Interfering in reproduction by: removing, shaking or oiling the eggs
4) Biotope management

Shooting

Shooting is one of the oldest used methods to regulate numbers and to cull populations. The effect of shooting geese can be large and can keep numbers in a stable state (Ebbinge, 1991). One of the many reasons that we currently see an increased growth in goose populations is the decline in hunting pressure since the 1970's and 1980's (Ebbinge, 1991). Ebbinge (1991) discusses that although hunting pressure has been lowered the feeding conditions for the geese have improved due to modern agriculture. The improved feeding conditions are a stronger contributing factor to the observed population growth than the demise in hunting pressure (Ebbinge, 1991).

Shooting is a direct killing agent but the use of shotgun means that many geese are hit by pellets. 62% of adult geese and 28% of first winter juveniles have at least one pellet in their body tissue (Jönssen *et al.,* 1985; Ebbinge, 1991; Noer *et al.*, 2007).Though initially this may not be lethal in many cases, a considerable portion is crippled and may not survive the winter. Crippling loss is calculated to be between 25-33% of the total numbers bagged by the hunter (Henny, 1967; Chapman *et al.*, 1969; Ebbinge, 1991). Approximately 7% of the total goose population survives, after being shot, annually and continues to live with embedded pellets in their body tissue (Noer *et al.*, 2007). To this figure should be added an unknown but not insubstantial proportion of seriously wounded individuals that do not recover, probably bringing the total wounding rate closer to 1 per killed goose (Noer *et al.*, 2007). In Denmark an action plan for reduction of game wounding by shotgun, yielded a success of 50% wounded but not bagged animals. This reduction was reached by a reduction in shooting distance when geese where shot at <25m distance and lured in by decoys (Noer *et al.*, 2007). Kill rate decreased with shooting distance (Noer *et al.*, 2007). Above 40m of shooting distance the probability that a shot hitting the bird resulting in an instant kill decreased to near zero (Noer *et al.*, 2006).

Shooting influences spatial distribution, animals can perceive humans as potential predators and often alter their behaviour in the presence of people (Casas *et al.*, 2009). By acting more "despotic" (Fretwell and Lucas, 1970) humans can take over the role of predator and thereby cause a major influence on survival and spatial distribution, disrupting the ideal free distribution (Kacelnik, Krebs, & Bernstein, 1992). Geese learn to avoid areas with high hunting pressure (Ebbinge, 1991), are able to acquire new behavioural patterns during their lifetime, learn from previous experience and alter their behaviour in an adaptive fashion (Klaassen *et al.*, 2005). Juvenile geese which are mostly not acquainted with hunters are more likely to get shot (Calvert & Gauthier, 2005). Juveniles also have the disadvantage that they are less agile because they are still in the learning phase when it comes to flying (Calvert & Gauthier, 2005). This is one of the reasons why juveniles when they survive their first year are most likely to grow quite old. Shooting influences family bonds which may have severe effects on the subsequent breeding performances, decreasing inclusive fitness and direct surviving chances of members of such disrupted families (Ebbinge, 1991). Orphaned juveniles are a more likely prey to predators (Ebbinge, 1991) and in the case of spring shooting breeding will be disrupted by recent mate-loss (Black, 2001).

Although shooting is found to have a significant influence on mortality and distribution it still is found to be an unmanageable tool for population reduction. The total kill can double over a hunting season without any change in the hunted population (Ebbinge, 1991). This doubling of total shot numbers can be due to very soft winters followed by a extremely good breeding season (Ebbinge, 1991). During such conditions goose numbers in the Netherlands reach peak levels and total numbers shot will be equally high (Ebbinge, 1991), not decreasing the population nor diminishing it's growth. When a species is numerous hunters are harvesting proportionally fewer individuals (Sokos *et al.*, 2013) and by harvesting small portions the remaining fraction will produce more offspring in the next year (Voslamber & Turnhout, 2004).

Overall it is acknowledged that in the Netherlands only very strong hunting in both summer and winter seasons ,as happened in the 1960's, can really decrease goose numbers, but research about the effect of hunting breeding geese and reducing population numbers has never been studied thoroughly (Voslamber & Turnhout, 2004).

A method of decreasing the breeding population could be to shoot the breeding females. Doubts exist if this will work because of the large quantity of birds without a nest one can expect the vacant breeding spots to be re-colonized quite fast (Voslamber & Turnhout, 2004). If the culling of breeding birds is conducted nation wide and over many years this might have effect but risk of overhunting is present with this method (Voslamber & Turnhout, 2004)

Gassing

Gassing of geese is a method which is used in the Netherlands on private lands but mainly in a 20km radius around the Amsterdam (Schiphol) Airport. Around Schiphol the problem arises that large flocks of mainly greylag geese forage on the shortly mowed sides of the runway and pose a threat to airport traffic by colliding with the airplanes (Van der Meide & Pieterse 2013). Unfortunately Schiphol is situated in a highly intensified farming landscape which is dominated by meadows and canals, basically the ideal goose habitat.

When in moult and flightless adult geese and flightless juveniles are caught by driving them in corral nets which end in a shipping container. The shipping container is then filled with CO_2 gas and all the geese are gassed till they die. The dead geese are transported to the food bank and processed to feed the more needy citizens of the Netherlands. This method is highly under debate because in the past geese which did not belong to the populations migrating to and fro Schiphol have been caught and processed. Animal rights organisations claim that the CO_2 gas burns in the eyes and lungs of the geese and that the method is therefore cruel and out dated.
At present, no studies have been conducted which solely can deal with effectiveness of the gassing method, on population numbers and the effects it has on the fitness and reproduction of local populations due to the fact that most of the time multiple culling methods are carried out (Kleijn *et al.*,2012).
A single study done on the Dutch North-Sea island Texel has shown that population growth was highly reduced in the year after culling the moulting individuals and their flightless chicks and this was attributed to the highly effective culling efforts (Kleijn *et al.*,2012).

Animal rights groups advocate to change the land use of the lands around Schiphol to deter the geese of using this area, but as the lands are highly suitable to dairy farms this prospect might be not that easy to obtain.

Scaring and disturbing

Hunting disturbance is often not included in discussions about sustainable harvest management (Sokos *et al.*, 2013). Although never proved (Sokos *et al.*, 2013), disturbance is thought to most likely have an impact on bird populations during periods of food scarcity or when birds have difficulty meeting their energy and nutrient requirements (Madsen, 1995).

Spring hunting is a major source of disturbance when it comes to other birds (pre-) breeding in the hunted areas (Madsen, 1995; Madsen & Fox, 1995; Fox & Madsen, 1997). In fall, hunting might reduce nutrient storage and fat accumulation necessary for migration in non targeted species like migratory meadow birds (Casas *et al.*, 2009). Hunting does not decrease foraging time but more the flight probability and duration (Casas *et al.*, 2009).

Several studies have shown that geese avoid areas that are disturbed by human activities (Owen, 1973; Madsen, 1995; Gill, 1996; Gill *et al.*, 1996; Fox & Madsen, 1997) and have shown changes in behaviour and movements (Madsen & Fox, 1995). A species with suitable habitat nearby may avoid disturbance simply because it has alternative sites to use (Gill *et al.*, 2001 Sokos *et al.*, 2013). The method of scaring geese away from vulnerable crops by local shooting is of questionable value (Mooij, 1991).
Greater snow geese where not affected in their breeding success by hunting disturbance (Bety *et al.*, 2003). Scaring feeding geese away from endangered vegetation can only be efficient when they can fly into refuges that are large enough to feed the number geese without overgrazing the vegetation (Aguilera, Knight, & Cummings, 1991; Mooij, 1991) As disturbance excludes geese from otherwise suitable foraging habitat, disturbance events may be seen as a form of reversible habitat loss (Gill & Sutherland, 2000; Cope *et al.*, 2003).

Studies demonstrated that ducks returned to disturbed areas after disturbance ended (Parrish & Hunter, 1969; Dooley *et al.*, 2010).This was confirmed by observations in areas of botulism infection where shots were deliberately fired to drive ducks away to prevent infection. This proved, however, to be impossible as the ducks returned to the preferred area shortly afterwards (Parrish & Hunter, 1969; Dooley *et al.*, 2010). For example, wigeon (*Anas Penelope*) move readily in response to disturbance (Madsen, 1998), but may be able to do so because habitat in the area is abundant. This is important for management because, although it seems that species that move easily when disturbed are those that are in need of most protection, in fact, these may be the species for which the cost of moving is smallest, and hence they are not in need of protection (Gill *et al.*, 2001; Sokos *et al.*, 2013).

Some farmers scare geese with fireworks, scarecrows, reflectors, dogs, flags etc to prevent crop damage but these are short term solutions and the geese will return if no suitable habitat is available (Aguilera *et al.*, 1991). The best way to reduce the negative effects of goose feeding in an area is to create goose-feeding reserves that are large enough to feed the number geese without overgrazing used areas (Mooij, 1991; Voslamber & Turnhout, 2004). These feeding sites are the refuges for geese disturbed elsewhere, outside these reserves the geese can be scared away from crops (Mooij, 1991). If no reserves are established the geese will return to the disturbed field shortly after the disturbance ended (Mooij, 1991; Voslamber & Turnhout, 2004). A better measure might be to attract raptors by placing posts in the middle of fields for the raptor to perch on (Oort, 2009).

Sound

Sounds and bird distress calls can be used as scaring techniques to repel birds. Distress calls are long-range communication signals. Synthetic modified calls can be more effective than natural ones (Aubin, 1990). In these modified calls the relevant tones are filtered out of the natural distress call and increased, this super-normal effect of “caricatures”, which are simpler then natural calls, proved to be great in gulls and starlings (Aubin, 1990). Distress calls are rarely given in nature but when a record of a distress call is played to often, habituation can take place. It is better to vary between normal sounds and then all of a sudden a distress call to increase the likelihood that birds will respond to the distress call with fleeing (Aubin, 1990). It is important to note that habituation is a natural phenomenon. Habituation will always take place but this process can be slowed down by variation in sound patterns and playback time (Aubin, 1990).

Some farmers use big-bang canons which work on gas or a calcium carbide / water mixture, screamer shells which are fired by shotgun or fireworks to scare birds of their lands. All these non-biological sound appliances will work, but will only have a short duration in effectivity before habituation takes over and the geese will fly a small roundtrip after each bang and just forage next to the canon (Van Eerden 1990).

Removing, shaking and oiling of eggs

To retard or stabilize population growth some wildlife managers have resorted to removal of all but 2 eggs out of the nest (Voslamber & Turnhout, 2004). In some breeding colonies the eggs (all but 2) are thoroughly shaken, killing the developing embryo inside, and placed back in the nest while in others the eggs are treated with corn-oil. Corn-oil stops the embryo from growing by a lack of oxygen (Voslamber & Turnhout, 2004). All three mentioned methods are equally time consuming and would only have effect if all eggs in the colony where to be hatched (Voslamber & Turnhout, 2004).

By far, not all nests are found and the method is highly disturbing to other birds breeding in the reeds such as bitterns (Botaurus *stellaris*).

Reducing the eggs gives the goslings which do hatch better foraging opportunities and increased survival due to reduced competition. In normal natural situations, not all eggs will hatch and besides that a large portion of the chicks will die, or be predated, in their first days after hatch (Voslamber & Turnhout, 2004). In general; the more chicks the higher the mortality due to density dependant effects and food limitations. Of the thousand incubated eggs only a very small fraction will survive the end of the first week (Voslamber & Turnhout, 2004).
In “de Scheelhoek” a nature reserve on the Dutch Delta island “Goeree-Overflakkee” reducing greylag geese egg numbers did not reduce the goose population. The population even increased from 100 breeding pairs to 400 in 5 years (Voslamber & Turnhout, 2004).

Biotope management

We have seen that geese like short grazed grass (Van der Graaf *et al*. 2002). Therefore farmland of which the function changes to nature reserve should be fallowed and extensively grazed. This extensive grazing causes changes in the grass composition and other vegetation and a shift towards taller less protein rich grass. The taller grass is not preferred by the geese firstly because they are woody and lack palatability and second because walking in it is much harder (Van der Graaf *et al*. 2002).
Foxes and mustelids do prefer taller grass, it provides them coverage while hunting (Voslamber & Turnhout, 2004). As taller grass attracts predators gosling survival is equally decreased.
In some locations geese will keep the grass short to facilitate their own food supply (Ebbinge *et al.*, 2003), by having short grass adjacent to tall grass, the landscape will become more heterogenic. In a heterogenic landscape flora and fauna are more diverse because different niche's can be exploited in this way goose grazing can promote species richness in certain areas (Van der Jeugd *et al.*, 2006; Voslamber & Turnhout, 2004).

Although no research is conducted on biotope management for geese in the Netherlands, it is suggested that geese can be lured in to areas of less concern by mowing the grass in these areas very short close to the water's edge (Voslamber & Turnhout, 2004). These suitable areas keep the geese out of areas of concern (Ebbinge *et al.*, 2003; Voslamber & Turnhout, 2004). The effects of luring geese into good areas can have adverse effects by increased production of offspring, creating even more crop damage to the adjacent farmers (Voslamber & Turnhout, 2004).

Farmers can choose a different kind of crop which they can plant close to the most sensitive areas such as water edges. Especially grains and cereals are most sensitive (Voslamber & Turnhout, 2004). Farmers can put chicken fences along waters edges or raise the shore entirely to prevent gosling rearing families to come ashore, this prevents short term damage and less individuals will survive the gosling stage and reach maturity decreasing population growth (Voslamber & Turnhout, 2004). Fences negatively influences other biota, such as hares, mustelids, roe deer etc, in means that they can not access dry land and might drown. Fences should only be used as a last resort measure.

Present goose management

In the Delta area, goose survival is mostly related to hunting, adult goose survival decreased significantly since 2006 when the barnacle geese hunt was re-opened (Van der Jeugd, *in press*). Annual numbers of shot barnacle geese increased from 679 in 2006 to 5,852 in 2011 in the Delta area (data FBE Zuid-Holland; Van der Jeugd, *in press*). In the Dutch Delta 25-30% of the summer staging non migrating goose portion is shot during the summer hunt (Van der Jeugd, *in press*). Still the population seems to grow, the Delta population should be declining through increased hunting pressure and egg reduction but is marked by an increase in geese numbers in the summer counts. This high survival may be attributable to a combination of the absence of migration and a prolonged breeding season (Van der Jeugd *et al.*, 2009).

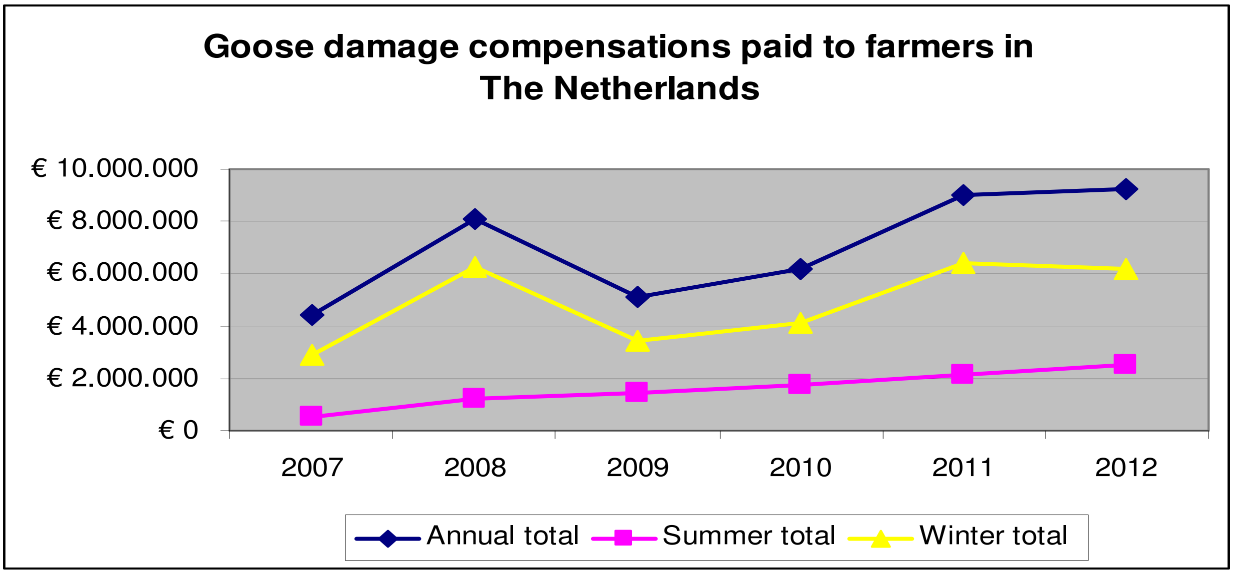
The total area where geese occur frequently is 1.200.000 ha, almost a quarter of the Netherlands (SOVON 1997). Of course it is unnecessary to claim all this land as goose area. With the current population approximately 50.000 ha would be sufficient to harbour geese and direct them away from areas of high concern (Ebbinge *et al.*, 2003).

Financial compensations are shared amongst farmers which experience damages caused by wildlife. These compensations are collected through tax and distributed through the "Faunafonds" (Faunafonds, 2012; Van Eerden, 1990). In 2012 the direct compensation for goose damage year round was 9.2 million euro for all goose species combined (Faunafonds, 2012) (See tab. 1). These are direct costs and do not include costs of farmers who have to buy different kind of food to feed their cattle, the compensation paid to farmers to function as goose reception area and other indirect expenses (Faunafonds, 2012). This figure includes the compensation paid for bean-, pink-footed-, brent-, and canada geese damage which is a combined total of approximately 0,5 million Euros. The Faunafonds makes no distinction between summer and winter damage of these species and their damage is relatively low.

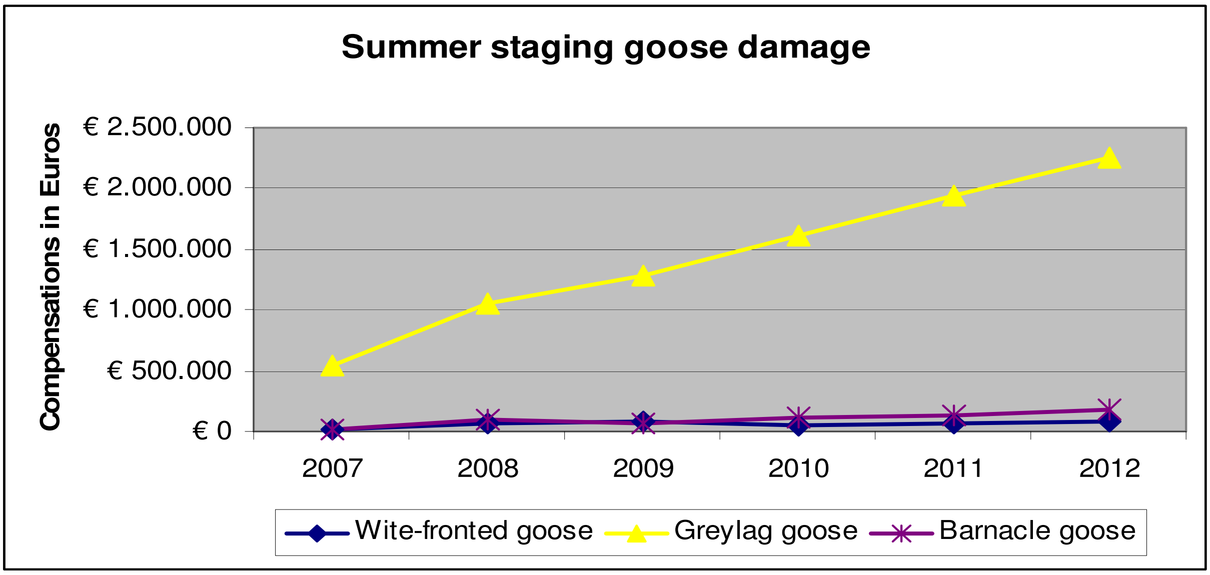
Summer damage done by greylag-, barnacle- and white-fronted geese was 2,5 million euro while in winter this was 6.2 million euro. In winter a great portion of the flyway population stages in the Netherlands. The Netherlands has the obligation to harbour these migratory populations to meet with European wildlife legislations. One has to note that in winter the resident flocks which stage year round are absorbed by the winter flocks so their individual damage cannot be calculated. The winter damage figures would be higher when one was able to distinguish between the migratory and non-migratory portion of each species. The first grass cut in spring is most valuable to farmers because it is richest in nutrients therefore goose grazing in spring is the most destructive period in the year to farmers (Ebbinge *et al.*, 2003). Geese are defined as summer-staging when they are still present after April the 1st, but most damage to meadows is done before this date. The winter geese combined by the resident summer-stagers cause damage to this first grass these high population numbers are the reason why winter damage is so much higher.
Annual compensations are increasing over the years (see graph. 1). Compensations to farmers are coupled to the cost of their product. This is illustrated by the year 2008 when due to warm weather (KNMI, 2008) and crop failure in other European countries the Dutch farming community yielded high profits and the farmers received more compensation (Faunafonds, 2009). The increase in 2012 compensation was caused by higher grass and grain prices (Faunafonds, 2012).

Goose	2007	2008	2009	2010	2011	2012
White-fronted **summer**	14.518	72.833	80.663	52.190	59.671	80.276
White-fronted **winter**	907.615	2.267.768	1.094.709	1.296.576	1.885.917	1.633.462
Greylag **summer**	536.124	1.055.586	1.279.060	1.614.118	1.947.459	2.247.664
Greylag **Winter**	1.344.536	2.246.282	1.594.771	1.917.884	2.937.937	3.068.951
Barnacle **summer**	19.886	106.893	65.537	111.068	127.598	185.395
Barnacle **winter**	658.140	1.707.528	768.345	870.525	1.573.538	1.506.266
Summer Total	**570.528**	**1.235.312**	**1.425.260**	**1.777.376**	**2.134.728**	**2.513.335**
Winter Total	**2.910.291**	**6.221.578**	**3.457.825**	**4.084.985**	**6.397.392**	**6.208.679**
Bean	29.619	88.345	57.651	70.341	105.156	62.968
Pink-footed	42.516	100.054	60.403	72.767	86.052	60.648
Brent	842.949	421.693	141.896	183.205	313.290	355.552
Canada	1.873	1.479	3.885	1.399	3.930	3.700
Annual Total	**4.397.776**	**8.068.461**	**5.146.920**	**6.190.073**	**9.040.548**	**9.204.882**

Table 1: Compensation paid by the Dutch "Faunafonds" for agricultural damage caused by geese in the period 2007-2012 (Faunafonds, 2012). Distinctions are made between summer staging (1st April -1st October) species (green) and winter (2nd October- 31st March). Damage done by the same species (blue). The annual total is composed of all species and is the total direct compensation paid to farmers.



Graph 1: Compensation paid to Dutch farmers for the damage inflicted to their crop by foraging geese in the period 2007-2012 (Faunafonds, 2012). Summer is 1st April – 1st October. Winter is 2nd October- 31st March.



Graph 2: Compensation paid to Dutch farmers for the damage inflicted to their crop by foraging of summer staging (1st April -1st October) geese in period 2007-2012 (Faunafonds, 2012).

Graph 1 shows a steady increase of summer staging geese in the total, which is set out per species in graph 2 (see graph 2). We can immediately see that greylag geese cause the bulk of the damage, because they forage on crop instead of grass, 87% of damage was made by greylag geese and the steep increase is caused by the fast population growth of summer staging greylags (Van der Jeugd *et al.*, 2006).

In the last years barnacle geese and white-fronted geese cause considerable less financial damage but their presence as a resident breeding bird is a novelty and, in summer, they are seen as a nuisance and invasive species. Still in absolute terms damage done to grassland is highest. In 75% of cases compensation for grassland is paid, as geese frequent these locations most often (Van der Jeugd *et al.*, 2006). Grassland is cheap to compensate and the relative damage is relatively low. The damage done to a small area of cropland (in 25% of cases) comprises the bulk of the financial compensation (Van der Jeugd *et al.*, 2006).

The Faunafonds acknowledges that they view the financial estimations and the control of summer staging geese as a problem and that the financial compensations in summer are much cruder and less accurate then in winter (Faunafonds, 2009). Farmers view summer staging geese as a larger problem to their business then wintering geese because the damage they create is demised by next season's spring growth (Faunafonds, 2009).

To resolve possible future conflicts caused by an increase in numbers and range of geese, an advanced planning approach should be taken to identify solutions before conflict becomes intense (Cope *et al.*, 2003; Ebbinge *et al.*, 2003). Support of farmers for harbouring wintering geese might be lost when compensations of summer staging geese are calculated inadequately (Faunafonds, 2009). The relative cost-effectiveness of extending payments to farmers against the establishment and running of new reserves must be considered alongside the aims for an integrated farming and wildlife conservation strategy (Cope *et al.*, 2003).

Discussion and conclusions

The most common management practices to regulate the goose population are culling and egg reduction, either by removing or shaking the eggs (Voslamber *et al.*, 2010). Culling is found to be far more effective than egg reduction (Voslamber *et al*., 2010; Rockwell *et al.*, 1997) because as stated above egg reduction will only create foraging space to juveniles and density dependant effects will become lower causing an increase in gosling survival. Culling the incubating portion of females at the nest has, by far, the greatest effects on deterring population growth due to the loss of inclusive fitness (Kleijn *et al.*, 2012).

We have seen that population control through egg reduction is not a viable option (Voslamber *et al.*, 2010). Hunting is found not very effective; juveniles do not breed in their first summer, and move around in the area more often than do their breeding counterparts (Tombre *et al.*, 1998). Juveniles are mostly not acquainted with hunters (Calvert & Gauthier, 2005), and also have the disadvantage that they are less agile because they are still in the learning phase when it comes to flying (Calvert & Gauthier, 2005). Therefore juveniles are more likely to be harvested by hunters which shoot at flying geese. This is amplified by the fact that the breeding colonies are mostly protected and hunting dos not take place there as much as in the surrounding fields. As summer staging geese are used to local conditions, which they experience year round, they learn from previous negative experiences (Holm & Madsen, 2013). The staging geese alter their behaviour in an adaptive fashion (Klaassen *et al.*, 2005). Therefore it is most likely that when hunting outside the breeding colonies the non-resident migrating geese are more likely to be shot because they are unaware of the local situation (Kleijn *et al.*, 2012). Shooting outside the breeding colonies will not decrease the local breeding population which are the individuals causing the bulk of the damage. We can conclude that hunting outside the breeding seasons and breeding locations is non-effective and only causes disturbance (Kleijn *et al.*, 2012). Only by culling geese inside the breeding locations during moult, the summer staging population can be deterred in its growth (Kleijn *et al.*, 2012). By catching in the breeding locations one can be sure that the local geese are caught and not transient migratory geese from surrounding areas, targeting the farm damage problem more accurately.
Prudent hunting with shooting distances <25m might have a substantial gain in bagging more and wounding less geese (Noer *et al.*, 2007).

Most financially costly are greylag geese foraging on cropland. The main problem is that greylags, unlike barnacle geese, do not breed in dense colonies but more spaced out. Catching and culling greylags will require increased effort and thorough mapping of breeding locations. When to many breeding adults or goslings are missed during the catching effort, next years population production will be increased through absence of density dependant factors (Kleijn *et al.*, 2012). The successful re-colonisation of the greylag goose is beneficial to nature conservation because by their grazing they promote open water and deter marsh plant succession (Van der Jeugd *et al.*, 2006). But an excessive number of greylags could deplete natural ponds of halophytes and cause eutrophication (Van der Jeugd *et al.*, 2006).

The reader must bear in mind that all techniques to reduce population densities mentioned in this article are unilateral solutions and are non effective or unsustainable in the way that they

requisite constant efforts of managers (Voslamber *et al.*, 2007). Stopping management efforts is equal to an almost straight return to the initial situation (Van der Jeugd *et al.*, 2006).
By adapting management and planning of new nature around geese populations the population growth can possible be managed. The role of natural predators in goose management should be acknowledged more and is at present underappreciated (Van der Jeugd *et al.*, 2006). The control of foxes could be slightly reduced, so that fox numbers will increase. Foxes prey on geese and cause havoc in the colonies (Tombre *et al.*, 1998). In areas where foxes appear geese will only breed in locations inaccessible to foxes (Voslamber & Turnhout, 2004). Reduction of fox hunting could potentially conduct geese, away from cropland, to locations in which they can do less harm, such as wetlands, reserves and islands.
The expected growth of 90.000 pairs of greylag geese can potentially be demised to 60,000 pairs when predation by foxes is increased (Van der Jeugd *et al.*, 2006).

Opportunities to future research

The discrepancy of higher goose mortality due to hunting and the increase in population size illustrates the importance of continuation of the ongoing research, in which monitoring of population size, hunting statistics and ring resighting data are analyzed.

More research needs to be conducted on the culling of summer staging geese and how this culling affects total population growth. The CO_2 gassing should also be examined, weather it causes pain / discomfort during the gassing process. When it causes harm, it could potentially be replaced by another gassing agent.

In locations where meadow birds are less sensitive a pilot can be conducted with a decrease in fox eradication pressure. These foxes might scare the geese onto islands and other wetlands which are inaccessible to foxes and away from farmland.

The barnacle goose population in the whole flyway experienced a potential genetic bottleneck due to the severe hunting pressure in the beginning of the 20^{th} century. After hunting diminished, the world population of barnacle geese grew exponentially but the breeding success decreased (Ebbinge, 1991). The major factor for the growth in population size is the lowering of the mortality rate (Ebbinge, 1991).
The Dutch barnacle goose population was founded by only a couple of individuals which had escaped or where released from a captive population. This small founding population had input from wild geese but still a genetic founder effect could be expected, which functions as another genetic bottleneck (Hartl & Clark, 2007). Due to the small number of founders most geese can genetically be related to each other. When populations carry a smaller set of genes they loose resilience against diseases. In weakened populations diseases can affect large percentages of the population. Diseases like avian influenza could make the transfer to humans as happened in Asia with poultry, therefore a large weakened goose population could pose a health risk to humans.

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