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Population decline of the Eurasian Curlew in Akershus, southeastern Norway

Mélissa Monthouel & Svein Dale

Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, P.O.Box 5003, NO–1432 Ås, Norway; e-mail: svein.dale@nmbu.no; melissa.mthl@gmail.com

Abstract. The Eurasian Curlew *Numenius arquata* is a species in decline, classified as near threatened (NT) worldwide, and vulnerable (VU) in Norway. In Akershus county, southeastern Norway, the population of breeding Eurasian Curlews was estimated at 50-60 pairs in 1982. No recent update exists of this population size estimate. In this study, we assessed the population size in 2017 in Akershus, and examined how the population size changed between 1971 and 2017 by using historical observation records of Eurasian Curlews. We estimated that there were 30 territories in Akershus in 2017 and found that the population declined by 47% since 1995 and 77% since 1971. In the period 1995-2017, the yearly rate of decline was 2.8%. We discuss possible reasons for the decline, such as intensive agricultural practices, high nest predation rates, and large-scale threats on the wintering grounds.

Keywords: Eurasian Curlew, *Numenius arquata*, population decline

INTRODUCTION

Many wader species undergo a general decline (MacDonald & Bolton 2008, Roodbergen et al. 2012, Bell & Calladine 2017). The Eurasian Curlew *Numenius arquata* (hereafter: Curlew) is declining (Brown 2015), and it is categorized as near threatened (NT) worldwide by the IUCN red list of threatened species (Birdlife International 2017). During the breeding season, Curlews prefer grasslands with medium vegetation height and seem to avoid tilled fields (Berg 1992a, b, 1993, 1994, Valkama et al. 1998, Durant et al. 2008). The decline of Curlews has been suggested to result from a poor breeding success caused by habitat fragmentation, changes in land-use, destruction by farming practices and predation (Berg 1992a, b, Grant et al. 1999, Valkama & Currie 1999). By feeding on young and eggs, predators such as foxes and crows represent the greatest cause of breeding failure for waders (MacDonald & Bolton 2008).

In Norway, the national Norwegian red list of species categorized Curlews as vulnerable (VU) in 2015 (Kålås et al. 2015). Their population declined by 43% in the last 17 years which represents a decline of 4.4% per year (Kålås et al. 2014), and population size may have halved in 34 years (Shimmings & Øien 2015). The Norwegian breeding population of Curlews uses not only farmlands as a breeding site, but also open bogs. However, one third of Norwegian bogs have been drained in the last century (Lier-Hansen et al. 2013) and this may have contributed to the decline. In addition, Dale and Hardeng (2016) showed that the populations of breeding Curlews on bogs in Akershus tended to decline.

In Akershus county, southeastern Norway, the breeding population size of Curlews was estimated to 50–60 pairs in 1982 (Olsen 1982). In this study, we assessed Curlew breeding population size in Akershus in 2017 by conducting surveys of all sites where Curlews have been recorded during the breeding season in recent decades. Using historical information on presence and absence of Curlews in specific years at all sites known to have been used, we analyzed the population trend during 1971–2017.

MATERIAL AND METHODS

Study area and study period

The study took place in Akershus county in southeastern Norway. In the breeding season of 2017, 112 sites were visited in the municipalities Aurskog-Høland (42 sites), Nes (31 sites), Sørum (13 sites), Ullensaker (9 sites), Nannestad (7 sites), Hurdal (5 sites), Eidsvoll (3 sites), Enebakk (3 sites), Fet (2 sites), Skedsmo (1 site) and Gjerdrum (1 site). All sites that were known to have had previous records of Curlew were surveyed (but see below for some exceptions). Previous records originated from fieldwork done by one of the authors during 1994–2016, supplemented by reports submitted to the bird reporting websites of the Norwegian Ornithological Society, Oslo and Akershus branch (nofoa.no) and the Norwegian Biodiversity Information Centre (artsobservasjoner.no), and records published in the journal of the Norwegian Ornithological Society, Oslo and Akershus branch (Toppdykker'n). The southwestern part of the study area (Figure 1) was

not surveyed in 2017 because only one site has had breeding indications (and only in 1977).

The sites varied in size but were usually around 1-2 km^2. Some sites were on open bogs located in forested landscapes, whereas some were in agricultural areas. Sites in agricultural areas were defined according to physical barriers such as strips or patches of forest, lakes, rivers and human settlements. Given the small population size in the study area and normal home range size, most sites likely had only one territory, if any at all. Typically, sites in forested areas are at higher altitudes than sites in agricultural areas, and so we referred to them as upland and lowland areas respectively. Akershus county has a total area of 4918 km^2 of which 833 km^2 are agricultural areas (17%), 147 km^2 are bogs (3%), and 3277 km^2 are forested (67%). The remainder consists mainly of lakes and urban areas.

Data collection in the field (112 sites mentioned above) took place during May-June. The spring arrival of Curlews in Norway takes place through April, and the departures can start as early as mid-July. Even though Curlews are present in the area from April to August, we selected a shorter period to minimize the risk of including migrating birds in our observation period (see also below for time periods chosen for historical data).

Data collection

The main purpose of surveys of sites with previous indications of breeding Curlews was to assess presence/absence in 2017. All sites were therefore primarily visited once and searched thoroughly for presence of Curlews. Presence of Curlews was regarded as evidence of an occupied territory, either by a single individual or a pair. There was only one site that showed evidence of more than one territory/pair in 2017. Determining whether a territory contained a single bird or a pair was not always possible due to the low number of visits

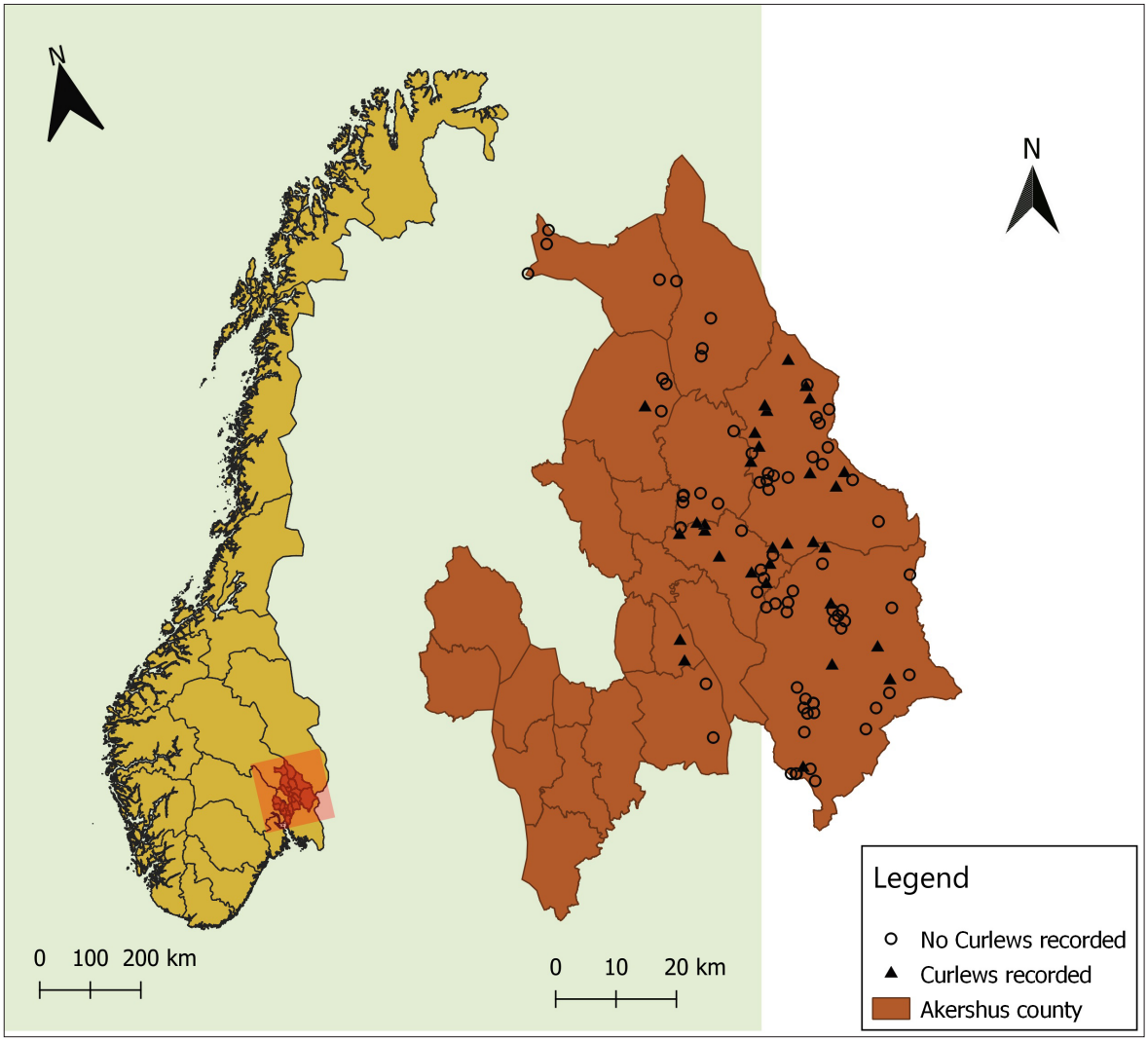

Figure 1. Map showing location of sites in Akershus where Eurasian Curlews were recorded during the breeding season in 2017, and previously used sites that were also surveyed in 2017 without Curlews being recorded.

to each site. Bogs in the forested areas were spatially well separated from each other and records of Curlews were therefore unambiguously associated with specific sites. However, many farmland sites were close to each other (see below), and they were generally visited at least twice to obtain additional information on exact location of birds to help in determining whether observations indicated one pair (or territory) or several pairs/territories close to each other. The observations from 2017 were plotted on a map to help determine the number of pairs/territories, especially in the agricultural areas of Akershus. If birds were observed twice or more within a radius of 1 km, they were considered as being from the same pair or territory (1 km criterion recommended by Robertson and Skoglund [1983] and used by Berg [1994]). If two birds were observed on the same day more than 2 km apart, they were considered as two different pairs or territories.

To analyze the population trend, historical records of Curlews from Akershus were compiled by using data from extensive surveys of bird communities at nearly 2000 sites in Oslo and Akershus since 1995 (Haavik & Dale 2012, Dale et al. 2015, Dale & Hardeng 2016). In addition, we retrieved information from published literature, in particular from the local ornithological journal Toppdykker'n, the bird reporting websites www.nofoa.no and www.artobservasjoner.no, as well as personal communications from several birdwatchers. All records of Curlew during the period 15 April–15 July were noted. To avoid observations that may concern Curlews on migration, all sites that were in wetlands and farmland in the lowlands included only observations during 1 May–30 June. On the other hand, birds on migration were not considered to be likely to use bogs in the forested areas as stop-over sites, so for bogs we accepted records 15 April–15 July.

The search for historical records of Curlews identified 13 additional sites that were not visited during the field work in 2017. For 9 of those sites, no birds have been seen there since 1986, but these sites still had their last visits during 2002–2015. Thus, Curlews were unlikely to be present at these sites in 2017. Of the remaining 4 sites with last records during 2001–2014, 3 were visited during 2013–2016, hence

Table 1. Overview of the sites where Eurasian Curlews were recorded in 2017 and their habitat use. Note that for all sites except one (Nordre Øyeren), there was only one territory/pair. Habitats are farmland (F), bog (B) and wetland (W).

Site	Municipality	Location	Habitat
Hemnessjøen	Aurskog-Høland	lowland	F
Nordby – Vålermåsan	Aurskog-Høland	lowland	F, B
Draurud – Ilebekkmåsan	Aurskog-Høland	lowland	F, B
Fagermosen	Aurskog-Høland	upland	B
Bogs at Kaldåker	Aurskog-Høland	upland	B
Mosetjenn	Aurskog-Høland	upland	B
Nordre Øyeren	Fet, Rælingen	lowland	F, W
Bjørkemåsan – Bjørke	Nannestad	lowland	F, B
Hetåkermåsan – Jælberg – Granholt	Nannestad	lowland	F, B
Hundstad – Østgard	Nes	lowland	F
Fenstad – Kampåa – Grindermåsan – Rolstad	Nes	lowland	F
Ryddingen	Nes	lowland	F, B
Aurstadmåsan	Nes	lowland	F, B
Ingeborgrudmoen – Vestgrenda - Sjøli	Nes	lowland	F, B
Kjennsmotjennet	Nes	lowland	F, B, W
Sagstusjøen	Nes	upland	B
Flæman	Nes	upland	B
Garsjøen - Rottjernet	Nes	upland	B
Tresjøene	Nes	upland	B
Rustad - Svardal	Nes, Sørum	lowland	F
Flakstadmåsan	Nes, Ullensaker	lowland	F, B
Fjuk	Sørum	lowland	F
Asak - Asakenga – Presterud - Refsum	Sørum	lowland	F
Sørum kirke	Sørum	lowland	F
Kvevli	Sørum	lowland	F
Nerdrum - Kville	Sørum	lowland	F
Gran - Fløgstad - Brotnu	Sørum, Ullensaker	lowland	F
Isingrud - Arteidmoen	Ullensaker, Sørum	lowland	F

giving recent information on presence that was used in statistical analyses (see below). The last site had become overgrown and unsuitable for Curlews at the last visit. Single or few observations of birds not showing any signs of breeding behaviour from 16 sites during early May or late June were regarded to concern migrating birds, and these sites were excluded from analyses. Thus, in total 320 year-records of Curlews from 109 sites with indications of breeding were included in analyses (mean 2.9 years with Curlews recorded for each site). Of the 109 sites, only 14 sites had information indicating that there had been two or more territories in any one year. Thus, for most sites the data basically consisted of presence/absence.

For all 109 sites with Curlew records accepted as indicating breeding, all sources of information were searched for negative reports, i.e. reports indicating that a site had been visited during the periods mentioned above, but no Curlews were seen. Negative reports are needed to avoid biased population estimates in the statistical analyses (see below). There were 384 year-records of no Curlews seen. Thus, there was a total of 704 year-records for the 109 sites, representing a median of 5.0 year-records for each site (mean 6.5, range 1–37 years). Records spanned 1971–2017 with a median of 5.0 sites visited per year (mean 15.0, range 0–95 sites). There was a clear change-point in amount of data from 1995, with a maximum of 6 sites visited per year during 1971–1994 (median 3.5, mean 2.8), and a minimum of 5 sites visited per year during 1995–2017 (median 26.0, mean 27.7, see Appendix 1). Due to the proximity of some sites, it was considered likely that birds at two sites close to each other could represent the same territory. To account for this, we merged sites that were immediately adjacent to each other (i.e. sites had common borders) to avoid any double counting. Thus, the 109 sites were merged to 70 sites.

Statistical analyses

To analyze the population trend, the package rtrim version 2.0.6 was used (Bogaart et al. 2018). This is a program for the analysis of time series of counts, using Poisson regression, and is particularly well suited for time series with missing observations for time points. Analyses were performed using model 2 (assumes that populations vary across sites but show the same growth everywhere and that growth rates are constant during specified time intervals). The main analysis was performed with data from 1995 to 2017. Results from this analysis gave us an estimate for the population trend between 1995 and 2017. We used data dating back until 1995 because only limited amounts of data existed from the years before 1995 (see Appendix 1), and probably also an underrepresentation of zero observations. From 1995, zero observations are likely to have been reported due to the initiation of a project of systematic surveys of the bird communities all over Akershus (see Dale et al. 2001). However, to provide an indication of the longer term population change, a second analysis was performed using all years (1971–2017).

RESULTS

Population size

During the fieldwork in 2017, 27 territories were recorded. To this number, we added two territories in Nordre Øyeren (based on information given by Nordre Øyeren bird station and observations reported at artsobservasjoner.no). Those 29 territories (Figure 1) were distributed at 21 sites in the lowlands and at 7 sites in the uplands (Table 1). In the lowlands, 11 sites were farmland habitats, 9 were a combination of bog and farmland habitats, and one was a wetland (Nordre Øyeren) (Table 1). All upland sites were on bogs. In addition, because one territory was recorded on Midtfjellmosen (Aurskog-Høland) in 2014 and this site was not visited in 2017, we assumed that this site was still occupied. Thus, the population size in Akershus in 2017 was estimated to 30 territories.

Population trend

The number of territories decreased by an estimated 47% in 23 years (Figure 2). The total number of territories went from an estimated 53 in 1995 (95% CI [37,69]), to 28 in 2017 (95% CI [22,34]), showing a significant decrease of 2.8% per year (Wald test for significance of slope parameter: Wald = 8.57, df = 1, $p < 0.01$).

When looking at the trend over 47 years, the number of territories decreased by an estimated 77% (Figure 3). The total number of territories decreased from an estimated 133 in 1971 (95% CI [82,184]) to 31 in 2017 (95% CI [25,37]), showing a significant decrease of 3.1% every year (Wald test for significance of slope parameter: Wald = 37.19, df = 1.00, $p < 0.001$).

DISCUSSION

We estimated that there were 30 territories of Curlews in Akershus in 2017. The first population trend analysis showed a 47% decline since 1995 (decrease of 2.8% per year) when considering 70 sites. The second analysis showed a decrease of 77% in 47 years (1971–2017), representing a decrease of 3.1% per year. However, the limited amount of data before 1995 makes this result less reliable than the result from 1995 to 2017. Olsen (1982) estimated that there were 50–60 pairs in 1982, so even compared to that estimate there has

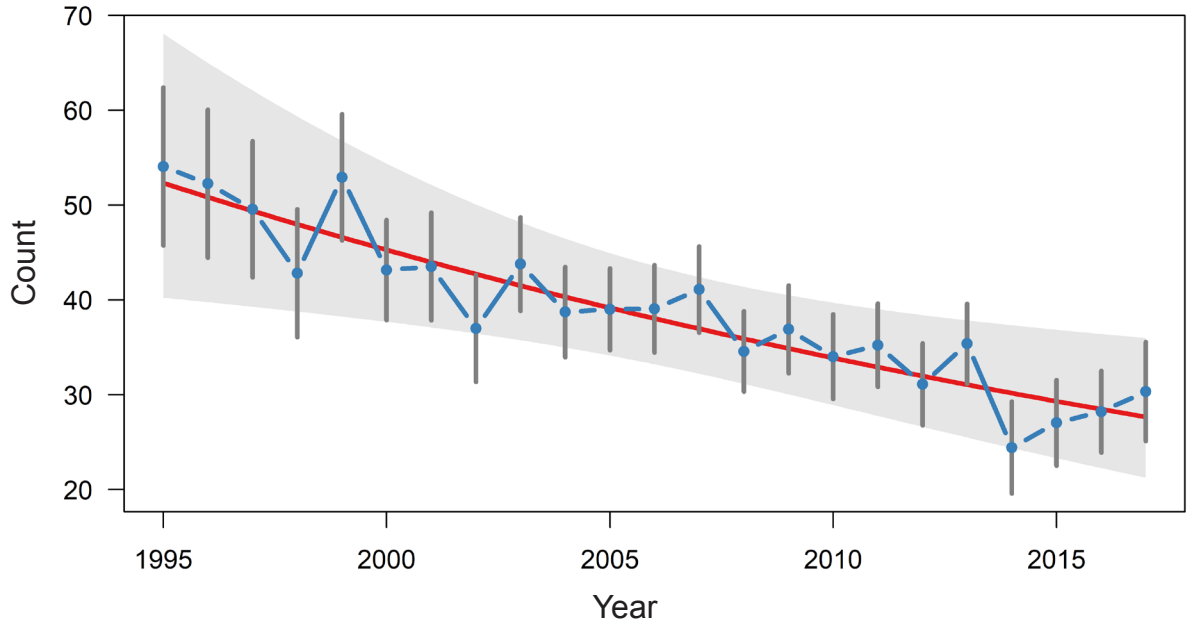

Figure 2. Number of territories of Eurasian Curlews in Akershus from 1995 to 2017 with 95% CI. The red line shows the overall population trend (shaded area shows confidence interval). The blue line shows estimated population size for each year (with SE error bars).

been a considerable decline. However, our estimations indicated that the population likely was larger than 50-60 pairs in 1982, probably because some breeding sites were unknown to Olsen (1982).

Breeding Curlews appeared to have an even steeper decline nationally, with 45% reduction of the population in the last 17 years, i.e. a decline of 4.4% per year (Kålås et al. 2014). This suggests that other regions in Norway may have a steeper decline of their breeding population than that in Akershus, which may indicate worse breeding conditions for Curlews. In Europe, Curlews declined by 45% in the past 32 years and by 13% in the past 10 years, representing decreases of 1.1–1.9% per year (EBCC 2014). Thus, the decline of breeding Curlews in Norway is worse than the European average, whereas the situation for Curlews in Akershus appears to fall in between. There are also indications that Curlews do better in Sweden and Finland than in Norway in recent years (Lindström et al. 2015).

In Norway, agriculture intensified since 1950, probably causing Curlews to decline. In southeastern Norway, the grain production increased by 50% between 1950 and 1975, resulting in a similar decline of grass production, and farmers turned more and more to silage instead of hay to conserve their fodder, which involves harvesting earlier in the season and creating more dense and uniform fields in early summer (Lundekvam et al. 2003, Wilson et al. 2004). Lundekvam et al. (2003) also reported that since 1975 the number of farms decreased, and the size of each farm increased to enhance productivity. Furthermore, statistics for Akershus for the period 1969-2018 (Statistics Norway 2019) indicate that loss of grass production and expansion of cereal production continued especially in the period 1969–1989. Berg (1994) showed that grasslands were particularly important for Curlews, and that they thrive best in mixed farmlands (see also de Jong 2012), indicating that these changes in the Norwegian agriculture have been highly negative for Curlews. In addition to threats on their breeding sites, Curlews also face many threats on their wintering grounds and during their migration. According to Pearce-Higgings et al. (2017), the main threats for non-breeding Curlews in the East Atlantic flyway are human disturbances, drainage of wetlands, climate change, the expansion of renewable energy, and the excessive harvesting of shellfish in the UK and the Netherlands.

Since nest destruction by farming practices is one of the main causes of the Curlew's decline (Berg 1992a, Valkama & Currie 1999, Brown 2015), postponing grass or crop harvesting represents a good management measure. In France, postponing grass harvesting to either 1 or 15 July increased significantly the number of breeding Curlews over the years (Broyer et al. 2014). In addition, a phenological mismatch exists between the nesting time of Curlews and the sowing time of farmers, which exposes nests to destruction (Santangeli et al. 2018). Because of climate change, Curlews nest earlier, but the time at which farmers sow their fields did not change as fast, and Curlews end up nesting on unsown fields more and more. Indeed, during our fieldwork, a nest was spotted in a

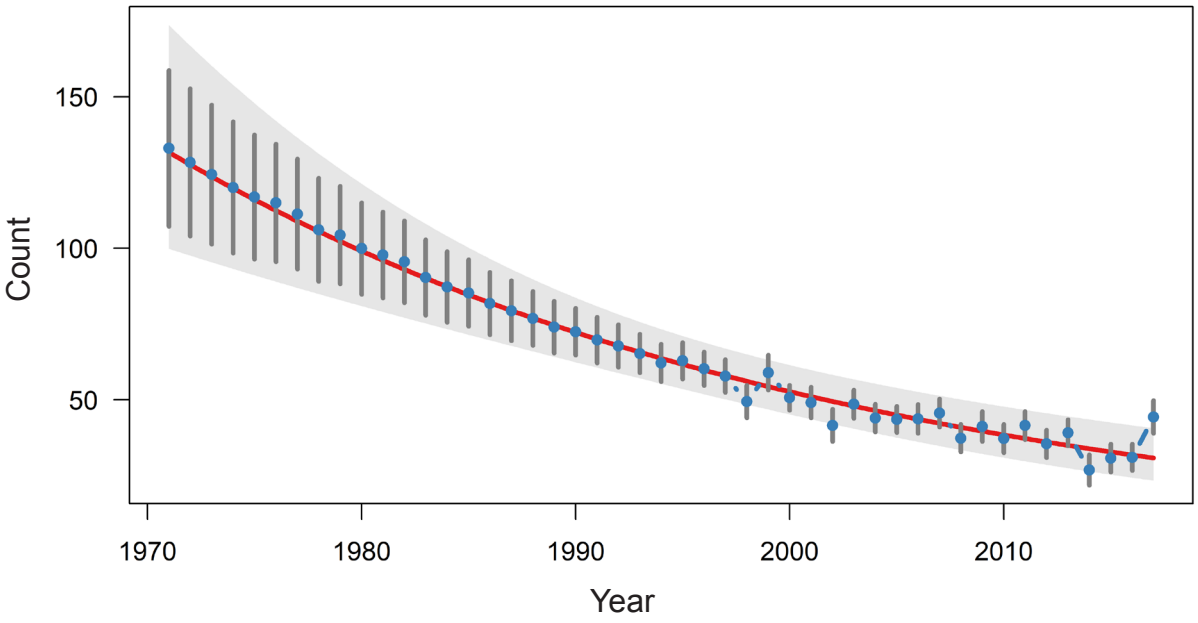

Figure 3. Number of territories of Eurasian Curlews in Akershus from 1971 to 2017 with 95% CI. The red line shows the overall population trend (shaded area shows confidence interval). The blue line shows estimated population size for each year (with SE error bars).

stubble field, but on the second visit to this site, the field had been tilled and sown and the nest was most likely destroyed. Thus, another management measure could be to start sowing fields earlier to avoid nest destruction. The other main cause of decline of Curlews is predation of nests and young (Berg 1992a, Grant et al. 1999, Valkama & Currie 1999, Douglas et al. 2014, Brown 2015). Thus, a third management measure could be to implement or increase predator control in areas where habitat conditions are not optimal. This management measure has been successful before in the UK by controlling predators through the presence of gamekeepers (Fletcher et al. 2010, Douglas et al. 2014). However, we suggest that such methods should be implemented only when predation is the only leading cause of decline. Indeed, predation and other threats work in synergy (van der Wal & Palmer 2008) and a population that does not face any threats due to habitat change and farming practices may sustain even a high predation pressure. Thus, we should first solve problems due to farming practices and land use changes before attempting to artificially reduce predation pressure through predator culling in areas where both are at work. Another strategy to prevent further decline of the Curlew in Akershus and elsewhere is to involve farmers in the conservation of the species by informing them about the problems faced by the species and by teaching them how to recognize and protect them. In the county of Møre og Romsdal, western Norway, such measures have been implemented to protect Curlews and Lapwings *Vanellus vanellus* (Bondelaget 2018). In that county, farmers will cooperate with naturalists and birdwatchers who will inform them of the presence of any nest spotted on their property.

For further studies, it would be interesting to find out what is the leading cause of decline of breeding Curlews in Akershus and to determine how important bog areas are for breeding Curlews. The decline of Curlews on bogs seems at least as strong as in farmland areas despite many of the bogs having changed little during recent decades (Monthouel 2018). By comparing the population trend in the uplands (mainly non-agricultural areas) and in the lowlands (agricultural areas), we could get more information about the role that farming practices and habitat changes in farmlands play in the decline of Curlews. If we can confirm that the trend in bogs is as strong as in farmland areas, then it appears likely that part of the decline may result from large-scale factors impacting Curlews during migration and in overwintering areas. If the decline in farmland areas turns out to be stronger than in bog areas, we could try to identify any nesting habitat preferences to gain a better idea about what measures should be implemented in agricultural areas.

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Year	No. of sites visited	Empty	Occupied	Proportion occupied
1971	1	0	1	1.00
1972	0			
1973	0			
1974	1	1	0	0.00
1975	6	0	6	1.00
1976	4	1	3	0.75
1977	4	0	4	1.00
1978	0			
1979	5	0	5	1.00
1980	3	1	2	0.67
1981	2	0	2	1.00
1982	4	0	4	1.00
1983	2	1	1	0.50
1984	1	1	0	0.00
1985	5	3	2	0.40
1986	4	2	2	0.50
1987	4	2	2	0.50
1988	1	1	0	0.00
1989	2	1	1	0.50
1990	0			
1991	4	2	2	0.50
1992	4	2	2	0.50
1993	5	4	1	0.20
1994	4	3	1	0.25
1995	13	3	10	0.77
1996	6	2	4	0.67
1997	8	3	5	0.63
1998	14	10	4	0.29
1999	22	7	15	0.68
2000	5	5	0	0.00
2001	17	6	11	0.65
2002	23	16	7	0.30
2003	19	8	11	0.58
2004	17	9	8	0.47
2005	16	10	6	0.38
2006	33	17	16	0.48
2007	26	11	15	0.58
2008	33	24	9	0.27
2009	34	16	18	0.53
2010	32	19	13	0.41
2011	38	19	19	0.50
2012	35	23	12	0.34
2013	35	18	17	0.49
2014	47	33	14	0.30
2015	36	23	13	0.36
2016	34	23	11	0.32
2017	95	54	41	0.43

Total: 704 year-records from 109 sites (mean 6.5 year-records per site)

Appendix 1. Overview of number of breeding sites for Eurasian Curlew visited per year during 1971–2017 in Akershus, southeastern Norway. For years in which at least one site was visited, the number of sites that were empty (i.e. no Curlews recorded) and the number of occupied sites are also given, and the corresponding proportion of sites that were occupied. Because there was a clear change-point in amount of data from 1995, with a maximum of 6 sites visited per year during 1971–1994 (median 3.5, mean 2.8), and a minimum of 5 sites visited per year during 1995–2017 (median 26.0, mean 27.7), analyses were done both for the whole period (1971–2017) and for the period with more comprehensive data (1995–2017; see main text). Note that the appendix is based on 109 breeding sites, whereas analyses presented in the main text were based on data after merging of neighbouring sites in order to avoid double counting (n = 70 sites used for analyses).