Conservation status of the world's swan populations, *Cygnus* sp. and *Coscoroba* sp.: a review of current trends and gaps in knowledge

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Abstract

Recent estimates of the world's swan *Cygnus* sp. populations indicate that there are currently between 1.5–1.6 million birds in 8 species, including the Coscoroba Swan

Coscoroba coscoroba as an honorary swan. Monitoring programmes in Europe and North America indicate that most populations increased following the introduction of national and international legislation to protect the species during the early- to mid-20th century. A switch from feeding primarily on aquatic vegetation to foraging on farmland (especially high-energy arable crops) in winter during the second half of the 20th century, is also considered a contributing factor. Trumpeter Swans *Cygnus buccinator* famously increased from just 69 individuals known to exist in 1935 (although small numbers were missed) to *c.* 76,000 at the present time, and most of the northern hemisphere swan populations have continued to show increasing/stable trends over the last 20 years. The exception to this pattern is a decline since 1995 in the Northwest European Bewick's Swan population, following an increase in its population size during the 1970s–1980s, which is now being addressed through implementation of an International Single Species Action Plan. A proposal to change enforcement regulations of the Migratory Bird Treaty Act in the United States is also of concern, as potentially undermining protection for Trumpeter Swans in North America, illustrating the importance of politics and legislation as well as on-the-ground measures for species conservation. Elsewhere, less is known about the trends and conservation status for swans in central and eastern Asia, though count and research programmes introduced in China, added to those underway in Japan and Korea, have recently greatly enhanced our knowledge of swan populations on the East Asian flyway. Trends for the Black Swan *Cygnus atratus* in Australia and for the Black-necked Swan *Cygnus melancoryphus* in South America are also poorly known, because of the large numbers involved for the former and a lack of coordinated counts across difficult terrain for the latter. These southern hemisphere species are considered vulnerable to water resource developments (*i.e.* where diversion of water is shrinking wetlands), and to droughts associated with El Nino events and climate change. More extensive monitoring is therefore required to determine whether swan populations and species are stable, fluctuating or in decline.

Key words: conservation effort, population sizes, swans, trends.

Swans have long been revered by man for their grace and beauty, whilst also long being exploited for food, feathers and sport. Until the development and increased accessibility of firearms during the 19th century, the risk of over-harvesting was relatively low, because the potential for mass exploitation was limited to local moulting concentrations, when the birds are flightless for *c.* 4 weeks during the summer (Matthews 1972). With the development of nature conservation during the 20th century, long-term monitoring of most of the world's swan species has been undertaken as part of waterbird count programmes, to provide information on population trends, assess their conservation status, and to inform the management of the birds and their habitats.

Information gained from national monitoring programmes to determine

waterbird numbers, trends in numbers and the location of key sites has been collated by Wetlands International for the Waterbird Population Estimates (WPE) programme, which serves to identify total numbers and trends for biogeographical populations globally (Wetlands International 2019a). These total population estimates are used to identify sites of international importance (defined as those holding ≥ 1% of the population; Scott 1980), which are priorities for protection under global conventions (*i.e.* the Ramsar Convention on Wetlands and the Convention on Migratory Species), and are also a focus for international conservation partnerships (*e.g.* the East-Asian Australasian Flyway partnership). The data also serve regional conservation legislation such as the European Union's Birds Directive and the African-Eurasian Waterbirds Agreement (AEWA), whose most recent Conservation Status Report No. 7 (CSR 7) has updated population status and trends for all of the populations migrating within the AEWA region. They also inform classification of the conservation status of species on the International Union for Conservation of Nature (IUCN) Red List, with all swan species currently classified as of "Least Concern" (IUCN 2016) at the global (rather than the population) level.

Trends in numbers and population sizes for some swan populations are reported at regular intervals; for instance, the surveys undertaken of Trumpeter Swans *Cygnus buccinator* and Tundra Swans (also known as Whistling Swans) *Cygnus c. columbianus* by the U.S. Fish and Wildlife Service in North America (most recently, at the time of writing, in Groves 2017; Olsen 2018; Roberts & Paddington 2018; U.S. Fish & Wildlife Service 2019). A review of current knowledge contributing to assessment of the conservation status of the world's swan populations is warranted, however, in order to identify gaps in knowledge where more data are needed, and thus identify not only populations of conservation concern but those for which the population size and trends are not known and the conservation status therefore is unclear.

Here we therefore describe the most recent published information on population sizes and trends for swan species globally, augmenting information provided in Wetland International's WPE (Wetlands International 2019a) with reports and expert opinion from members of the IUCN-SSC/Wetlands International Swan Specialist Group and other researchers. The overall aims are: to review current swan population trends; to identify areas where further work is required (*e.g.* through conservation action or filling gaps in knowledge); to outline potential threats to swan populations; and thus assess where there may be cause for concern and conservation action.

General approach

Given that Wetlands International collates information on waterbird population trends globally, we commenced by inspecting the most current population size records for the Cygnini tribe, either using Waterbird Population Estimates No. 5 (WPE 5) or, for the AEWA region, the Conservation Status Report No. 7 (CSR 7), both of which can be accessed via the online database (http://wpe.wetlands.org/). The Cygnini encompasses not only the *Cygnus* sp. but also the *Coscoroba* genera with its one species –

the Coscoroba Swan *Coscoroba coscoroba*. The Coscoroba Swan's taxonomic status continues to be a matter of debate – with molecular analysis not supporting a close relationship between *Coscoroba* and the other swans (review in Callaghan *et al.* 2005) – but as it is consistently reported in conjunction with other swan species (*e.g.* Scott & the Wildfowl Trust 1972) it is included here for completeness. Population trend assessments developed for the CSR 7 on migratory waterbirds within AEWA (Wetlands International 2019b, c) are also considered in the species accounts. These were derived mainly on analysis of the mid-January International Waterbird Census (IWC) – systematic surveys of waterbirds at specific wetland sites – undertaken since 1967 by national count programmes across Europe and more widely (Delany *et al.* 1999).

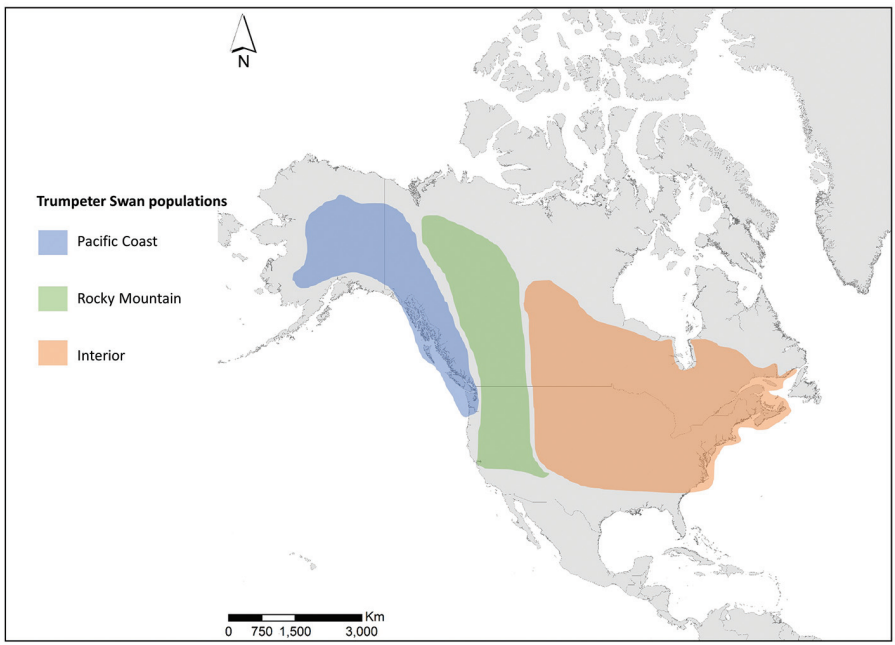
Of the five swan species and subspecies in the northern hemisphere, the Tundra Swan and Trumpeter Swan of North America, and the Bewick's Swan *C. c. bewickii* (conspecific with the Tundra Swan) and Whooper Swan *C. cygnus* in Eurasia, all migrate over long-distances between their breeding and wintering areas (Kear 2005), whereas the Mute Swan *C. olor* is relatively sedentary in its native Eurasia and also in North America where it has expanded after being introduced from the 19th century onwards (*e.g.* Snow & Perrins 1998; Petrie & Francis 2003; Gayet *et al.* in press). Here we consider the migratory swan populations by region (*i.e.* North America *vs.* Eurasia), in order to consider threats and conservation measures in relation to the common environmental conditions encountered on their trans-continental flyways. The three swan species of the southern hemisphere – *i.e.* the Black-necked Swan *Cygnus melancoryphus* and the Coscoroba Swan of South America and the Black Swan *Cygnus atratus* of Australia – are likewise considered in relation to conditions occurring in these regions. These three species are all nomadic and move opportunistically; for instance, Black Swans and also Black-necked Swans disperse to ephemeral wetlands to breed when these become available (Kingsford *et al.* 1999, 2010; Vilina *et al.* 2002). The conservation status of the various Mute Swan populations globally are described in relation to whether they are native or non-native species in the countries concerned.

North America

Trumpeter Swans

Historically, Trumpeter Swans bred across a wide area of North America, and the species was also widespread in its wintering range (Rogers & Hammer 1998; Engelhardt *et al.* 2000). Hunting caused numbers to drop to near-extinction in the early 20th century – it was thought that only 69 remained in 1935 (although it is considered that a couple of thousand birds surviving in remote parts of Canada and Alaska were not counted) – and use of established migration routes waned (Gale *et al.* 1987; Mitchell & Eichholz 2010). Three main populations persist (Fig 1a): the Pacific Coast population (PCP) which breeds in Alaska, the Rocky Mountain population (RMP) which breeds in the Rocky Mountains from Yukon and Northwest Territories south to the northern United States, and the Interior population (IP) which includes restored flocks in South Dakota, Minnesota,

(a)



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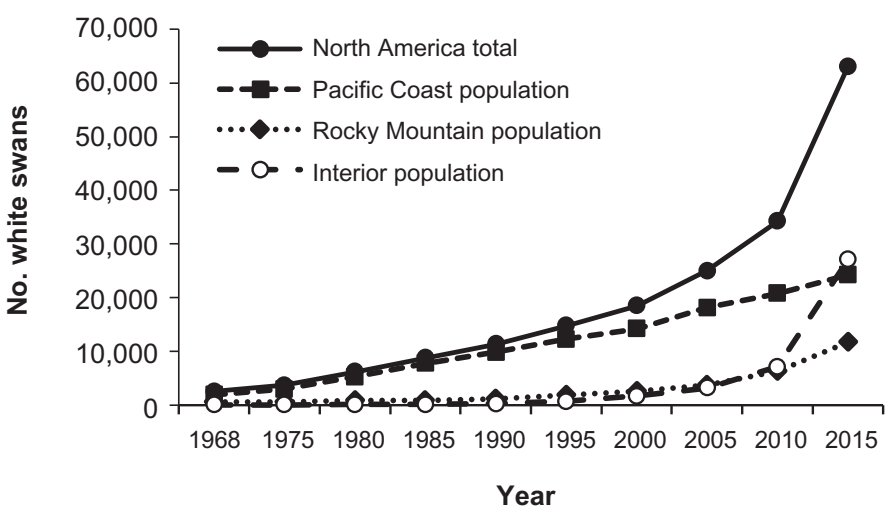


Figure 1. Trumpeter Swans: (a) distribution and (b) population trends, both from Groves (2017). Note: the swans' distribution is very patchy within the broad range depicted. For detailed distribution see Groves (2017).

Wisconsin Michigan and Ontario (Mitchell & Eichholz 2010). The RMP and particularly the IP are augmented by species reintroduction programmes undertaken over several decades. Legal protection from persecution (since the 1917 Migratory Bird Convention Act in Canada and the 1918 Migratory Bird Treaty in the USA) and more recent conservation measures (*e.g.* reintroduction programmes and creation of reserves which protect habitats used by the swans) have resulted in numbers recovering during the second half of the 20th century. Nonetheless, their distribution remains patchy and restricted in comparison with former times.

Systematic monitoring of the species – the North American Trumpeter Swan Surveys (NATSS) – commenced in 1968, with the survey repeated in 1975 and conducted at 5-year intervals thereafter. In 1968–2010, the NATSS estimated Trumpeter Swan abundance, productivity and distribution in the northern United States and Canada, through counts made between January–September but primarily in April–September (Groves 2017). Monitoring productivity (number of cygnets) became optional in 2015 to make the surveys more cost effective; trends in numbers therefore are now described in terms of "white" swan (adult and yearling) abundance. Aerial surveys of the swans' breeding grounds, also undertaken in each year of the 5-year surveys, expanded as swans were known or suspected to have moved into adjacent habitat. Totals recorded in the breeding range up to the year 2000 therefore represented a comprehensive population census (of all adults and cygnets) prior to autumn migration (Conant *et al.* 2002); more recently some summer surveys have adopted a stratified sampling approach because of the increase in area and numbers involved (Hawkings *et al.* 2002). Counts made in autumn and spring (less frequently in mid-winter), which involved a combination of aerial and ground surveys, were designed by coordinators of the PCP, RMP and IP censuses and are thus reported on a population basis (Groves 2017).

Total population sizes recorded on the breeding grounds increased from 2,847 birds in 1968 to 7,696 in 1980, 13,337 in 1990 and 17,155 in 2000 (Conant *et al.* 2002). These were broadly similar to estimates made in the wintering range, where numbers increased from 2,572 white Trumpeter Swans in 1968 to 11,344 in 1990, and 18,486 in 2000, then rose more rapidly to 25,006 in 2005 and 34,249 in 2010 (Moser 2006; Mitchell & Eichholz 2010; Groves 2017; Fig. 1b). That the winter counts exceeded numbers recorded on the breeding grounds in 2000 appears to be attributable to a marked increase in the number of non-migratory IP swans not included in the arctic surveys (Fig. 1b), which in turn may be at least partly due to reintroduction programmes undertaken in the swans' historic IP range (in the mid-western USA and Ontario, Canada) since the early 1980s (Shea *et al.* 2002; Handrigan *et al.* 2016).

The most recent pan-continental survey, in 2015, found that total numbers have now reached > 63,000 white birds (Table 1). Moreover, if cygnet numbers are included for the PCP and the RMP (where cygnets are still counted), a total of 31,793 for all swans in the PCP, 17,164 in the RMP and 27,005 (white birds only) in the IP

Table 1. Number of swans estimated for each species globally, derived from the Waterbird Population Estimates (WPE; Wetlands International 2019a), and additional current estimates for each swan species. * = not including *c.* 50,000 Black Swans (with numbers declining) in New Zealand in 2011 (Williams 2013), and a total of *c.* 13,000 Mute Swans globally in countries where they are considered to be non-native species: North America, Japan, Australia and New Zealand. IUCN status: LC = "Least Concern" (IUCN 2016).

Species (no. of populations)		IUCN Red List status	Current estimate	Year of current estimate	Source
Black-necked Swan	(2)	LC	25,000–100,000	1990–2000	Wetlands International 2019a; BirdLife 2019a
Black Swan	(1)*	LC	165,000–180,000	2008	Kingsford *et al.* 2011; this paper
Mute Swan	(7)*	LC	> 650,000	2015	Wetlands International 2019a,b,c; this paper
Trumpeter Swan	(3)	LC	76,000	2015	Groves 2017; this paper
Whooper Swan	(5)	LC	249,000	2011	Laubek *et al.* in press; Hall *et al.* 2016; Jia *et al.* 2016; Wetlands International 2019a,b,c
Tundra Swan	(2)	LC	187,000	2017	Pacific Flyway Council 2001; Olson 2017; Roberts & Padding 2017
Bewick's Swan	(3)	LC	120,000	2015	Beekman *et al.* 2019; Wetlands International 2019a,b,c; this paper
Coscoroba Swan	(1)	LC	10,000–25,000	2006	Wetlands International 2019a; BirdLife 2019b
TOTAL*	**(24)**		1.5–1.6 million		

counted in 2015 indicate that total numbers of Trumpeter Swans (including cygnets) now exceed 76,000 (Groves 2017). Population trends are increasing for all three populations, but particularly for the IP between 2010 and 2015 (Fig. 1b).

Tundra Swans

Tundra Swans – the more numerous of the North American swan species – breed at high latitudes in arctic Canada and Alaska, with small numbers also breeding in Chukotka in the Russian Arctic (Limpert & Ernst 1994). Chukotka-breeding Tundra Swans were estimated at 600–1,000 birds in the early 21st century (Syroechkovski 2002), and the proportion of these that migrate to wintering sites in North America has yet to be determined, though only small numbers are recorded wintering in Japan each year (mean ± s.d. = 35 ± 36 birds/year between 2000–2017, range = 7–160; Ministry of the Environment 2018; T. Shimada, pers. comm.). Counts, ringing and tracking data have described two populations within North America: the Eastern Population (EP) and the Western Population (WP), which migrate to winter along the Atlantic and Pacific seaboards of the United States respectively (Limpert & Ernst 1994; Ely *et al.* 2014; Fig. 2a).

Tundra Swans in both the EP and WP are monitored annually by the Mid-winter Waterfowl Surveys on the Atlantic Flyway and the Pacific Flyway of North America. These aerial surveys, which are a cooperative effort between state and federal wildlife agencies undertaken since 1955, and with the same areas surveyed each year, aim to obtain a complete count of waterfowl in key wintering areas during a 1–2 week period in early January (U.S. Fish and Wildlife Service 1989, 2019; Serie *et al.* 2002). The data are considered to provide a reasonable index of population size and long-term trends, with productivity indices also determined from ground counts and aerial photographs of the proportion of grey-plumaged young recorded in flocks at sample sites (Serie *et al.* 2002). For many years Tundra Swans were protected from hunting in North America, but in 1982 the US Fish & Wildlife Service (USFWS) permitted the legal hunting of the WP and in 1984, despite strong opposition, this was expanded to the EP with "experimental" hunting allowed in North Carolina (Sladen 1991). Analysis of the annual Mid-winter Waterfowl Survey data, together with harvest survey data, therefore is also key to the USFWS setting of annual bag limits, which ensure that the population meets conservation objectives for the species.

The number of WP swans recorded during the Mid-winter Waterfowl Surveys on the Pacific Flyway averaged at *c.* 55,300 birds during the second half of the 20th century (1949–2000), and increased by 50% in the 1970s and 1980s (Pacific Flyway Council 2001). The population reached an all-time high of 122,521 swans in 1997 and nearly as many in 1999, with the most recent estimate of 71,400 recorded in 2017 (Pacific Flyway Council 2001; Olson 2017; Fig. 2b). Historically, EP swans have been more numerous than WP swans, and began to increase significantly in the mid-1970s, growing by 55% between the mid-1950s and the late 1990s and peaking at *c.* 110,000 in 1992 until more recently 115,400 were recorded in 2017 (Pacific Flyway Council 2001; Roberts & Padding 2017; Fig. 2b).

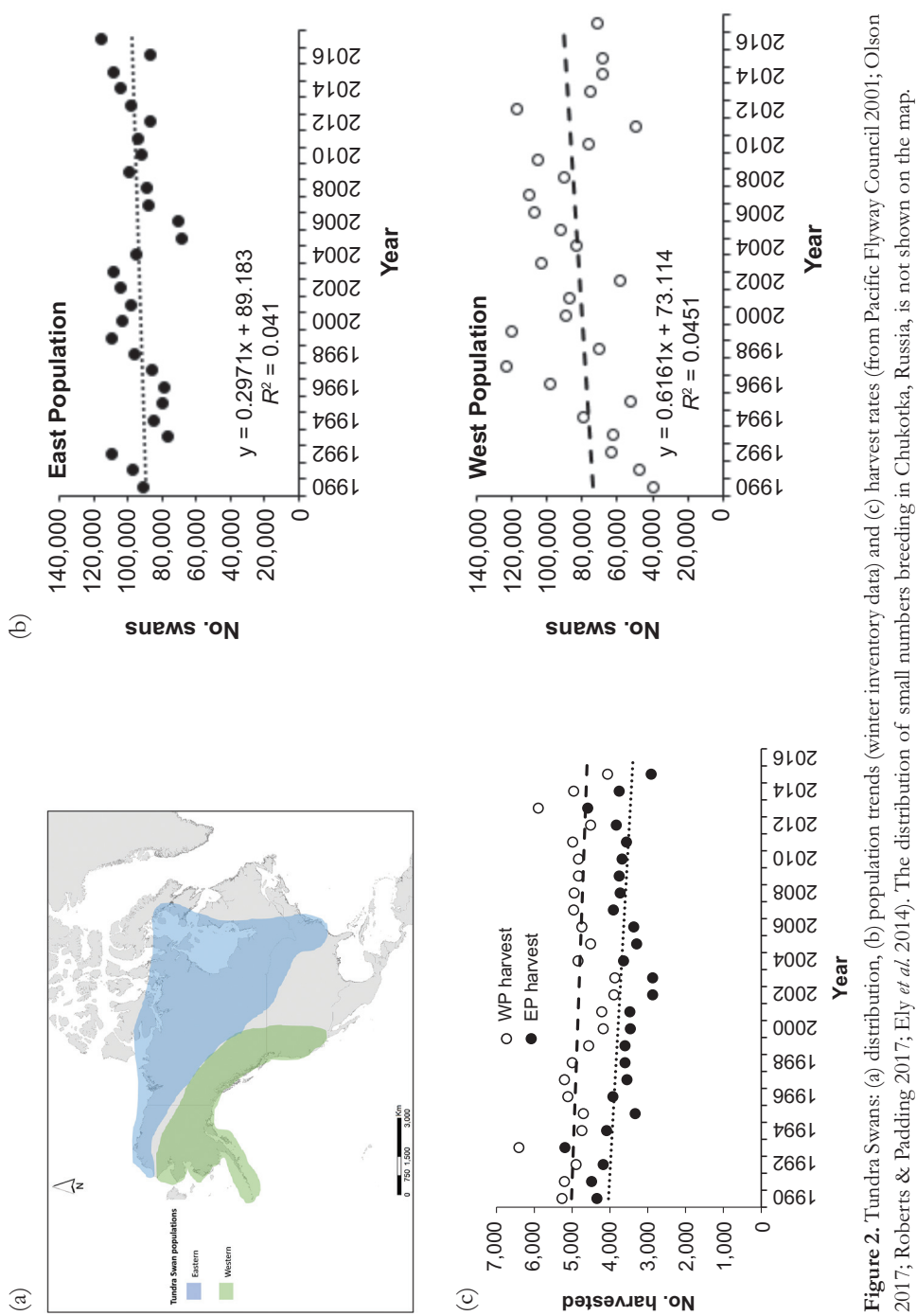


Figure 2. Tundra Swans: (a) distribution, (b) population trends (winter inventory data) and (c) harvest rates (from Pacific Flyway Council 2001; Olson 2017; Roberts & Padding 2017; Ely *et al.* 2014). The distribution of small numbers breeding in Chukotka, Russia, is not shown on the map.

Overall, the combined number of EP and WP swans increased at an average annual rate of about 2.1% during the period 1955–1989 (Serie & Bartonek 1991a) and maximum counts of > 210,000 Tundra Swans in North America were recorded in 1999 (228,818 birds) and 2003 (210,923 birds; Fig 2b). Numbers have since declined a little, with the most recent combined total being of 186,825 swans counted in 2017. The EP averaged at *c.* 70,800 ± 3,300 and the WP at 102,500 ± 10,800 in the 5 years from 2013 to 2017 with, despite marked annual fluctuations, both populations seeming relatively stable in the long term (from 1990 onwards; Fig. 2b).

The number of Tundra Swans harvested each year is also monitored, and regulated under provisions of the Migratory Bird Treaty Act of 1918 (Serie & Bartonek 1991b). Mean numbers taken each year over the 1990–2017 period are of 4,825 (WP) and 3,730 (EP) (Fig. 2c), with monitoring indicating that this is not causing either population to go into decline (Fig. 2b).

Threats and conservation issues

Monitoring of migratory swans in North America is undertaken with the aim of meeting conservation and management objectives set by the Pacific, Central and Mississippi Flyway Councils for both species. For the Trumpeter Swans, these are to maintain ≥ 25,000 total swans (white birds and cygnets) in the PCP and to have *"at least 2,000 birds and 180 successful breeding pairs by 2001"* in the IP; objectives now met for both populations. For the RMP, whilst overall abundance objectives have also been achieved, regional objectives relating to abundance, distribution and the number of breeding pairs have been met in some areas but not others (Groves 2017). Overall, the recovery in Trumpeter Swan numbers from the 69 birds recorded during the early 20th century is considered a major conservation success story, and the species continues to be in good conservation status with numbers increasing for all three populations. There are also currently no plans for an open hunting season for Trumpeter Swans, although a very limited take is permitted to allow for accidental hunting of Trumpeter Swans in Tundra Swan hunts, estimated at *c.* 2.1% of the Tundra Swan harvest (Drewien *et al.* 1999). There is concern, however, over plans to amend guidelines for interpreting the Migratory Bird Treaty Act (MBTA) of 1918, and its strict prohibition on the unregulated killing of birds, which has been one of the guiding documents for avian protection in North America since the early 20th century. Specifically, a legal memorandum by the U.S, Department of the Interior has changed a long-held interpretation on what constitutes "incidental take", and the change has profound implications for many migratory birds, including swans, in North America (Mitchell 2018). How closely Tundra Swan bags are currently inspected for Trumpeter Swans is unclear, and the source of Trumpeter Swans harvested in Tundra Swan hunts is also not known. Thus, although population growth rates indicate that incidental harvest is unlikely to cause a decline, there is concern that incidental harvest of Trumpeter Swans in some places (*e.g.* Utah) might remove "pioneering" swans dispersing into a region and consequently slow range expansion. Incidental take could also include mortality from environmental contamination

(*e.g.* from mining, use agricultural chemicals, *etc.*), which is now prevalent in the Tundra and Trumpeter Swans' migratory ranges (*e.g.* Blus *et al.* 1999; Parsons *et al.* 2010).

Following increases in North America during the mid-20th century, Tundra Swan numbers are now limited by hunting, and desired population levels and distributions have been described in management plans. Harvest objectives for both EP and WP hunt plans are to harvest the optimum allowable number of swans each year whilst maintaining populations at satisfactory levels to meet goals of the various management plans. A 10% harvest rate of the three-year average winter population index was established as an initial guide until more definitive data became available, and if the three-year average winter population index for EP and WP Swans fell below 60,000 and 40,000, respectively, season closures were to be considered (Serie & Bartonek 1991b). The 10% harvest rate was reduced to 5% in 1996 to stimulate population growth (Serie *et al.* 2002), and numbers are consistently above the population target levels.

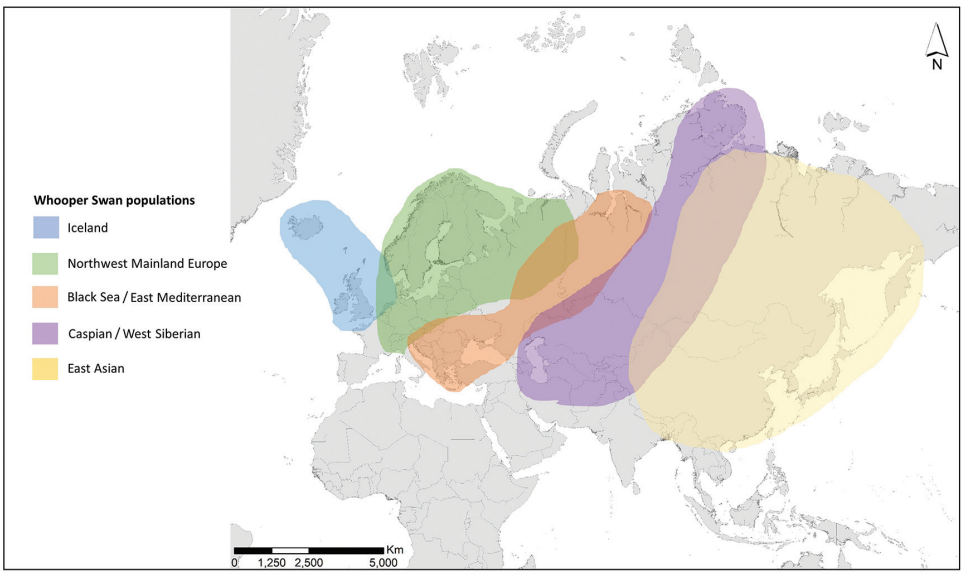
Eurasia (migratory swans)

Whooper Swan

The Whooper Swan breeds across the boreal zone of Eurasia, from Iceland to Kamchatcka, and five main populations have been described: the Icelandic, Northwest Mainland Europe, Black Sea/East Mediterranean, Caspian/West Siberian and East Asian populations, with some overlap in distribution considered likely to occur in the wintering ranges (Rees 2005; Wetlands International 2019a; Fig. 3a). The extent of population interchange is not known. Ringing of Whooper Swans since the early 1980s, and more recent satellite-tracking of individual birds, have shown that although the vast majority of the Icelandic population winters in Britain and Ireland a few individuals migrate to continental Europe (*e.g.* Garðarsson 1991; Newth *et al.* 2007; Griffin *et al.* 2011). Conversely some from the Northwest Mainland European population (marked in Finland) have migrated to southeast England, but their numbers are thought to be low (Laubek 1998; Hall *et al.* 2016).

Coordinated international censuses of migratory swans, undertaken at 5-year intervals across Europe, have estimated the total population size and trends in numbers for the Icelandic population since 1986 and the Northwest Mainland European population since 1995 (Hall *et al.* 2016; Laubek *et al.* 2019). Both populations have more than doubled in numbers since the censuses commenced, and estimates of *c.* 34,000 for the Icelandic population and *c.* 138,500 for the Northwest Mainland European population in 2015 are the highest recorded to date (Hall *et al.* 2016; Laubek *et al.* 2019; Fig. 3b). Much less is known regarding the other three Whooper Swan populations, but trends analysis and population estimates for the Black Sea/East Mediterranean population, undertaken by Wetlands International in 2015, updated the previous estimate of 12,000 swans dating back to 1983 to *c.* 14,000 individuals based on IWC totals of 3,000–7,000 individuals counted in the region between 2011–2015 (Rüger *et al.* 1986; Wetlands International 2019b,c). Trends statistics indicated a strong increase in numbers in the long-term (1989–

(a)



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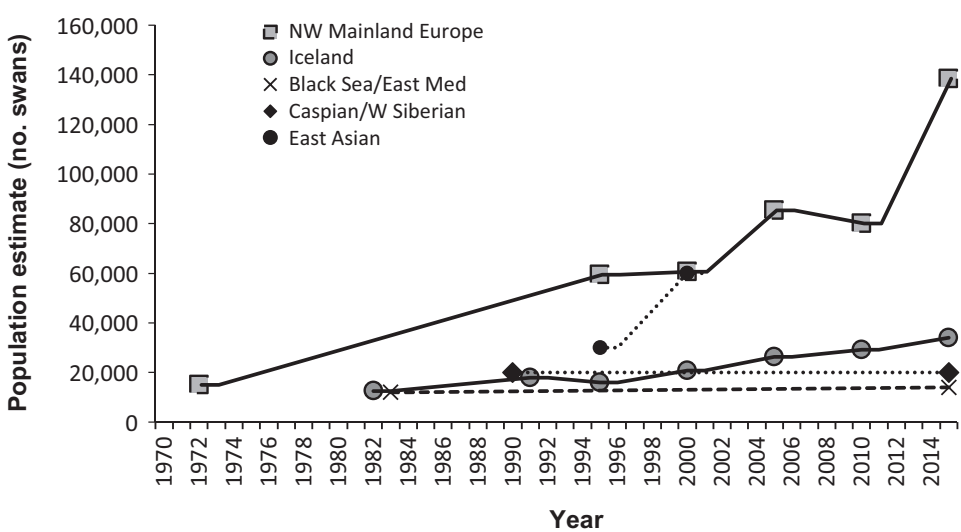


Figure 3. Whooper Swans: (a) distribution and (b) population estimates (from Miyabayashi & Mundkur 1999; BirdLife/Wetlands International 2018; Laubek *et al.* 2019; Wetlands International 2019a).

2015) but more recent trends (2006–2015) are uncertain, with large year-to-year fluctuations and gaps in coverage recorded (Wetlands International 2019c). Numbers in the Caspian/West Siberian population were estimated at *c.* 20,000 in 1996 (Scott & Rose 1996; Wetlands International 2019a), and analysis of IWC count totals which varied markedly from 100–17,000 individuals between 2011–2015 (with low counts probably reflecting a lack of coverage in some years) retained the population estimate of 20,000 birds (Wetlands International 2019c). Main wintering grounds for the species in the northern part of the Caspian Sea were not monitored, however, and weather conditions cause shifts in distribution between years, which may potentially also result in movement to the Black Sea/East Mediterranean wintering areas. Both the short-term (10-year) and longer-term (25-year) trends therefore were classed as "uncertain".

The population estimate of 60,000 birds adopted by Wetlands International for the East Asian Whooper Swan population, which dates back to 1999 (Miyabayashi & Mundkur 1999), was a marked increase on the 30,000 in 1995 reported by Rose & Scott (1997), but the change was more likely attributable to improved monitoring of Whooper Swans in the region rather than a doubling in numbers over a 5-year period. More recently, a study summing Whooper Swan counts from South Korea, Japan and China (*i.e.* covering most of the wintering range for the population, except perhaps for swans wintering in the D.P.R. of Korea) suggested that the population size was lower, with 49,700 swans counted in 2006 and 41,800 in 2011 (Jia *et al.* 2016). Trends analyses have not been undertaken for the East Asian Whooper Swan population as a whole, but mid-January counts made of Whooper Swans in Japan from 1970 onwards indicate that numbers wintering in the country increased from 11,095 recorded during the first census to an average of 31,000 during 1995–1999 (Albertsen & Kanazawa 2002). More recently, national totals have been stable at an average of 31,262 (s.d. ± 4,092) swans counted annually from 2000–2017 inclusive (Ministry of the Environment 2018); maximum numbers recorded in Japan to date are of 38,660 birds in 2006, with the most recent count (made in 2017) a little below that at 29,741 birds (Ministry of the Environment 2018; T. Shimada, pers. comm.). Given that Japan appears to receive a high proportion of the East Asia Whooper Swans in mid-winter, it seems that the trends for East Asian Whooper Swans are currently stable, but in the absence of regular internationally coordinated counts to monitor numbers and shifts in distribution between wintering areas in Russia (Kamchatka Peninsula), China, Japan, D.P.R. Korea (North) and the Republic of Korea (South) (Miyabayashi & Mundkur 1999), this remains speculative.

The combined number of Whooper Swans globally therefore is currently estimated at 266,543 birds, with the majority (56%) in the Northwest Mainland European population (Table 1; Fig 3). Several of the flyway population totals are based on analyses of IWC data however, which are thought to underestimate numbers for at least the Northwest Mainland Whooper Swan population (Laubek *et al.* 2019), and this might be the case for other populations

(or even species) also, so further count data are required to confirm numbers and overall trends for Whooper Swans globally.

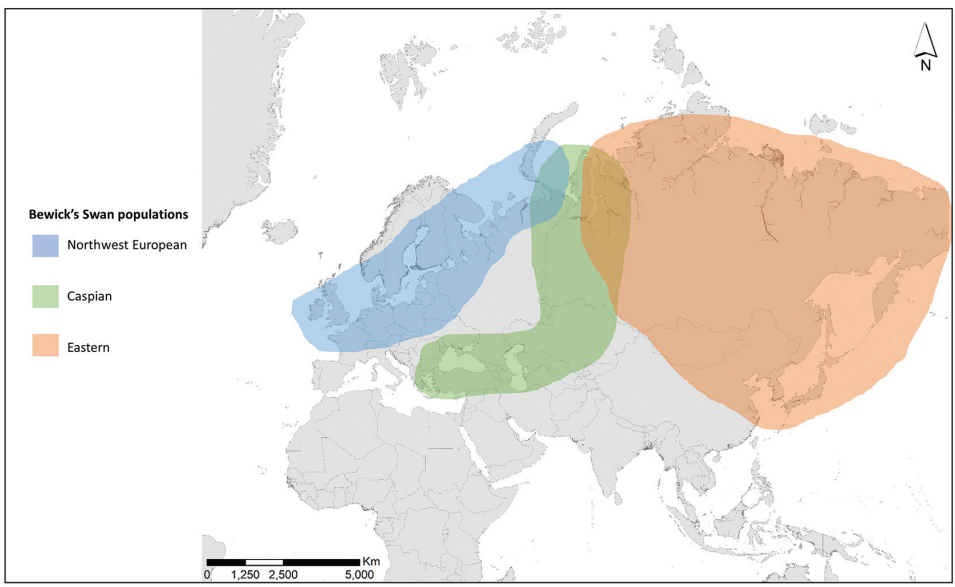
Bewick's Swan

Bewick's Swans breed at high latitudes across the Russian arctic tundra from Cheshskaya Bay in the Nenets Autonomous Okrug (NAO) in the west to Chaun Bay, Chukotka, in the east, and extending north to Kolguev Island, Vaygach Island, Novaya Zemlya and the Lyakhovskiy Islands of the New-Siberian Archipelago (Rees 2006). Three main populations have been described: the Northwest European population breeds in European Russia (west of the Urals) and winters in northwest Europe, the Caspian population winters primarily around the Caspian Sea, and the Eastern population migrates to China, Japan and Korea (Fig 4a). Recent tracking studies suggest that Bewick's Swans breeding in Chukotka and wintering in Japan actually may be sufficiently discrete to be considered a separate subpopulation or a fourth population (*e.g.* Wang *et al.* 2018). As for the Whooper Swans in Europe, trends in the numbers and distribution of the Northwest European Bewick's Swan population have been monitored through the IWCs since the mid-20th century (Nagy *et al.* 2012), verified by coordinated 5-yearly mid-winter censuses of the species from January 1984 onwards (Beekman *et al.* 2019). Following an increase in the Northwest European population during the 1980s to mid-1990s, there was a 39% decline in numbers between 1995–2010, which led to an International Single Species Action Plan being adopted by AEWA (Nagy *et al.* 2012; Fig 4b). The 2015 coordinated census suggested a slight recovery to 20,100 birds in 2015, but the next census (scheduled for January 2020) should determine whether the decline is reversed or ongoing (Beekman *et al.* 2019, with Wetlands International trends analyses for the most recent 10-year period (2006–2015) showing the population to be in steep decline (Wetlands International 2019c).

The Caspian population is receiving increasing attention, particularly regarding its contribution to numbers wintering on the Evros/Meriç Delta in Greece/Turkey, where peak counts rose from ≤ 10 in the early 2000s to *c.* 8,400 by 2016 (Vangeluwe *et al.* 2018). Population size was estimated at 500–1,000 in the late 20th century so, although Syroechkovski (2002) considered this to be an underestimate because of the difficulty in separating Bewick's from Whooper Swans *Cygnus cygnus* overwintering in the northern part of the Caspian Sea, if swans in Greece/Turkey emanate mainly from the Caspian area, most had previously been missed and/or there has been a significant increase in population size (Rees & Rozenfeld accepted, *European Breeding Bird Atlas 2nd edition*). Even on omitting Greece, there is good evidence from Wetlands International's analyses of the IWCs for a strong increase in the Caspian population since the start of the 21st century (particularly since 2010), with *c.* 800–3,000 individuals counted annually in the region between 2011–2015 inclusive (Wetlands International 2019c).

For many years relatively little was known regarding the status of Bewick's Swans in the Eastern population, primarily because a lack of data from China, and numbers were put at around 40,000 birds during the late

(a)



(b)

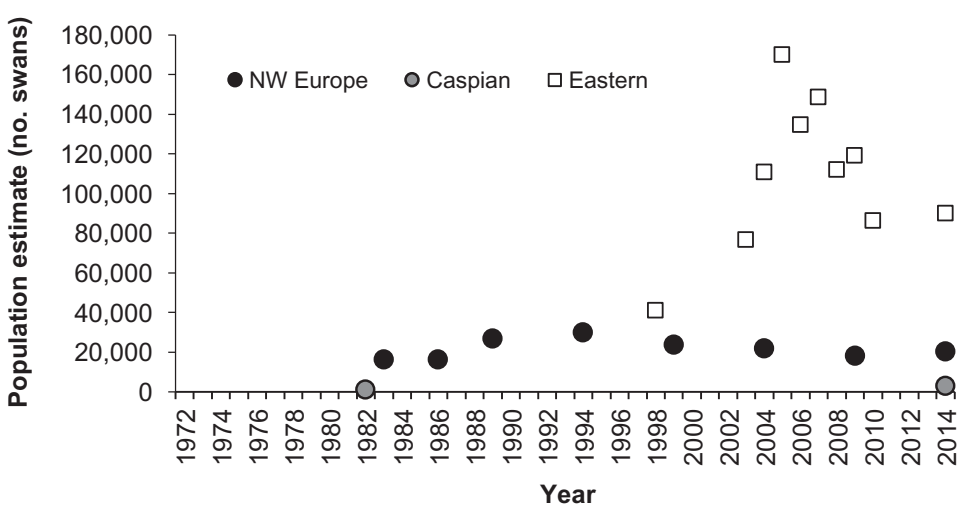


Figure 4. Bewick's Swans: (a) distribution (from Rees & Beekman 2010) and (b) population estimates (from Jia *et al.* 2016; Beekman *et al.* 2019; Wetlands International 2019a; L. Cao, pers. comm.).

20th century. These included an estimated 10,000 in China, 20 in D.P.R. Korea and 26,000 in Japan, with numbers in the Republic of Korea having declined from a high of 1,300 in 1992 to 156 in January 1999 (Miyabayashi & Mundkur 1999). Surveys of the Yangtze River floodplain initiated in 2004–2005, and still ongoing, found substantial numbers in China (Barter *et al.* 2006; Cong *et al.* 2011; Jia *et al.* 2016), however, resulting in a major upward revision in population size estimates for the Eastern Bewick's Swan population. Annual waterbird censuses made in Japan found that numbers of Bewick's Swans wintering in the country increased steadily during the second half of the 20th century, from just 542 birds counted in 1970 to 31,198 in 1996 (Albertsen & Kanazawa 2002), after which the growth rate slowed, but a maximum count of 45,283 was recorded in 2004. Although numbers in Japan declined thereafter, with 35,596 recorded in 2017, they seem to be relatively stable at 37,116 (s.d. ± 5,833) between 2000–2017 (Ministry of the Environment 2018). Because the timing of national censuses are not coordinated across the wintering range, fluctuations in numbers counted in China which may reflect a shift in winter distribution. Also, given the threats to swans at Chinese wintering sites (*e.g.* illegal harvesting and habitat loss; Ma & Cai 2002), it is still not possible to be certain about the stability of the Eastern population. Nonetheless, summing uncoordinated counts made in the key wintering areas of China and Japan over the past two decades indicates that numbers reached 169,800 in 2006, and 148,300 in 2008, but more recently have been estimated at *c.* 90,000 in 2017 (35,596 in Japan; *c.* 55,000 in China; Ministry for the Environment 2018; Cao Lei, pers. comm.; Fig. 4b), with the trend put as "fluctuating" (Table 2).

Overall, Bewick's Swan numbers are estimated at around 120,000 globally, with the proportion of swans wintering in Greece that follow the Northwest European versus the Caspian flyways yet to be determined. Recent tracking of swans fitted with GPS loggers on the Yamal Peninsula have also described previously unknown migration routes to central Asia (Vangeluwe *et al.* 2018), and further surveys are required to determine the numbers wintering at these sites.

Threats and conservation issues

Whooper Swans and Bewick's Swans have very similar distributions across Eurasia and, although Whooper Swans generally breed at lower latitudes and few Bewick's Swans winter in Poland, eastern Denmark and Sweden, mixed species flocks frequently occur in major parts of the wintering range. The question of whether increasing numbers of the larger and generally more dominant Whooper Swans are having a detrimental effect on Bewick's Swan populations therefore is being considered, particularly given that they utilise similar food resources during winter. There was no evidence for food resources limiting use of an internationally important wintering site for both species in Britain, however, and there was also no evidence for Bewick's Swan body condition varying in line with trends in population size over the decades (*e.g.* Wood *et al.* 2018, 2019a,b).

Both species are legally protected from hunting across most of their range. Although protection levels for Whooper Swans are lower than for Bewick's Swans in parts of

Russia (Newth *et al.* 2019), there is not an open season analogous to that for Tundra Swans in North America. There is illegal hunting of both species, however (Newth *et al.* 2011), and this likely occurs in different populations, albeit to a greater extent for some than for others depending on variation in hunting intensity along different migration routes. For instance, x-raying of live-caught swans wintering in Britain found that the proportion of birds with embedded shotgun pellets was consistently higher for Bewick's Swans (34.1% in the 1970s, 38.8% in the 1980s, 27.1% in the 1990s and 22.7% in the early 2000s respectively) than for Whooper Swans (14.9% with pellets in the 1980s; 13.2% in the 2000s; Newth *et al.* 2011). The apparent decline in the proportion of Bewick's Swans being shot at a time when the population was in decline suggests that hunting *per se* was not the only reason for the decline in the Northwest European population from the mid-1990s. However, given the high proportion of Bewick's Swans sampled found to have been shot at, a reduction in illegal hunting should help towards recovery of the population, not least because during the 2010s the proportion of swans with embedded pellets has returned to higher levels typical of the 1970s–1980s (WWT unpubl. data; J. Newth pers. comm.).

Whilst Whooper Swan numbers are increasing in northwest Europe, the status of three of its populations – the Black Sea/East Mediterranean, Caspian/West Siberian, and East Asian populations – remain poorly known, largely because of difficulties in making comprehensive surveys in areas without the benefit of ornithological count networks. Moreover, Bewick's Swan populations currently seem to be in a state of flux, with population declines in some areas and increasing numbers in others, and the extent to which the different demographic variables (survival/productivity/emigration/immigration) are responsible, and whether the changes are attributable to climate and other environmental factors trends, has yet to be determined. Changes in demography and migration routes do however seem likely to vary in relation to the differing conditions encountered by the swans across Eurasia.

Mute Swan

The Mute Swan is native to Europe and Asia, where it ranges from Ireland in the west to China in the east, and has the most southerly breeding range of all Eurasian swans (Rowell & Spray 2004; Fig. 5). Non-native populations have also become established, through introduction programmes or accidental releases, particularly in North America, Japan, Australia and New Zealand, with smaller numbers occurring in Mauritius, South Africa and the United Arab Emirates (Gayet *et al.* in press). Even in central and western Europe, breeding and release of Mute Swans in several countries from the 16th century onwards means that it is not always possible to distinguish between wild and introduced stocks (Gayet *et al.* in press), so we do not attempt to separate them further here.

Seven Mute Swan populations have been described for Eurasia, in: Ireland, Britain, Northwest Mainland & Central Europe, Black Sea, West & Central Asia/Caspian, Central Asia and East Asia (Wetlands International 2019a). Population delineation is not well established, though ring re-

Table 2. Current population estimates and trends for swan species globally. INC = increasing; DEC = decreasing; STA = stable; UNC = Uncertain; ? = general trend indicated, but this uncertain. [a] Numbers of Bewick's Swans in the Caspian population may be underestimated if the majority of the *c.* 8,400 birds counted in February 2016 (Litvin & Vangeluwe 2016) are from this population.

Species	Population	Current estimate	Year of estimate	25-year trend	10-year trend	Source
Trumpeter Swan	Pacific Coast	31,793	2015	INC	INC	Groves 2017
	Rocky Mountain	17,164	2015	INC	INC	Groves 2017
	Interior	> 27,005	2015	INC	INC	Groves 2017
Tundra Swan	Western	71,400	2017	INC	STA	Olsen 2017
	Eastern	115,425	2017	INC	STA	Roberts & Padding 2017
Whooper Swan	Icelandic	34,004	2015	INC	INC	Hall *et al.* 2016
	NW Mainland Europe	138,448	2015	INC	INC	Laubek *et al.* 2019
	Black Sea/East Med	14,000	2015	INC	INC?	Wetlands International 2019b,c
	Caspian/W Siberian	20,000	2015	UNC	STA/FLU	Wetlands International 2019b,c
	East Asian	42,000	2011	UNC	STA?	Jia *et al.* 2016
Bewick's Swan	NW European	20,148	2015	DEC	DEC	Beekman *et al.* 2019
	Caspian[a]	3,000	2015	INC	INC	Wetlands International 2019b,c
	Eastern	90,000	2017	FLU	FLU	Jia *et al.* 2016; this paper

Table 2 (*continued*).

Species	Population	Current estimate	Year of estimate	25-year trend	10-year trend	Source
Mute Swan	Ireland	9,130	2016	DEC	STA	Burke *et al.* 2018
	Britain	50,000	2019	INC	STA	Frost *et al.* 2019; Wood *et al.* 2019c
	NW Mainland & Central Europe	250,000	2019	INC	INC/STA	This paper
	Black Sea	49,000–72,000	2015	STA?	STA?	Wetlands International 2019b,c
	West & Central Asia/Caspian	250,000	2015	INC?	INC?	Wetlands International 2019b,c
	Central Asia	10,000	1993	UNC	UNC	Wetlands International 2019c
	East Asia	3,000	1999	UNC	UNC	Miyabayashi & Mundkur 1999; Wetlands International 2019c
Black Swan	Australia	165,000–180,000	2008	STA?	STA?	This paper
Black-necked Swan	South America	25,000–100,000	1990–2000	UNC	UNC	Wetlands International 2019a
	Falkland Islands	750–1500	1990–2000	STA?	UNC	Wetlands International 2019a
Coscoroba Swan	South America	10,000–25,000	2006	UNC	UNC	Wetlands International 2019a

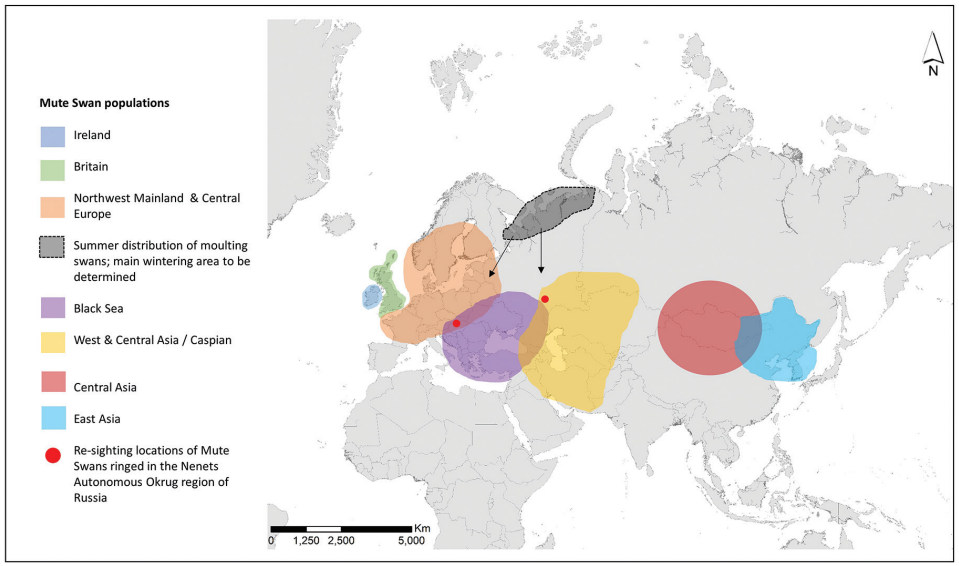


Figure 5. Distribution of native Mute Swan populations (from BirdLife International and Handbook of Birds of the World 2016). "Summer distribution" of Northwest Mainland and Central European Mute Swans in European arctic Russia (with arrows indicating possible autumn migration routes) is based on regular observations and recent ringing of the species during moult within the Nenetskiy National Okrug (WWT and Nenetskiy zapovednik, unpubl. data). The route taken between summering and wintering is not known, but one ringed individual was re-sighted in Hungary in mid-winter and a second in the Kuzhenerskiy district of Russia *c.* 1,000 km south of the ringing site. Overlapping ranges are where population boundaries/interchange are poorly understood.

sightings suggest that there is relatively little movement between the Irish, British and Northwest Mainland European populations (Fransson & Pettersson 2001; Spray *et al.* 2002; Bakken *et al.* 2003; Bønløkke *et al.* 2006). The species is generally more abundant, and estimates of population size and trends are therefore made more sporadically than for the migratory swans of the northern hemisphere.

The history of the Mute Swan in Ireland is poorly understood; introduced birds were known to be present in the 1700s, but whether the species also occurred there in the wild seems unclear (Rowell & Spray 2004). The first comprehensive monitoring of waterbirds in Ireland was undertaken in the early 1970s, and a follow-up survey was carried out over a decade later in winters 1984/85–1986/87, at which time the Mute Swan population for Ireland was estimated at 10,000 birds (Sheppard 1993). A long-term monitoring programme, the Irish Wetland Bird Survey (I-WeBS), commenced winter 1994/95 and counts of 5,200–6,000 in 1995 and 1996 for this widely scattered species resulted in the population estimate of 10,000 birds being retained (Delany *et al.* 1999). The 1988–1991 Breeding Birds Atlas project in Britain and Ireland suggests that

the Irish population may have been higher (19,000–20,000 birds) than previously supposed (Ogilvie & Delany 1993). Trend indices for Northern Ireland determined through the UK's Wetland Bird Survey (WeBS) showed an increase from the mid-1980s to the early 2000s (Rowell & Spray 2004), and the Irish population as a whole was estimated at 11,440 during 1994/95–2003/04 (Crowe *et al.* 2008). Continued annual monitoring of waterbirds through the I-WeBS and WeBS schemes has more recently estimated Mute Swan numbers at 9,130 (7,032 and 2,094 in the Republic and Northern Ireland respectively) for winters 2011/12–2015/16, representing a long-term decline in numbers (put at 24.9%) since the mid-1990s (Burke *et al.* 2018).

It has been suggested that the Mute Swan was introduced to Britain by the Romans and, although archaeological evidence indicates that the species was widespread much earlier throughout Britain (Yalden & Albarella 2009), the Romans may have instigated its domestication, as the species was being kept in a semi-domesticated state for food by the 11th century (Birkhead & Perrins 1986; Rowell & Spray 2004). At one time the Crown claimed possession of all the Mute Swans in England, but over time ownership rights for swans were granted to the clergy and local noblemen in certain areas. By the late 19th century swan-keeping had declined, and the wild population increased as a result of escapes from semi-domestic flocks (Birkhead & Perrins 1986). Mute Swans were of conservation concern in Britain in the mid-20th century, as lead poisoning mortality caused by the birds ingesting spent lead fishing weights whilst foraging for grit reduced the population to 17,600 in 1978. Numbers increased steadily following legislation in January 1987, banning the use of weights with sizes deemed most likely to be ingested by swans (0.06–28.35 g), to an estimated 74,000 birds for winters 2004/05–2008/09 (Musgrove *et al.* 2013) with population growth stabilising at around this time (Wood *et al.* 2019c). Frost *et al.* (2019) recently put numbers lower, at 50,000 birds, but this was attributed to a methodological change in the approach used to estimate numbers, involving environmental stratification (considered more accurate for this species), rather than a real decline in population size.

Less is known about the other Mute Swan populations in Eurasia, although trends analyses of IWC data found a strong long-term (1972–2015) increase in the Northwest Mainland & Central European population. Short-term (2006–2015) trends are given as uncertain/stable, and IWC count totals were of 132,000–200,000 individuals between 2011–2015, resulting in a total population estimate of *c.* 250,000 birds (Wetlands International 2019c). In CSR 7 the population size was however based on a breeding population of 57,821 to 80,792 pairs in the 24 countries within the flyway, which multiplied by three gave a population estimate of 173,000–243,000 birds and a resulting 1% criterion of 2,000 birds, a 20% downscale from the 2,500 birds that had been published in WPE 3, 4 and 5 (Wetlands International 2019a). Estimating population size and trends for a long-lived species only from the size of its breeding population is problematic, however, as the approach assumes that breeding pairs have an average

of one cygnet surviving to winter, and ignores the fact that there is a large non-breeding bird component that aggregates to moult during the breeding season. In Denmark alone, the last two national censuses of moulting swans both recorded 50,000 birds in 2006 and 2012 (Nielsen *et al.* 2019) and, although Denmark probably hosts most moulters (given that many birds from Poland, Germany and the Netherlands fly to moult in the country; Bønløkke *et al.* 2006), flocks of thousands are also known to moult in the Netherlands and Germany (Blüml & Degen 2009; Sellin 2013; Hornman *et al.* 2016). The data source for the breeding population estimate was the European Union Birds Directive Article 12 dataset for 2008–2012, supplemented with Birdlife International (2015) European Red List data for countries outside EU. Unfortunately, only seven of the 24 flyway countries potentially holding Mute Swans from the Northwest Mainland & Central European population had submitted wintering population totals, summing to 158,000–186,000 birds. Two major wintering countries had not reported their numbers, notably Sweden where 50,500 birds were recorded wintering in 2015 (Nilsson & Haas 2016) and the Netherlands with 28,000 in the same year (Hornman *et al.* 2016), whilst other non-listed countries are likely to add some thousands each, *e.g.* Austria (average count = 2,770 for the period 1970 to 2014, but with the latter year being near the average, judged from an index figure; Teufelbauer *et al.* 2015), Switzerland (6,623 and 7,334 in 2015 and 2016, respectively; Strebel 2016) and the Czech Republic (3,000–4,000 wintering in 2009–2013; Musilova *et al.* 2014). Hence, in line with the "increasing-stable" population trend indications for 2000–2015 (Wetlands International 2019a), it is clear that the population has not declined, but more likely increased. We therefore maintain the previous estimate of 250,000 birds, and call for a more comprehensive review where data from the same (or at least adjacent) wintering years are compiled, because we believe that the winter counts give a better estimate for the population size.

The West & Central Asia/Caspian population is also considered to be abundant, with the population put at *c.* 250,000 individuals from IWC count totals of *c.* 500–31,000 individuals between 2011–2015. Trend analysis for the population was based on data from just four countries (particularly Turkmenistan and Iran; also Azerbaijan and Kyrgyzstan) and both long- and the short-term trends were classed as "uncertain" due to large year-to-year fluctuations and missing data (Wetlands International 2019c). The Black Sea population was put at 45,000 in the mid-1990s (Scott & Rose 1996) and more recent assessment of IWC count totals (*c.* 11,000–22,000 individuals counted each year between 2011–2015) again estimates that the population is of *c.* 45,000 birds. Both long-term (1998–2015) and short-term (2006–2015) trends are classed as "uncertain" because of large year-to-year fluctuations and missing data, particularly from the Ukraine (where larger numbers are known to winter, *e.g.* Scott & Rose 1996), but with an overall declining tendency in the long term, though more stable in the short term (Wetlands International 2019c).

Further east, much better information is also needed on the Central Asian and the

East Asia populations of Mute Swans, which have been estimated at 10,000 and 1,000–3,000 birds respectively since the 1990s (Wetlands International 2019a; Table 2).

Total numbers of Mute Swans in areas where the species is native are therefore put at *c.* 642,000 (Tables 1 & 2), although given the gaps in coverage this is likely to be an underestimate. Moreover, Mute Swans from introduced populations occur, most notably in North America where *c.* 13,000 were recorded in 1993 (Ciaranca *et al.* 1997) with numbers increasing since then to *c.* 50,000–60,000 birds (review in Gayet *et al.* in press), although given population control measures in the region these recent figures require verification. An estimate of 17,520 individuals in Michigan in 2013 (D. Luukkonen, unpubl. data) made it the largest Mute Swan population in North America, though recently finalised management goals and objectives of the Michigan Department of Natural Resources are for there to be no more than 2,000 Mute Swans in Michigan by 2030 (Michigan Department of Natural Resources 2012; Knapik *et al.* 2019). Elsewhere introduced Mute Swan populations have remained relatively limited in numbers, with only 200–300 birds occurring in each of Japan (up to 367 in 2017), New Zealand and Australia (del Hoyo *et al.* 1992; Ministry for the Environment 2018), and several formerly introduced populations (in Iceland, South Africa and the United Arab Emirates) have now disappeared (Gayet *et al.* in press).

Threats and conservation issues

The Mute Swan is protected across most of its range in Europe under Annex II of the European Bird Directive (Directive 2009/147/EC), according to which the species can only be hunted potentially in Germany and Austria, where numbers are increasing, although culling is sometimes practised under licence in relation to crop damage in other countries (*e.g.* the Netherlands), even if damage is not always proven (Esselink & Beekman 1991). Non-lethal control measures such as fencing and other deterrents are used to keep birds away from some areas and illegal shooting of Mute Swans is known to have occurred in the UK because of perceived damage to valuable habitat at salmonid fisheries (review in Gayet *et al.* in press).

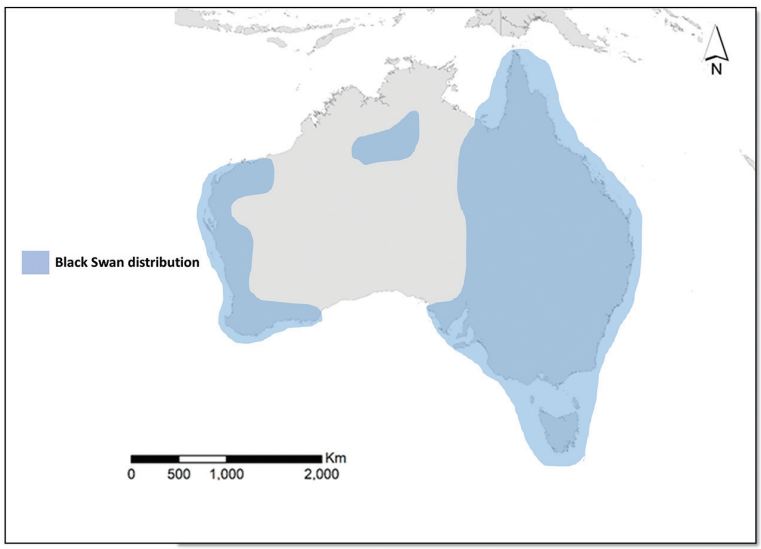
Although increasing Mute Swans numbers can have some negative effects within its native range, this seems to be a particular issue in North America where it is considered an aggressive non-native invasive species, and deleterious effects are reported as including depletion of aquatic and agricultural vegetation and displacement of other waterbirds (*e.g.* Tatu *et al.*, 2007; Stafford *et al.* 2012). A combination of population control actions, including public education, culling of adult swans and egg-oiling, therefore have been used to reduce the number of Mute Swans at Chesapeake Bay in Maryland (from 3,995 individuals in 1999 to 41 in 2014; Hindman *et al.* 2016a,b, 2018), and to stabilise abundance at *c.* 9,000 birds in Michigan (Arsnoe & Duffiney 2018; Gayet *et al.* in press).

Australasia

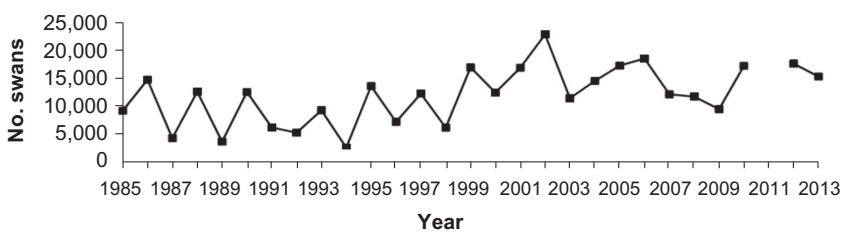
Black Swans

Black Swans are endemic to Australia, where they occur across the whole continent except for central and northern regions (Fig. 6a),

(a)



(b) Tasmania



(c) South Queensland

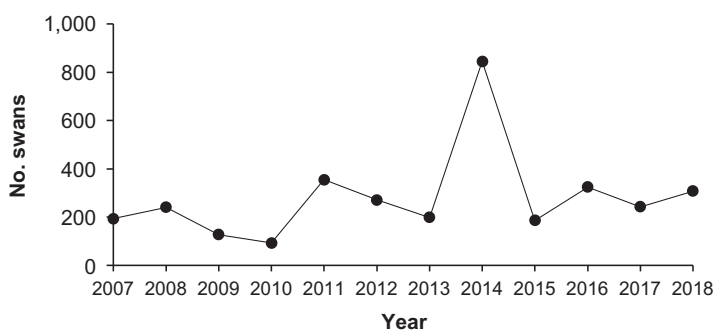


Figure 6. Black Swans: (a) distribution in Australia (based on Kingsford *et al.* 2011), (b) maximum counts recorded in Tasmania (based on Gaffney 2019) and (c) maximum counts recorded in south Queensland (J. Coleman, unpubl. data).

and are one of the most abundant species recorded during continent-wide waterbird censuses (Kingsford *et al.* 2011). Monitoring Black Swan numbers therefore is undertaken only occasionally, and population estimates are thus less precise than for some of the other swan species, but the estimate of 100,000–1,000,000 birds given in the WPE (Wetlands International 2019a) seems particularly wide-ranging. The most recent census of 136,005 Black Swans recorded via aerial surveys during the national waterbird survey of Australia in 2008 was incomplete (Kingsford *et al.* 2011), but with an estimated 70–80% of the population covered (R. Kingsford, pers. comm.) a total population estimate of 165,000–180,000 based on these counts is towards the lower end of the range given in the WPE. Numbers are generally thought to be stable since the late 20th century, but habitat loss due to inland river regulation and coastal development probably may inflict some long-term decline (Wetlands International 2019a). Annual waterbird surveys conducted at 76 wetlands in Tasmania indicate that numbers there fluctuated markedly between *c.* 1,000–24,000 birds over the period 1985–2018, but the trend was generally stable (Gaffney 2019; Fig. 6b). More recent count data collected in a study area in southeast Queensland (Coleman 2014) shows similar variability in numbers, but overall again demonstrated a stable trend over time between 2007–2019 inclusive (J. Coleman, unpubl. data; Fig. 6c).

A Black Swan population is also established in New Zealand following introductions in the 1860s, though recent molecular and morphometric studies of fossil remains indicate that a potentially distinct *Cygnus sumnerensis*, divergent from modern (Australian) Black Swan *C. atratus*, was present at the time of human colonisation (Rawlence *et al.* 2017). The national population was put at *c.* 50,000 in 2011; it was formerly more numerous, but widespread loss of aquatic plants from most lowland lakes greatly reduced their numbers (Williams 2013). Black Swans have also been introduced to European countries for ornamental purposes, but their numbers have not expanded to the extent observed in New Zealand, or for Mute Swans in North America.

Threats and conservation status

Black Swans are fully protected in all states in Australia, and are not subject to active control measures. Although regular counts are lacking, numbers are probably declining in river basins subject to water resource development (*e.g.* the Murray-Darling Basin; Kingsford *et al.* 2017). Reductions in flows and innundation of wetlands (Kingsford 2000) is a serious threat to Black Swan populations. Breeding distribution and timing is influenced by appearance of ephemeral wetlands, and as such the species is sensitive to drought conditions.

In New Zealand, where the Black Swan is non-native, it is a quarry species with up to 7,000 shot in 2011. The loss of aquatic vegetation (the preferred food for this species) in recent years has seen the population go into decline (Williams 2013).

South America

Black-necked Swans

The total number of Black-necked Swans, which occur in the southern part of South

America, is also not known. A combination of national and regional counts puts the total at < 100,000 in the mid-1980s to mid-1990s, of which 20,000 were thought to be in Chile, 50,000 in Argentina, at least 20,000 in Uruguay, 2,000–3,000 in southern Brazil and 750–1,500 on the Falkland Islands (Schlatter *et al.* 1991a; Rose & Scott 1997; Rees 2005). More recent estimates, for the period 1990–2000, are of 25,000–100,000 on continental South America and 900–1,800 on the Falkland Islands (Wetlands International 2019a), at which time numbers were considered to be stable. Counts made in southern Chile (including northern Patagonia and the Araucanian Lake District) estimated 25,000 Black-necked Swans in the region during the 1990s, with *c.* 10,000 on Chiloé Island and similar numbers colonising areas to the north of Chiloé, between Chacao Channel and Budi Lake (Schlatter *et al.* 2002). Numbers at the Carlos Anwandter Sanctuary, a Ramsar Site on the Cruces River in Chile, increased over the period 1985–2000 from 640 in 1985 to a peak of 14,533 in 1997, but with marked variation in numbers associated with rainfall events (Schlatter *et al.* 2002). Loss of aquatic vegetation at the site, however, resulted in numbers rapidly declining to just a small number of individuals present in 2000–2004, before recovering to 6,000–7,000 in 2017 (Vilina & Flores 2017; Jaramillo *et al.* 2018).

The species does not undertake seasonal long-distance migrations in the manner of the migratory swans of the northern hemisphere but redistributes in response to local conditions. A sharp increase, from 2,178 to 6,426 birds in Chile between January and late May 1989 was attributed to immigration, resulting from climatic drought in Argentina (Schlatter *et al.* 1991). Vilina and Cofre (2018) report that during dry periods in central Chile, waterbirds can mainly be found in the southeast coastal wetlands, which could explain the occasional recording of 20,000 Black-necked Swans and 1,000–2,000 Coscoroba Swans on Seno Ultima Esperanza in Puerto Natales (51°28'S, 73°06 W), in the Magallanes region (Vuilleumier 1997).

The current status of Black-necked Swans is unclear, but it is thought that they are now likely to be in decline because the species is vulnerable to high mortality during severe droughts associated with ENSO (El Niño – Southern Oscillation) events (Schlatter *et al.* 2002), such as the droughts of 1998–99 and the central Chile mega-drought of 2010–2015 (Garreaud *et al.* 2017; Y. Vilina, pers. comm.).

Coscoroba Swan

As for the Black-necked Swan, the number of Coscoroba Swans is unclear. It occurs slightly further south (Fig. 7a,b) and in Chile it was mainly found in Patagonia during the mid-20th century. In general, it has a patchier distribution than the Black-necked Swan, making it more difficult to assess total numbers and trends in abundance. Moreover, although it frequents lowland sites, it also occurs on Andean lakes at up to 1,000 m (Rees & Brewer 2005). In 1994 it was recorded for the first time at the El Yali wetland, almost 1,500 to the north of its previous breeding range within Chile, in the "Mediterranean, Forests, Woodlands and Scrub" biome (World Wide Fund for Nature classification; Vilina 1994), and has since extended to breed at several other wetlands

(a) Black-necked Swan

(b) Coscoroba Swan

Figure 7. Swan distribution in South America: (a) Black-necked Swans and (b) Coscoroba Swans.

in this ecoregion (Brewer & Vilina 2002; Silva-García & Brewer 2007).

Trends in numbers were considered stable in the late 20th century and the species was estimated at 10,000–25,000 in 2006, roughly equating to 6,700–17,000 mature individuals (Wetlands International 2019a; BirdLife 2019b). The species only occasionally occurs on the Falkland Islands; successful breeding by a pair on Pebble Island in 2000/01 was the first breeding record for Coscoroba Swans in the archipelago since 1860 (Wetlands International 2019a).

Threats and conservation status

The conservation status of South America's swan species is not well known and their population ecology (habitat requirements; movements) is poorly understood in comparison with some of the other swan species. The lack of coordinated count programmes within and across countries means that species abundance and trends in numbers are unclear, although both species are considered susceptible to the rapid loss of wetland habitat associated with more frequent drought events in recent years (Y. Vilina, pers. comm.). Ringing and re-sightings studies are required to provide a better understanding of movements of swans in South America, for instance to determine whether the Andean Mountains restrict east-west movements (and *vice versa*) for both species, and thus assess whether relatively discrete populations exist. Ringing of Black-necked Swans has recently been initiated at the Carlos Anwandter Sanctuary on the River Cruces in south-central Chile and it is hoped that resightings will provide information on the swans movements and survival rates. Given the distances involved, Black-necked Swans on the Falkland Islands are considered to be generally separate from those in continental South America, but data on the movements of individual birds is needed to confirm this assumption.

Current population estimates mean that South America's swans do not meet the

thresholds for classification as "Vulnerable" in the IUCN Red List for birds (*i.e.* < 10,000 mature individuals with a continuing decline of > 30% in ten years or three generations; BirdLife International 2019a,b), but the lack of data on population trends means that this assessment is not secure. The large ranges for the two species do not approach the thresholds for Vulnerable under the range size criteria (*i.e.* occurrence over < 20,000 km^2, combined with a declining or fluctuating range size, habitat extent/quality, or population size with a small number of locations or severe fragmentation; BirdLife International 2019a,b), but again better coordinated monitoring within and across countries would help to elucidate the situation.

Both the Black-necked Swan and the Coscoroba Swan are adversely affected by drought, which can cause loss of breeding habitat, and are also susceptible to human development having a detrimental effect on their food supply. Numbers of Black-necked Swans at the Carlos Anwandter Sanctuary in Chile, the most important breeding area for the species west of the Andes, plummeted from 4,000–8,000 birds in 2000–2004 to only a few hundred recorded annually in 2005–2010 as a result of a dramatic drop in the abundance of Brazilian Aquatic Grass *Egeria densa* (the primary food for the swans) in the area. The decline was attributed at the time to the operation of "Celulosa Arauco" pulp mill, and better management of liquid waste saw a recovery in numbers and resumption of breeding on the wetland from 2012, a total of 6,000–7,000 adults recorded at the site in December 2016 (Vilina & Flores 2017; Jaramillo *et al.* 2017). A new and recent threat to Black-necked Swans in the Carlos Anwandter Sanctuary is the South American Sea Lion *Otaria flavecens*, which has learnt to hunt swans and has now killed at least 200 birds at the site (Y. Vilina, pers. comm.).

Overview

On the basis of this review, we estimate that the total number of swans globally is in the region of 1.5–1.6 million individuals (Table 1), but with a further > 110,000 swans (*c.* 60,000 Mute Swans; 50,000 Black Swans) considered to be non-native invasive in some areas where they have been introduced outside their traditional range. Most of the northern hemisphere swans are increasing or stable in numbers with the notable exception of the Northwest European Bewick's Swan population, and information on abundance and/or trends is lacking for swans wintering in the Caspian region and Central Asia. Moreover, plans to change enforcement regulations of the Migratory Bird Treaty Act in the United States are also of concern, as potentially undermining protection for Trumpeter Swans in North America.

Information on population size and trends is also rather imprecise for swan species in Australia and South America (*e.g.* with trends estimates for Black-necked Swans dating back to the 1990s), and there are gaps in knowledge for a number of populations in Eurasia, indicating several key regions where data deficiency should be addressed (Appendix 1). Whilst undertaking censuses in large remote areas is challenging, and also of low priority when species are considered to be in favourable conservation status and the work would draw on limited conservation

resources, nonetheless regular assessments are important for ensuring that rapid population changes are not missed. Large-scale environmental change, for instance in climate and land-use, means that waterbird populations including swans may switch quite promptly from being in favourable conservation status to going into rapid decline (as noted for the Northwest European Bewick's Swans; Beekman *et al.* 2019). The situation for swans and other waterbirds in areas susceptible to drought and water resource development (*e.g.* South America; Australia; Caspian region) therefore should be monitored, to inform site protection, habitat management and other conservation actions required where the extent and habitat quality at wetlands used by these species are diminishing or being degraded. The swans' large size, which makes them relatively easy to monitor, should make them useful indicator species for determining demographic changes and shifts in distribution resulting from changes in local or regional environmental conditions. More detailed analytical studies are also required, to determine reasons for declines or changes in distribution. With most swan populations currently considered to be increasing (Table 2), studies of the swans' population ecology are also required to provide a sound scientific basis for conflict management, for instance where agricultural producers are concerned about potential reductions in crop yields where goose and swan populations have increased (Davis *et al.* 2014).

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Appendix 1. Monitoring priorities for the world's swan populations.

Species	Population	Monitoring priorities
Trumpeter Swan	Pacific Coast	5-year censuses; annual age assessments
	Rocky Mountain	5-year censuses; annual age assessments
	Interior	5-year censuses; annual age assessments; ringing to monitor & analyse migratory/dispersal patterns for birds ringed in the reintroduced populations
Tundra Swan	Western	5-year censuses; annual age assessments; harvest rates; monitor incidental take of Trumpeter Swans in Tundra Swan harvest (*e.g.* Drewien et al. 1999)
	Eastern	5-year censuses; annual age assessments; harvest rates; monitor incidental take of Trumpeter Swans in Tundra Swan harvest (*e.g.* Drewien et al. 1999)
Whooper Swan	Icelandic	5-year censuses; annual age assessments; ringing data for survival estimates and to assess population interchange
	NW Mainland Europe	5-year censuses; annual age assessments; ringing data for survival estimates and to assess population interchange
	Black Sea/ East Med	Develop censuses & annual age assessments; ringing/ tracking studies for population delineation
	Caspian/ W Siberian	Develop censuses & annual age assessments; ringing/tracking studies for population delineation
	East Asian	Develop censuses & annual age assessments; ringing/tracking studies for population delineation
Bewick's Swan	NW European	5-year censuses; annual age assessments; ringing for survival estimates and to determine level of population interchange with Caspian population

Appendix 1 (*continued*).

Species	Population	Monitoring priorities
Bewick's Swan (*cont.*)	Caspian	Develop surveys to determine population size and trends; annual age assessments; ringing/tracking for survival estimates and to determine level of population interchange with NW European population
	Eastern	Coordinate international surveys to determine total population size and trends; annual age assessments; tracking to describe subpopulations
Mute Swan	Ireland	Censuses to update population size estimates at 10-year intervals
	Britain	Censuses to update population size estimates at 10-year intervals
	NW Mainland & Central Europe	Censuses to update population size and distribution estimates at 10-year intervals
	Black Sea	Develop censuses to determine population size, trends and distribution
	West & Central Asia/Caspian	Develop censuses to determine population size, trends and distribution
	Central Asia	Develop censuses to determine population size, trends and distribution
	East Asia	Develop censuses to determine population size, trends and distribution
Black Swan	Australia	Census population size & develop trend estimates at 10-year intervals
Black-necked Swan	South America	Develop coordinated counts to determine population size & trends; develop ringing programme to understand movements & survival rates
	Falkland Islands	Develop coordinated counts to determine population size & trends; develop ringing programme to understand movements & survival rates
Coscoroba Swan	South America	Develop coordinated counts to determine population size & trends; develop ringing programme to understand movements & survival rates