Bewick's swans in a changing world

Species responses and the need for dynamic nature conservation

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Chapter 1

Introduction

Nature and wildlife are increasingly under pressure all over the globe. Humans always had a pervasive impact on ecosystems and biodiversity (Svenning et al., 2016) and this accelerated in the industrial era, when humans altered their environment drastically to fulfil their growing needs (Steffen et al., 2007). This resulted in, a.o., overfishing in the oceans, deforestation in tropical forests, degradation of soils worldwide (Delgado-Baquerizo et al., 2020; Montibeller et al., 2020; Rice and Garcia, 2011) and huge increases in CO_2 emissions (Boden et al., 2017) causing global warming at an unprecedented rate (IPCC, 2014). Our impact has caused the Earth and its climate to change. We currently experience different weather patterns and more extreme events, such as cyclones and extensive forest fires (Coumou and Rahmstorf, 2012; Elsner et al., 2008; Krawchuk et al., 2009). There is a growing awareness that the changes will eventually be beyond repair and affect our current way of living drastically (Ripple et al., 2017). In addition, the human impact on the planet has caused biodiversity to decline rapidly, to the extent that it has the potential to threaten our own existence just as much as other drivers of global change, through loss of ecological function (Cardinale et al., 2012).

The beauty and value of nature has since long been recognized and appreciated. Not for nothing nature, and nature's spirit, was an important subject of (pre-)historic human societies, and still is in many indigenous peoples' beliefs and traditions. Their beliefs and traditions translated into common practices that guided interactions with, and use of natural resources. For example by ritualized hunting traditions, and assigning sacred places, safeguarded by community lore in the form of story-telling and myths. As human societies grew larger and their needs grew simultaneously, the impact on ecological systems became bigger. A 'tragedy of the commons' scenario arose where "*freedom of the commons brings ruin to all*" (Hardin, 1968). In the past several societies have collapsed as a result of overexploitation of natural resources and resulting ecological disaster, in part due to the tragedy of the commons (Diamond, 2005). A large difference today is that our current human society is a global one, which makes the risks of a collapse due to environmental reasons a communal threat to all people on this planet.

But it is not just us on this planet, we share the Earth with millions of species that have evolved over many years to be fit for their way of living. With the current speed of change occurring in their environments, many of these species face challenges in adapting to the new circumstances (IUCN, 2020). In addition, our current 'traditions' of using natural resources are far from sustainable and the pressure on fish stocks, (tropical) forests (land conversion for agriculture) and valued animal parts (through [illegal] wildlife trade) is demanding.

One may argue that all organisms have the right to exist for intrinsic reasons (Batavia and Nelson, 2017), in addition, for arguments outlined above, we need to embrace biological diversity as a part of our way of living, and protect and respect it for our own existence as we know it as well. As Hardin (1968) wrote: "*.. it is clear that we will greatly increase human misery if we do not, during the immediate future, assume that the world [and its resources] available to the terrestrial human population is finite*".

Our view on nature and how to protect it has evolved over the past decades (Meine, 2013; Redford et al., 2013). In the early years of modern conservation (1960s) a 'nature for itself' viewpoint was the center of protection measures (Mace, 2014). Many national parks were created in this period as a recognition of the value of nature. This 'fencing' approach has later gained critique (but see (Hutton et al., 2005) mainly concerning the dispersal and the freedom of movement of species, especially nomadic or migratory species (Harris et al., 2009), and their evolutionary potential (Hayward and Kerley, 2009). As people became more aware of the threats individual species were facing due to human activities (such as hunting and degradation of habitat) the viewpoint of ‘nature despite people’ prevailed in the 1970s-80s (Mace, 2014), leading to the formation of minimum viable population sizes as the basis for wildlife management practices (Soule, 1987). Despite all efforts, biodiversity dwindled and species continued to go extinct (Pimm et al., 1995). In the 1990s a more utilitarian view on nature gained support (Balmford et al., 2002), and ‘nature for people’ was materialized in the ecosystem services approach (Chan et al., 2006; Fisher et al., 2009; Mace, 2014; Wallace, 2007). The extensive Millennium Ecosystem Assessment report was centered around these services and their contribution to human well-being (Millennium Ecosystem Assessment, 2005, 2003). Despite the growing awareness of the importance of biodiversity, the overall trends of species and the quality of ecosystems continued to deteriorate (Butchart et al., 2010). In the Strategic Plan for Biodiversity 2011-2020 a ‘people and nature’ perspective was more prevalent, putting co-existence and sustainability central (CBD, 2020a; Mace, 2014) .

Shaped through all these phases of the nature conservation movement, the importance of preserving and restoring biological diversity has been laid down in various treaties. A global example is the Convention of Biological Diversity (CBD, 2020b). With early working group meetings and drafts starting already in 1988, the CBD was adopted in 1992 and entered into force by the end of 1993 with 168 parties that agreed “[..] *to conserve and sustainably use biological diversity for the benefit of present and future generations*” (CBD, 1992). Fostered by the CBD and follow-up work programs, protocols and meetings, all parties are obliged to create national biodiversity strategies and action plans and adopt these as policy instruments. As a result the importance of conserving biodiversity and even the intrinsic value of nature has been incorporated in various legal frameworks. Currently, Europe is the continent with the most extensive nature legislation today, see de Klemm and Shine (1993) for other continents. Currently, the Birds Directive (European Commission, 2009, 1979) and Habitats Directive (European Commission, 1992) form the key components of EU nature legislation. Under these directives, the aim is to obtain or keep a ‘favourable conservation status’ (FCS) for all habitats and species of community concern (Habitats Directive article 1e and 1i, respectively; Evans and Arvela, 2011). The definition of FCS is a point of discussion but is stated to be “*[..] more than avoiding extinctions*” (Evans and Arvela, 2011). To protect the species and habitats listed in the Annexes of these Directives, EU member states designate protected areas, together forming the Natura 2000 network of protected areas (European Commission, 2020).

Protecting fixed areas such as the Natura 2000 sites has been criticized in the light of climate and land-use change and resulting distribution shifts in both time and space by species (Hannah, 2008; Hannah et al., 2005; Peters and Darling, 1985). Although the Natura 2000 sites in Europa are created to form a network, which is thought to be quite effective in preserving species that have overlapping ranges in current and future climatic circumstances (Araújo et al., 2004), the individual sites are assigned based on the current presence of biodiversity values (species and/or habitats). Also, the connectivity of the Natura 2000 network varies greatly (Opermanis et al., 2012) and is not undisputed (Verschuuren, 2015). Whether or not the network is sufficient for conserving a species under global climate change scenarios depends largely on the dispersal abilities of the species and the intervening land uses and concurrent threats (Alagador et al., 2012; Mazaris et al., 2013). In addition, if a species’ range extends outside the area covered by the network, conservation cannot be guaranteed. The question is whether and how effective protection of habitats and species, including their resilience and adaptive values, can be safeguarded under the current environmental legislative structures that are in place.

In this thesis I aim to reflect on that by studying the case of the western population of Bewick's swan (*Cygnus columbianus bewickii*). This large bodied, migratory bird that winters in northwestern Europe and breeds at the tundra in Arctic Russia, migrates approximately 3000 km twice a year to track optimal circumstances for the different phases of its annual cycle. Monitoring efforts of this population started when the late sir Peter Scott, founder of the World Wildlife Fund (later the Worldwide Fund for Nature, WWF) and the first Wildfowl and Wetland Centre at Slimbridge, started painting Bewick's swans from his window in 1964 and recognized they each had a unique, individual bill pattern (Scott, 1978). This observation has led to an > 50 year monitoring programme still going on today (Aldred, 2014; Rees and Bowler, 1996). Based on individual recognition programmes (using bill patterns, legrings, neckbands and most recently also GPS-tracking devices as unique identifiers) a wealth of information has been gathered on, a.o., the return rates (Evans, 1982), family life (Evans, 1979; Rees, 2006), survival and breeding success of individuals (Wood et al., 2018; Wood et al., 2016). Resightings and recoveries of marked swans have revealed the migratory movements between wintering and breeding grounds (Evans, 1982) (Evans, 1982; Rees, 1991) and later the full migration route including stopover sites (Beekman et al., 2002; Rees, 2006). Observations in the wintering area revealed site and habitat usages (Beekman et al., 1991; Dirksen et al., 1991; Dirksen and Beekman, 1989; Nolet et al., 2014; Nolet and Gyimesi, 2013) , interference and interspecific competition (Gyimesi et al., 2011, 2010) and food intake rates and giving up densities (Gyimesi et al., 2012; Nolet et al., 2001; Nolet et al., 2002; Nolet and Klaassen, 2009; van Gils et al., 2007; van Gils and Tijsen, 2007). Information from the breeding area and stopover sites during migration is more sparse, but expeditions to Arctic Russia were very informative and mapped the breeding distribution and densities (Mineyev, 1991), gathered important data on breeding biology (Rees et al., 1997), and recorded daily time budgets in the breeding season (Krivtsov and Mineyev, 1991). Visits were paid to some stopover sites as well, mainly the White Sea and Estonia. The White Sea was found to be an important stopover area in spring (Nolet et al., 2001; Nolet and Drent, 1998), but not so much in autumn (Beekman et al., 2002). In Estonia large flocks used the Baltic Sea coastal area to rest and refuel (Luigujõe et al., 1996; Nolet et al., 2007; Rees and Bowler, 1991).

In addition to individual recognition programmes, observations and expeditions, international monitoring was set up in the form of counts in 1973 with follow-ups in 1976, 1979, 1984, 1987 and 1999. From 1995 onwards, the Wetlands International / IUCN SSC Swan Specialist Group organized an International Swan Census (Bewick's swans and Whooper swans) every 5 years in January (Beekman et al., 2019). The results of this long-term effort show that the population has undergone substantial changes in numbers over the past decades, first rising to ~30,000 individuals in the mid-1990s and then declining to approximately 18,000 in the 2010s (Fig. 1.1). The decline has led to several measures being taken. In 2015 the Bewick's swan was included on the European Red List for Birds with the status 'Endangered' (Birdlife International, 2015) In addition, the Bewick swan was made a target species of the European Natura 2000 framework under the Birds Directive Annex I. This means that a favourable conservation status (FCS) must be pursued by parties. As the species was declining and this FCS became threatened, an international species action plan was developed under the auspices of AEWA (Agreement on the Conservation of African-Eurasian Migratory Waterbirds; (Nagy et al., 2012).

On the basis of the hypotheses about the decline stated in the action plan, several research projects (of which the current thesis is a part) were initiated to identify the causes of the decline.

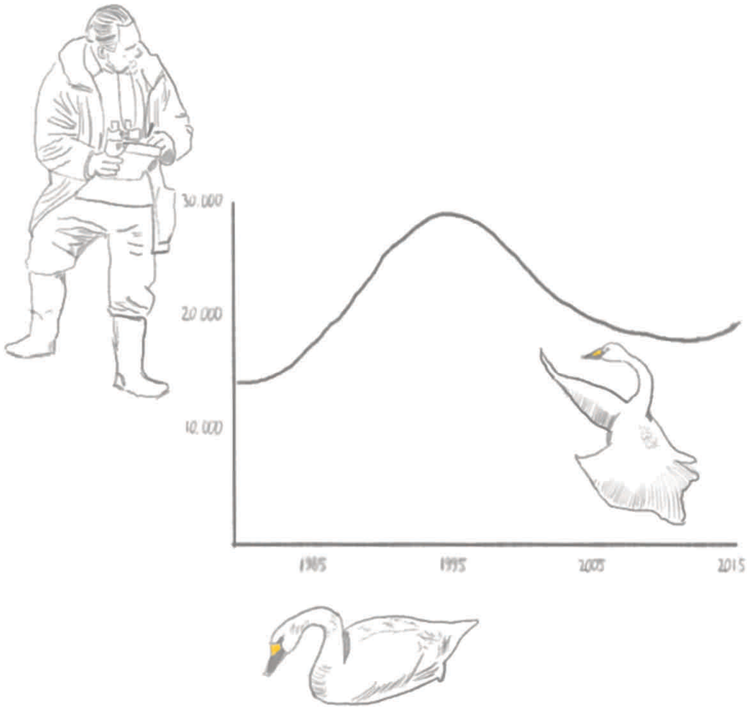

Figure 1.1: *Population trend of the Bewick's swan in the past 50 years. In the background a drawing of a statue by Nicola Godden of sir Peter Scott observing 'his' Bewick's swans. The statue is sited at the entrance of the London Wildfowl and Wetlands site in Barnes, London.*

Part I of this thesis follows up on earlier studies that utilized the long-term resighting data to investigate potential changes in survival and breeding success of individual Bewick's swans over time (Wood et al., 2018; Wood et al., 2016), as a demographic cause of the decline. As these efforts did not yield conclusive results, **Chapter 2** describes an effort to integrate multiple long-term datasets (counts, assessments of reproductive success in winter, and resightings) to capture and explain the variation in demographic rates and how they contributed to the variation in the population growth rate that we have seen over the past decades.

In part II, **Chapters 3 and 4** describe the technical process of classifying and exploring a different way of storing accelerometer (ACC) data that were gathered by the GPS tracking part of this thesis. For the classification, described in chapter three, captive Bewick's swans were observed to match their behaviours with the accelerometer signal. In chapter four a different way of storing ACC data, in the form of summary statistics (SS) was explored, as a more efficient way to collect this type of data. **Chapter 5** is an example of how remotely collected behavioural data can provide information to inform management and conservation practices.

Part III of this thesis focuses on changes in the distribution and phenology of the Bewick's swan, both on the population and the individual level. In **Box 1** GPS tracking data between 2007 and 2019 is used to map individual migration trajectories and compare these among and within individuals to discuss repeatability and driving factors. In **Chapter 6**, we focus particularly on the wintering ground and look at "short-stopping" and "short-staying", two processes that represent the shortening of migration distance to the breeding grounds (an northeast-ward shift in the case of the Bewick's swan) and the shortening of the time spent in the traditional wintering grounds of the population, respectively. Both processes are assessed on the population and the individual level. In **Chapter 7**, we zoom in on the winter area, and study whether this can be regarded as a (well-connected) network of nodes and links, and whether the important sites for the Bewick's swan population have changed over time.

In **Chapter 8** a reflection on all results is given, embedded in an overall discussion on the conservation of species with dynamic properties by protecting existing values of habitats and species under the current Directives and Natura 2000 framework.