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AEWA European Goose Management Platform

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ADAPTIVE FLYWAY MANAGEMENT PROGRAMME FOR THE NW/SW EUROPEAN POPULATION OF THE GREYLAG GOOSE *ANSER ANSER*

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The 5th Meeting of the AEWA European Goose Management International Working Group is taking place remotely in an online conference mode.

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List of acronyms and abbreviations

AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
AFMP	Adaptive Flyway Management Programme
AV	Agreement Value
CMS	Convention on the Conservation of Migratory Species of Wild Animals
DV	Directive Value
EC	European Commission
EGM IWG	European Goose Management International Working Group
EGM IWG4	The 4th meeting of the EGM IWG
EGMP	(AEWA) European Goose Management Platform
FCS	Favourable Conservation Status
FO	Fundamental Objective
FRH	Favourable Reference Habitat (in sense of 'habitat for the species' in DG Environment, 2017)
FRP	Favourable Reference Population
FRR	Favourable Reference Range
FRV	Favourable Reference Value
ISSMP	International Single Species Management Plan
IWC	International Waterbird Census
MCDA	Multi-criteria Decision Analysis
MOP	Meeting of the Parties
MU	Management Unit
TF	Task Force

Introduction

The International Single Species Management Plan (ISSMP) for the NW/SW European population of the Greylag Goose *Anser anser* (Polowny et al., 2018) was developed according to Paragraph 4.3.4 of the AEWA Text, Annex 3. This provides for developing ISSMPs for populations which cause significant damage, in particular, to crops and fisheries. In addition, it responds to AEWA Resolution 6.4, which requested the establishment of a multispecies goose management platform and process to address the sustainable use of goose populations and to provide for the resolution of human-goose conflicts, targeting as a matter of priority Barnacle and Greylag Geese.

The ISSMP for the Northwest/Southwest European population of the Greylag Goose was adopted at the 7th Session of the Meeting of the Parties to AEWA (MOP7), 4-8 December 2018 in Durban, South Africa. The ISSMP provides a mandate for developing a population-specific Adaptive Flyway Management Programme (AFMP) for the Northwest/Southwest European population of the Greylag Goose, recognising that there are regional differences in migratory behaviour and the human-wildlife conflicts involved within this population. This AFMP shall be formally adopted by the European Goose Management International Working Group (EGM IWG) and then reviewed periodically.

A document on the process and the outline for the development of the Adaptive Flyway Management Programme (AFMP) for the Northwest/Southwest European population of the Greylag Goose (Doc. AEWA/EGMIWG/4.12/Rev.1[2]) was presented and adopted at the 4th Meeting of the EGM IWG on 18-20 June 2019, Perth, Scotland, United Kingdom (EGM IWG4). This document follows the agreed outline of the AFMP.

The aim of the AFMP is to establish an agreement amongst Range States on the implementation of those activities in the Greylag Goose ISSMP that require coordination at the population and/or at Management Unit (MU) levels. Specifically, this AFMP addresses the following activities:

1) Establish Management Units (MUs; Chapter 1), hierarchical Favourable Reference Values (FRVs; Chapter 2) and population targets (Chapter 3 and Annex 3) at flyway, MU and national levels iteratively to ensure that national targets are consistent with the flyway targets and with legal requirements at all levels;
2) Establish an internationally coordinated population management programme for both MUs, including offtake under hunting and, if necessary, under derogations (Chapter 4 and Annex 4) encompassing monitoring, assessment and decision-making protocols (Chapter 6 and Annex 7);
3) Establish indicators to assess progress toward the Fundamental Objectives (Chapter 5 and Annex 6) and guide the implementation of further activities of the Greylag Goose ISSMP through population-specific workplans (Annex 1).

In addition, this AFMP will assist Range States in coordinating the implementation of their derogation schemes and contain information that is relevant for assessing the need for derogations at Range State level (Annexes 2 and 5).

The AFMP provides a framework for joint management of the NW/SW European population of Greylag Goose to ensure that the fundamental objectives (FOs) agreed in the ISSMP are achieved. However, each Range State remains responsible for national planning and implementation, including of derogation measures if needed, within the framework of the ISSMP.

This AFMP covers the period of 2020 – 2026.

[2] https://egmp.aewa.info/sites/default/files/meeting_files/documents/AEWA_EGM_IWG_4_12_GG_AFMP_rev_1.pdf

1. Definitions of Management Units (MUs)

The ISSMP has mandated the EGM IWG to define the Management Units (MUs) in the AFMP to recognise regional differences in migratory behaviour and human-wildlife conflicts. The EGM IWG at its 4th meeting in June 2019 (Doc. AEWA/EGMIWG/4.14[3]) agreed to distinguish two MUs (Figure 1):

MU 1 (migratory)
Breeding: Norway, Sweden, Denmark, Finland
Stopovers: Denmark, Germany, France
Wintering: Netherlands, Denmark, Sweden, France, Spain, Portugal[4]
MU 2 (sedentary)
Breeding: Germany, Netherlands, Belgium, France
Wintering: Germany, Netherlands, Belgium, France

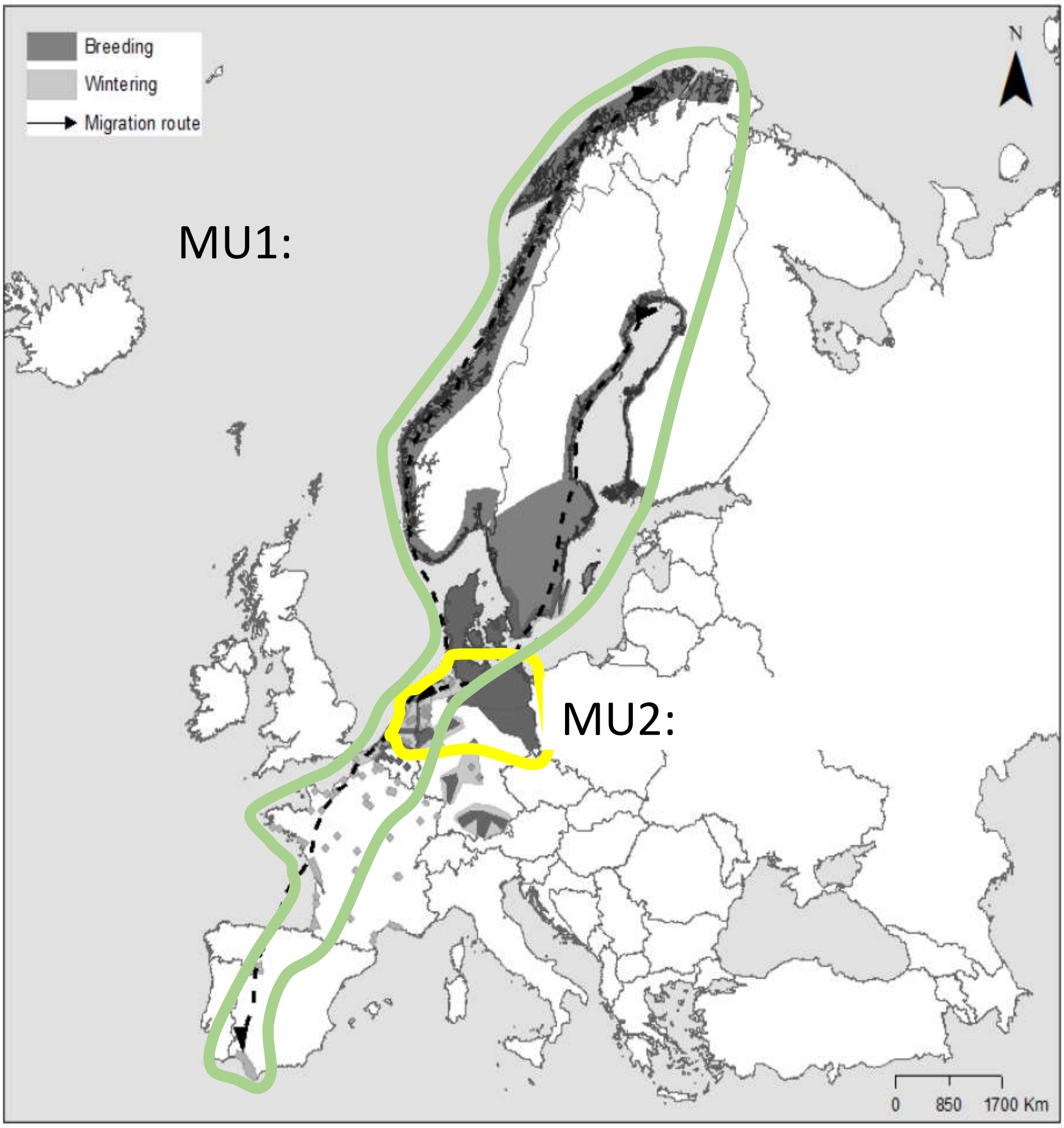

Figure 1. Agreed management units of the NW/SW European population of Greylag Goose.

[3] https://egmp.aewa.info/sites/default/files/meeting_files/documents/AEWA_EGM_IWG_4_14_Def_GG_MUs.pdf
[4] Portugal was originally not included by the population also winters there.

2. Definitions of Favourable Reference Values (FRVs)

The ISSMP has mandated the EGM IWG to set the Favourable Reference Values (FRVs) in the AFMP for the breeding and non-breeding seasons. The FRVs represent the minimum levels of population size, range and habitat necessary to consider a population being in Favourable Conservation Status (FCS). Following the EGM IWG4, a revised document setting out the principles of defining FRVs for the NW/SW European population of the Greylag Goose was circulated on 5 August 2019 and later revised based on written feedback from Range States and a workshop held with the European Commission (EC) and EU Member States on 31 January 2020 (AEWA/EGMIWG/Inf.5.10[5]).

Range States were requested to define their national Favourable Reference Range (FRR), Favourable Reference Habitat (FRH) and the breeding Favourable Reference Population (FRP) values. If no information was provided by the Range States, the breeding numbers reported for the 2013-2018 period under Article 12 of the EU Birds Directive[6] were used. National FRV values were aggregated at MU- and population-level and summarised in Table 1.

Table 1. National, management unit and population level FRVs

Country	bFRP (pairs)	bFRR (km2)	bFRH (Y/N/?)	wFRP (inds)	nFRR (km2)	nFRH (Y/N/?)
Norway	10,000	73,500	Y	562	66,800	Y
Sweden	15,492	155,900	Y	30,690	84,100	Y
Finland	2,700	22,000	Y	n.a.	n.a.	n.a.
Denmark	6,400	45,400	Y	8,920	49,500	Y
Germany	49,780[F]	203,338[F]	?	192,675	?	?
Netherlands	21,000	37,869	Y	110,554	38,136	Y
Belgium	2,000	15,058	Y	11,184	11,100	Y
France	200	18,200	Y	3,695	?	?
Spain	n.a.	n.a.	n.a.	24,939	?	?
Total MU1	**34,592**	**296,800**	**4/0/0**	**(125,569)**	**249,636***	**5/0/3**
Total MU2	**73,040**	**274,465**	**3/0/1**	**(265,133)**	**49,236**	**2/0/1**
Total Population	***107,631***	***571,265***	***7/0/1***	***383,218***	***249,636***	***5/0/3***

Keys:

inds: individuals
b: breeding
n: non-breeding (i.e. both staging and wintering)
w: wintering
Y/N: Yes/No
n.a.: not applicable
?: no data provided
F: in the absence of FRVs provided by the country, it is based on the value reported by the country for 2013-2018 to the European Commission under Article 12 of the EU Birds Directive
*: The sum of national nFRRs in all Range States of this MU

[5] https://egmp.aewa.info/sites/default/files/meeting_files/information_documents/AEWA_EGM_IWG5_Inf_5_10_Defining_FRVs_for_GG.pdf

[6] Available at http://cdr.eionet.europa.eu/ for each EU Member States under European Union (EU) obligations > Birds Directive > Report on Implementation Measures.

Favourable Reference Population (FRP)

The **FRP for the breeding season** (bFRP in Table 1) is **35,000 pairs for MU1**, **73,000 pairs for MU2** and **108,000 pairs for the whole population** after rounding.

The national wintering FRPs were calculated from the national breeding FRPs, using the same factor of 3.63 individuals to convert pair into mid-winter numbers as in the MCDA (Johnson, 2020b) and using the available re-sighting data of neck-banded birds (Table 2). The calculated FRPs for the mid-winter season are presented in Table 1 for each country (wFRP). The **wintering FRP is 383,000 individuals for the entire population** after rounding (Table 1). Theoretically, an estimate of mid-winter FRPs can be calculated based on the breeding numbers for both MUs, but these values cannot be used in practice because in winter the two MUs mix particularly in Germany, the Netherlands and Belgium and a proportion of the birds winter outside of the range of the NW/SW European population[7].

Table 2. Distribution of re-sightings of Greylag Goose in wintering countries from various breeding countries

Wintering **Breeding countries**	**NO**	**SE**	**DK**	**DE**	**NL**	**BE**	**FR**	**ES**	**Other**
Norway (NO)[1]		0.3%	3.3%	14.7%	47.5%	2.0%	2.3%	29.8%	
Sweden (SE)[1]	1.0%	53.7%	7.8%	8.2%	25.5%	0.3%	1.0%	1.9%	1.0%
Finland (FI)[2]		3.9%		3.9%	3.9%			19.4%	69.0%
Denmark (DK)[3]			13.7%	9.6%	19.2%	4.1%	5.5%	48.0%	
Germany (DE)[3]				98.2%	1.8%				
Netherlands (NL)[1]			0.2%	3.5%	92.5%	3.2%	0.1%		
Belgium (BE)[4]					5.0%	95.0%			
France (FR)[4]							100.0%		

Keys:

[1] Based on data for mid-winter in the period of 2008-2012 in Bacon et al. (2019)

[2] Based on data for January in Appendix 2 in Andersson et al. (2001)

[3] Based on data for mid-winter in the period in all years in Bacon et al. (2019)

[4] Assumed. Breeding populations in these countries are very small and unlikely to influence the results significantly.

Favourable Reference Range (FRR)

The **breeding FRR** is estimated at **297,000 km² for MU1**, **274,000 km² for MU2** and **571,000 km² for the entire population** after rounding.

The **FRR for the non-breeding season** cannot be determined for the population and its MUs because national FRRs are not yet set in some countries (Table 1).

Favourable Reference Habitat (FRH)

All countries from MU1 reported that there is sufficient habitat to support the FRP in the **breeding season**. In MU2, there is sufficient habitat to support the FRP in Belgium and the Netherlands. No assessment is received

[7] Therefore, there is a difference of c. 7,500 birds between the sum of the wFRPs of the two MU and the wFRP of the population derived by adding up the calculated national wFRP values within the range of the flyway of the NW/SW European population of Greylag Goose.

from Germany (Table 1). Thus, the FRP is set at the level of the 2013–2018 level (Current Value) of the breeding population there and it is logically not possible that there would be not enough habitat to support the current population in that country. Consequently, there is sufficient habitat to support the FRP in all countries of the flyway.

For the **non-breeding season**, sufficiency of habitat cannot be assessed separately for the two MUs because of the mixing of individuals. Therefore, it is only evaluated at the national and at the population level. Three countries have not reported whether there is sufficient habitat to support the wintering FRP. In all the five other countries, there is sufficient habitat to support the FRP (Table 1).

3. Population targets above the FRVs

The ISSMP has also mandated the EGM IWG to set population targets above the FRP in the AFMP and it has been agreed to use the Multi-criteria Decision Analysis to solicit expert knowledge and stakeholder opinion. The MCDA process, see Johnson (2020b) in Annex 3 for details, has identified two candidate targets with nearly identical scores, 0.7514 and 0.7513, respectively. Therefore, the preferred target is to be identified by the EGM IWG at its 5th meeting in June 2020.

Based on the entire MCDA analysis and subsequent deliberations of the EGM IWG5, the preferred targets for management units MU1 and MU2 are:

[Option A: 70,000 and 100,000 breeding pairs, respectively, resulting in an approximate wintering population size of 617,000 individuals.]

[Option B: 70,000 and 80,000 breeding pairs, respectively, resulting in an approximate wintering population size of 545,000 individuals.]

The proposed wintering population size target is approximately [Option A: 80%] [Option B: 70%] of the population size reported in the ISSMP. [Option A: It represents similar proportions also for the two MUs in the breeding season]. [Option B represents approximately 80% of the size of the breeding population in the ISSMP for MU1 and approximately 70% for MU2].

In MU1, the target (70,000 pairs) is twice as much as the FRP (35,000 pairs), but the target is only 10,000 – 15,000 pairs less than the ISSMP or the Current Value (Figure 2). Therefore, maintaining this population around the target would require a rather tight management of the offtake both through harvest and derogation at both the staging and wintering areas. This MU is a high priority for establishing a dynamic, model-based harvest management system.

In MU2, the target [Option A: of 100,000 pairs is 37% higher than the FRP] [Option B: of 80,000 pairs is 10% higher than the FRP]. In this MU, the CV is much higher than the value reported in the ISSMP mainly because of the substantially higher estimate for Germany (Figure 2). Current Values of the national populations in Germany, Belgium and France are close to the national bFRPs. Therefore, these populations require a tight management to ensure that they are maintained above the bFRP. However, a more substantial reduction [(Option A: c. 38,000 pairs)] [(Option B: c. 58,000 pairs)] of the breeding population is possible in the Netherlands without failing to maintain the population around the target. However, the Netherlands shall exercise derogations with extra care after the arrival of birds from MU1.

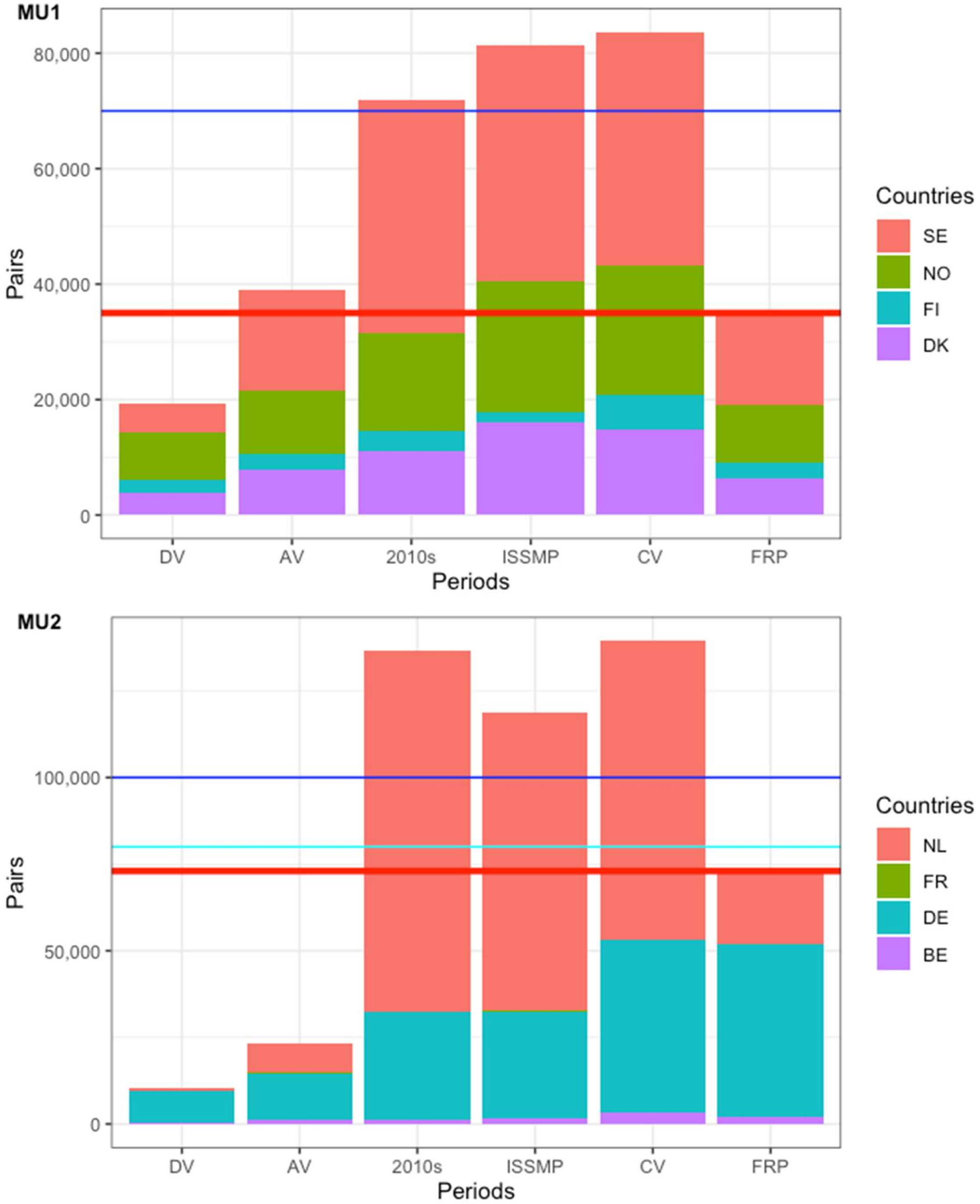

Figure 2. Best single value estimates or geometric means of the minimum and maximum breeding population estimates for MUs 1 and 2 of the NW/SW European population of Greylag Goose population compared to the FRP and the target population size. The bold red line represents the FRP, the dark blue line represents the target for Option A and the light blue one for Option B if different from Option A. DV: approximated based on Heath et al. (2000), AV: based on BirdLife International (2004), 2010s: based on BirdLife International (2015), ISSMP: based on the figures in Table 4 in the ISSMP, CV: based on EU Member States Birds Directive Article 12 reports, for Norway were used the values from the ISSMP; FRP: based on the FRP figures in Table 1 in this document.

4. Population Models to support harvest management

By adopting the ISSMP, Range States have agreed to maintain the population around the target level (Means Objective 4) and, to this end, to "*establish an internationally coordinated population management programme (including both hunting and, if necessary, killing under derogations) for the transboundary management units encompassing monitoring, assessment and decision-making protocols*" (Action 4.2).

Population models are important tools of adaptive harvest management to forecast the impacts of various off-take levels on the population size. However, up-to-date, coordinated, and reliable monitoring data on abundance and offtake throughout the flyway is not available currently. Hence, it is not possible to establish a model-based management of the population at this time.

Furthermore, Johnson (2020a; Annex 4 to this AFMP) concluded that reported estimates of Greylag Goose population size and/or offtake at the flyway level are likely biased. It suggests that the most pressing need is to investigate and strengthen monitoring protocols for Greylag Goose population size estimation and offtake both under hunting and derogation.

Hence, in the face of this deep uncertainty, an information-gap ("info-gap") decision model was developed to allow decision makers in the interim to make informed choices about the magnitude of offtake until more reliable monitoring information is available for the NW/SW European population of Greylag Goose.

As true levels of abundance and offtake on a management-unit basis are unknown, it is necessary to use the growth rate of the flyway population as an interim management criterion. The growth rate criterion has been selected based on the results of the MCDA analysis (Johnson, 2020b), which shows that the population target is likely to be at least 20% less than the current population size. In the face of deep uncertainty about current levels of offtake and abundance, a precautionary approach of seeking to reduce population size is necessary. Therefore, it is proposed to adopt a management criterion of 15% reduction in population size over 10 years, which means an annual growth rate of lambda = 0.98 (Figure 3). As it is unlikely to meet this criterion precisely, a growth rate of 0.96 < lambda < 1.00 is suggested as an acceptable range (i.e., population size decreasing by less than 4%/year). Accordingly, an increasing population, or a population declining more than 4% per year, would be considered unacceptable. Note that the lower limit of annual lambda = 0.96, if realized, would reduce population size by 34% in 10 years.

Based on this criterion, the info-gap analysis suggests that 40% increase in the nominal level of offtake compared to the offtake values mentioned in the ISSMP might be needed to achieve the above management criterion. However, the probability of meeting this management criterion is low (<20%) under all investigated scenarios in the face of deep uncertainty. This means that there is an 86% probability that the population will either increase or decline by more than 4% annually. Furthermore, the current level of offtake, and whether that has changed from that reported in the ISSMP, is unknown. Moreover, the info-gap analysis does not take into account special needs and population trajectories of the MUs and their different segments, and thus it carries a high risk of not meeting the MU-specific population targets if not replaced by a more reliable decision-making tool. Therefore, the info-gap decision analysis does not provide a sound basis for adaptive, dynamic decision-making, which ultimately will be necessary to reliably manage Greylag Goose abundance in accordance with population targets in the two management units. Only up-to-date, coordinated, and reliable monitoring data on abundance and offtake from throughout the flyway will allow us to realize that goal. In order to establish the preconditions for the dynamic, model-based management of the population in the long-term, the following actions need to be implemented before the 2023/2024 hunting season:

1) Establish the necessary monitoring frameworks outlined in Chapter 6;
2) Develop and present new population models by the EGM IWG in 2023.

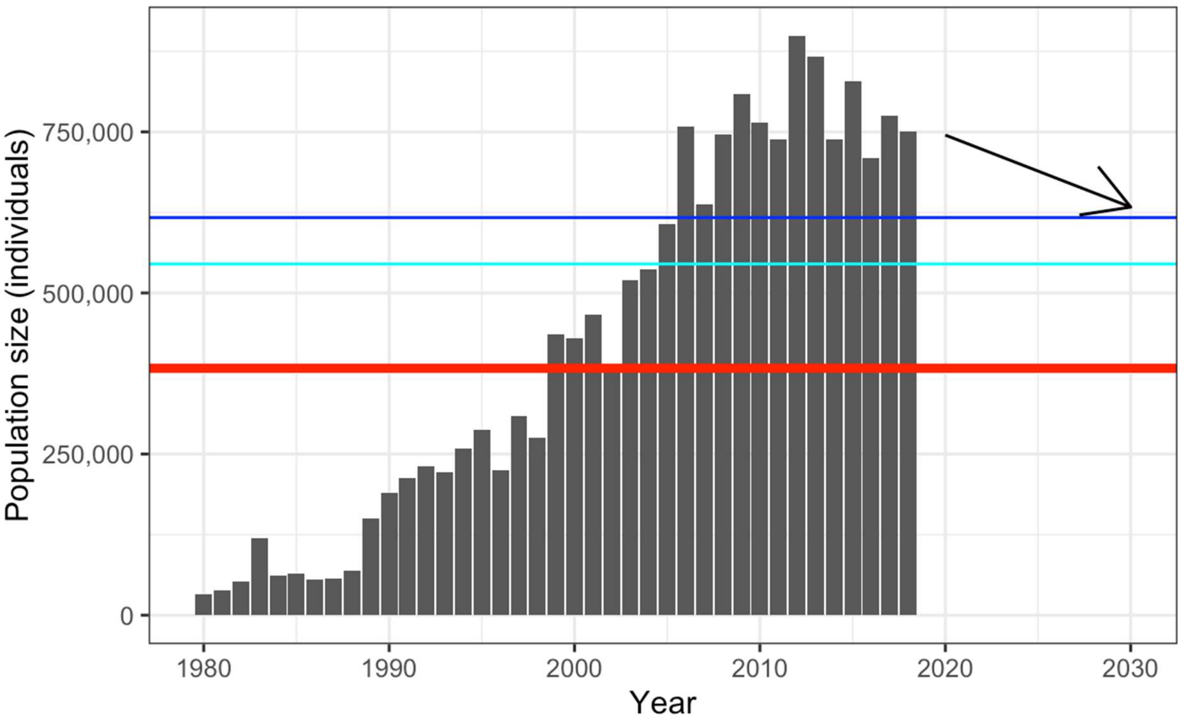

Figure 3. The proposed management of the NW/SE European population of Greylag Goose in relation to the FRP (bold red line) and to the population targets (Option A: the blue line, Option B: the cyan line). The past population development is represented by the bars showing the annual imputed IWC totals and the arrow indicates the projected population trajectory based on the recommended 15% decline in 10 years.

5. Monitoring indicators and programmes

The ISSMP has mandated the EGM IWG to define in the AFMP indicators to measure the progress towards its Fundamental Objectives and to design a monitoring programme to collect the data for these indicators. The proposed indicators are presented in Table 3 for each Fundamental Objective and detailed indicator factsheets describing the rationale of the indicator selection, a more detailed definition of the indicator and the methodology of data collection, data flow, indicator calculation, gap filling and methodological uncertainties is provided in Annex 6.

Table 3. Indicators for fundamental objectives

Fundamental objective	**Related indicators**	**Reporting dates**
I. Maintain the population at a satisfactory level	I.1 Population size compared to the target population size	Annually by 30 April (see also Chapter 6)
	I.2 Range extent compared to Favourable Reference Range (FRR)	31 Dec. 2025
II. Minimize agricultural damage and conflicts	II.1 Relative change in damage payments	31 Dec. 2025
III. Minimize the risk to public health and air safety	III.1 Risk of zoonotic influenza transmission to the general public	No national reporting required
	III.2 Number of bird strikes with aircrafts caused by Greylag Goose	31 Dec. 2025
	III.3 Number of Greylag Geese passing over commercial airports	31 Dec. 2025
IV. Minimize the risk to other flora and fauna	IV.1 Area of natural habitat or habitat of threatened species negatively affected by Greylag Goose	31 Dec. 2025
V. Maximise ecosystem services	V.1 Number of people enjoying watching geese	31 Dec. 2025
	V.2 Number of recreational Greylag Goose hunters	31 Dec. 2025
	V.3 Number of Greylag Geese killed and used	31 Dec. 2025
VI. Minimise costs of goose management	VI.1 Relative change in cost of goose management	31 Dec. 2025
VII. Provide hunting opportunities that are consistent with maintaining the population at a satisfactory level	VII.1 Available sustainable hunting quota	Annually at the EGM IWG meeting

6. Protocols for the iterative phase

Management evaluation and adaptation of the NW/SW European population of Greylag Goose follows three iterative phases running in parallel (Figure 4):

1. A 10/12-year cycle of the ISSMP[8];
2. Two 6-year cycles of the AFMP, and within the AFMP:
    3. 1-year cycles of:
        i. Indicators/monitoring related to population models/harvest assessment;
        ii. Update of population models and harvest assessment;
        iii. Annual implementation of actions by range states;
        iv. Update work plans.

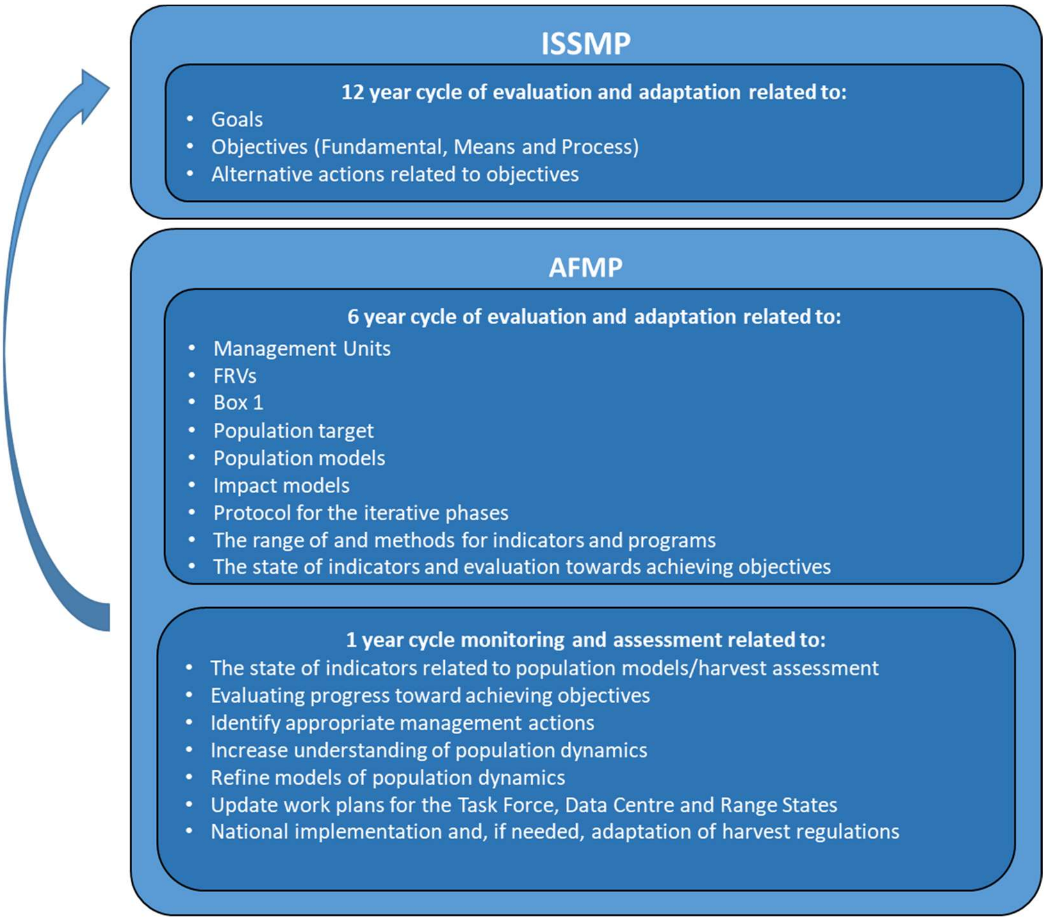

Figure 4. Flow chart of the three iterative phases of the AFMP

[8] The lifespan of the ISSMP is 10 years. However, it might be logical for the EGM IWG to recommend to the AEWA MOP to expand it to 12 years to include two 6-year-long AFMPs.

10/12-year cycle of the ISSMP

The 10 (or 12 year[9]) cycle of the ISSMP encompasses evaluation and adaptation related to:

- Goals;
- Objectives (Fundamental, Means and Process);
- Alternative actions related to objectives.

6-year cycle of the AFMP

The 6-year cycle of the AFMP encompasses evaluation and adaptation related to:

- Management Units (Chapter 1);
- FRVs (Chapter 2);
- Box 1 (Annex 2);
- Population target (Chapter 3, Annex 3);
- Population models (Chapter 4, Annex 4);
- Impact models (Annex 5);
- Protocol for the iterative phases (Chapter 6);
- The range of and methods for indicators and programs (Chapter 5, Annex 6);
- The state of indicators and evaluation towards achieving objectives (Chapter 5, Annex 6).

The AFMP is evaluated and adapted next time in 2026 by the EGM IWG.

1-year cycles within the AFMP

The annual cycle within the AFMP encompasses monitoring and assessment related to:

- The state of indicators related to population models/harvest assessment (Action 4.2 in the ISSMP);
- Evaluating progress toward achieving objectives;
- Identify appropriate management actions;
- Increase understanding of population dynamics;
- Refine models of population dynamics;
- Update work plans for the Task Force, Data Centre, Range States (Annex 1);
- National implementation and, if needed, adaptation of harvest regulations.

Indicators/monitoring related to objectives and population models

Short-term (2020-2022) needs to set the stage for MU-based models in 2023

From June 2020 to June 2022 the "info-gap" decision model will be used to identify possible management actions at the population level (Chapter 4, Annex 4). However, the info-gap does not allow management of Greylag Goose towards separate abundance targets in the two management units. Therefore, the following activities shall take place to set the stage for MU-based models in 2023 (in parenthesis the relevant years for this phase are listed):

1. An evaluation of potential bias in reported offtake in each range state (between 2020-2022);
2. Development and implementation of a coordinated and systematic monitoring program including development of indicator fact sheets for the long-term data need (2020-2022);
2. Monitoring of:

[9] Currently the timespan of the ISSMP is 10 years, but it might be logical to expand it by two years to include two 6-year AFMP cycles.

a. Mid-winter population counts for each range state (January 2021 and 2022);
b. Breeding pairs per range state derived either from:
   Option A: Summer counts per range state + proportions of young and older birds (July 2020[10] and 2021) + development of protocol to convert summer counts to breeding pairs (2020-2022);
   Option B: Number of breeding pairs per range state from reporting to the Article 12 of Bird Directive for the period of 2013-2018 + Common Bird Monitoring Index (2020 and 2021);
c. Offtake (harvest + derogation) per range state, distinguished between "breeding" period (1 February-31 July) and "post-breeding" period (1 August-31 January) seasons where possible (season 2020/21 and 2021/22);
d. Crippling rate for the same periods as offtake (season 2020/21 and 2021/22);
e. Multi-state Capture-Marking-Resighting (CMR) analysis to estimate annual survival rates and MU transition probabilities (between 2020-2022);

3. Data collation and analysis (April-May 2021 and 2022);
4. Harvest assessment at population level (May 2021 and 2022);
5. Decision making (EGM IWG) (mid-June 2021 and 2022);
6. Implementation by Range States (2021 and 2022).

During the period June 2020-June 2022, it will not be possible to make harvest recommendation at MU level. Furthermore, for optimal management recommendations, monitoring data shall be submitted the same year as the data is collected, e.g. monitoring activities from the season 2020/2021 shall ideally be submitted by 30 April 2021 and used during the assessment in 2021. However, during the period 2020-2022, this is not possible, and management recommendations will be based on data from the previous season. Hence the assessment in 2021 will be based on data from the season 2019/20, and the assessment in 2022 will be based on data from the season 2020/21. This also means that existing data from before 2019/2020, which is not already submitted to the Data Centre, should be submitted before the assessment in 2021.

Long-term needs for annual monitoring
To be able to carry out modelling of abundance and offtake as well as management at MU level, a coordinated and systematic monitoring program must be established and maintained. The monitoring program and the specific activities are listed below. The activities shall start up at the time indicated below in parenthesis and thereafter continued and take place each year, and every 3 year for "Number of breeding pairs per range state from reporting of the Bird Directive" in Option B:

1. Monitoring of:
   a. Midwinter counts for each range state (from January 2023 onwards);
   b. Breeding pairs per range state based on:
      Option A: Summer counts per range state + proportions of young and older birds (from July 2022 onwards);
      Option B: Number of breeding pairs per range state from reporting to the Article 12 of Bird Directive for the period of 2013-2018 + repeated in every 3 or 6 years (i.e. in 2021 and/or 2024, to be agreed by the EGM IWG) + Common Bird Monitoring Index (from 2022 onwards)
   c. Offtake (harvest + derogation) per range state, distinguished between "breeding" period (1 February-31 July) and "post-breeding" period (1 August-31 January) seasons (from season 2022/23 onwards);
   d. Crippling rate for the same periods as offtake (from season 2022/23 onwards)

[10] Only for existing setups.

   e. Multi-state CMR analysis including the process of capturing and marking
   f. Optional: samples of tail fans or wings in early autumn to index reproductive success
2. Data collation and analysis (from April-May 2023 onwards)
3. Optimal harvest strategy at MU level (from May 2023 onwards)
4. Decision making (EGM IWG) (from mid-June 2023 onwards)
5. Implementation by Range States (from 2023 onwards)

Based on this information, it will be possible to make the first harvest recommendation at MU level at the EGM IWG meeting in 2023 the earliest, provided that necessary data is made available. Furthermore, during the assessment in 2023 and onwards, up-to-date data have to be available, hence during the assessment in 2023 data from the season 2022/2023 shall be used.

Monitoring data is to be submitted to the EGMP Data Centre on an annual basis, and in a timely manner before the annual IWG meeting, hence no later than 30 April. This is for the Data Centre and Modelling Consortium to perform the assessment and the EGMP Data Centre to produce status reports providing recommendations to the annual IWG meetings.

References

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Annex 1. Annual workplans

According to the ISSMP for the NW/SW European population of Greylag Goose, the AFMPs set out annual workplans for the ISSMP actions relevant for the population/management unit. At the current stage, due to the limited data available on the population size and offtake, Greylag Goose harvest cannot be managed at MU-level. In addition, most management actions will be overlapping. Therefore, it is proposed to establish one workplan for both management units. As the role of the workplan is to guide the implementation of the ISSMP, the prioritisation and timescale agreed in the ISSMP provides a framework for the work planning process. The ISSMP prioritises actions as Essential, High and Medium priority and assigns time-scales to actions as follows: *Immediate*: launched within the next year, *Short*: launched within the next 3 years*, Medium*: launched within the next 5 years, *Long*: launched within the next >5 years, *Ongoing*: currently being implemented and should continue, *Rolling*: to be implemented perpetually. In essence, this timescale system can be seen as a mechanism to stagger the implementation of actions taking into account both their dependencies and urgencies (Figure 5).

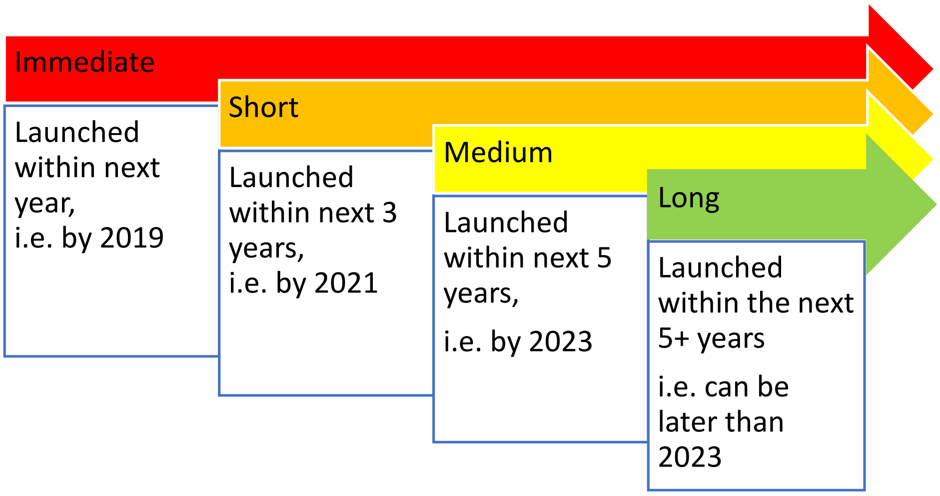

Figure 5. Timescale for the implementation of the ISSMP for the NW/SW European population of Greylag Goose.

The timescale in combination with the priorities set in the ISSMP can be used to phase the implementation of actions. Thus, the most important would be to implement Essential actions that have an Immediate timing, followed by High priority with Immediate timing, etc.

Implementation of the ISSMP requires work by different entities (Figure 6). Some actions should be done at national level as part of national workplans. To facilitate coordination amongst Range States, it is proposed to establish a species-specific Task Force for the Greylag Goose (AEWA/EGMIWG/5.16).

On the other hand, there are actions that are cross-cutting, affecting not only the population/management unit for which the work plan is developed but also some populations of other EGMP species such as the Barnacle Goose and possibly also the Pink-footed Goose and the Taiga Bean Goose: e.g. B.3 Create a toolbox for decisions in relation to determining significant damage. The implementation of such tasks by population/management unit specific Task Forces would be inefficient and best taken up by a cross-cutting TF (e.g. the Agriculture TF) or by the EGMP Data Centre.

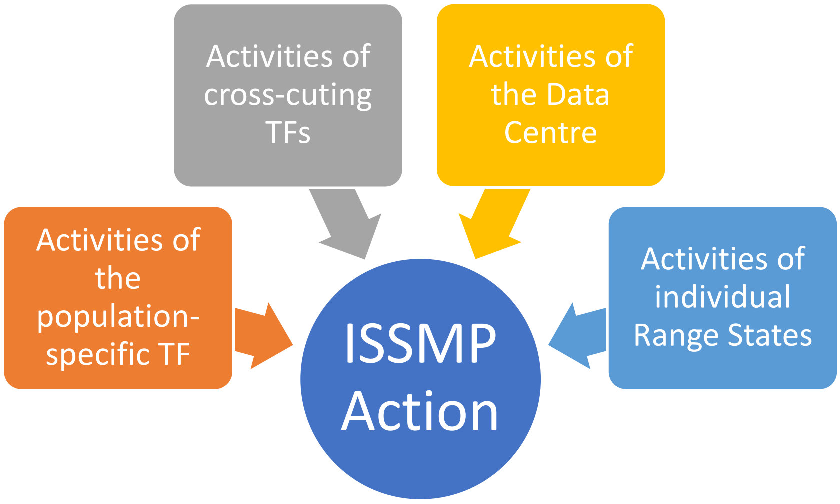

Figure 6. Entities contributing the implementation of the implementation of the Greylag Goose ISSMP and would need to develop annual workplans.

It is proposed that each EGM IWG entity contributing to the implementation of the ISSMP for the NW/SW European population of Greylag Goose uses a common structure to produce its own workplan. This structure includes the ISSMP actions relevant for the time period (i.e. 2020/2021 between the 5th and 6th meeting of the EGM IWG), their priority and timescale as defined in the ISSMP, list of activities to be implemented by the entity (e.g. a Range State, the Greylag Goose Task Force, Data Centre and the relevant cross-cutting Task Forces). It is recommended that in the period of 2020/2021, the EGM IWG entities focus on implementing the activities that have a timescale of Immediate or Short and focus first on the Essential ones followed by High and then by the Medium priorities as capacity allows.

An online form is available at:
https://docs.google.com/spreadsheets/d/1M64HWxzVagM9W0mG8iMMeVYS3_-M44W6QsHvvUonST8/edit#gid=1472654637

It is proposed that the Data Centre will develop their workplans before the EGM IWG5. EGMP Range States, the proposed Greylag Goose Task Force and the Agriculture TF will develop their own workplans following the adoption of the AFMP at EGM IWG5, but before 30 September 2020. The workplans of the Greylag Goose TF, the Agriculture TF and the EGMP Data Centre will be adopted by the EGM IWG in writing and revised at the next meeting of the EGM IWG in June 2021 (EGM IWG6).

Annex 2. Box 1 of the ISSMP for the Greylag Goose

The ISSMP requires the use of a more detailed analysis concerning damage and site protection, as set out in Box 1 of the ISSMPs with the purpose to assist Range States in assessing the need for derogations from the provisions of Articles 5-8 of the EU Birds Directive and in coordinating the implementation of their derogation schemes. Each AFMP should therefore contain information that is relevant for assessing the need for derogations at Range State level.

A two-year project (2019-2021) is funded by the German Federal Ministry for Environment and Nuclear Safety (BMU) and coordinated by the EGMP Data Centre. The project started in December 2019 and is expected to end in July 2021 with results ready for the 6th Meeting of the EGM IWG (EGM IWG6 in June 2021). In December 2019, a questionnaire for each species was sent to the Range States. The deadline for responses was set by 31 January 2020 and later postponed to 31 March 2020. Responses have been received from most countries (Table 1). However, the degree of information from the countries varies from very little information to almost full response to all questions. A questionnaire regarding air safety is treated separately by direct contact to the relevant national air safety organisations. The EGMP Agriculture Task Force will be consulted for matters regarding agricultural damage. All data will be synthesized and used for the final report at the end of the project period in 2021.

Table 1*. All countries requested for data in relation to Box 1. Responses received by the deadline 31 March 2020 are indicated by an X.*

Country	Greylag Goose NW/SW European population
Belgium	X
Denmark	X
Finland	X
France	X
Germany	
Netherlands	X
Norway	X
Spain	X (Andalusia only)
Sweden	X

Annex 3. Setting population targets

Setting Population-Size Targets for the NW/SW European Population of Greylag Geese Using Multi-Criteria Decision Analysis

Prepared by the EGMP Data Centre:
Fred A. Johnson and Henning Heldbjerg, Aarhus University, Denmark

HIGHLIGHTS

- Twenty-one European goose experts used their professional judgement to state the relationship between Greylag Goose abundance and nine management objectives.
- Objective weights expressed by EGMIWG members were highest for habitat impacts, agricultural damage, and bird strikes, intermediate for government costs, cultural and aesthetic values, and sport hunting, and lowest for amenity fouling and disease transmission.
- By combining the judgements of goose experts and the relative importance of objectives expressed by EGMIWG members in a multi-criteria decision analysis (MCDA), we identified preferred population targets for the two management units of Greylag Geese.
- The most preferred target for management unit #1 (migratory segment) is 70 thousand breeding pairs. The most preferred target for management unit #2 (sedentary segment) is 100 thousand breeding pairs. Both targets represent about a 20% reduction from current values and the approximate wintering population size associated with this candidate is 617 thousand.
- However, targets of 70k and 80k breeding pairs for units MU1 and MU2, respectively, had nearly an identical score to the most preferred candidate. The approximate wintering population size associated with this candidate is 545 thousand.
- The MCDA should not be perceived as dictating a preferred set of candidate targets; rather it narrows the range of candidates that may be worthy of further discussion, particularly if there are considerations not fully captured by the analysis.

Summary

In 2018 the European Goose Management International Working Group (EGMIWG) approved multi-criteria decision analysis (MCDA) as a framework for deliberations concerning the setting of management targets for the NW/SW European population of Greylag Geese (*Anser anser*). Phase I of the MCDA involved identification of the fundamental management objectives of the International Single Species Management Plan (ISSMP), and an expert elicitation of the expected consequences of varying levels of Greylag Goose abundance in the two established management units. Across all objectives, there tended to be more agreement among technical experts in the shapes of the relationships with Greylag Goose abundance during the breeding season than during the winter. When weighted by country-specific abundance, most relationships were nearly linear, although the slopes of the curves varied among objectives. In particular, the curves were nearly flat for habitat impacts (objective #6) and public health (objective #8) during the winter, suggesting that Greylag Goose

abundance had little influence on those objectives during the wintering period. For cultural and aesthetic values (objective #1), the weighted curves were parabolic, reflecting the view that maximization of this objective occurs in the mid-range of Greylag Goose abundance. In phase II of the MCDA, members of the EGMIWG were asked to assign weights to the management objectives, reflecting the perceived importance of each objective. Once objective weights were solicited, they were used to identify a preferred alternative (a set of management-unit population targets in this case). Because objective weights varied among members of the EGMIWG, we used a well-established consensus-convergence model to identify a set of consensus weights. Consensus-convergence weights were highest for habitat impacts, agricultural damage, and bird strikes, intermediate for government costs, cultural and aesthetic values, and sport hunting, and lowest for amenity fouling and disease transmission. Accordingly, the highest scoring candidate targets tended to be those with the lowest breeding and wintering abundances. Based on the entire MCDA analysis, the preferred breeding-pair targets for management units MU1 (Norway, Sweden, Denmark, Finland) and MU2 (Netherlands, Belgium, NW Germany) are 70 thousand and 100 thousand, respectively (weighted score = 0.7514). However, targets of 70 thousand and 80 thousand breeding pairs for units MU1 and MU2, respectively, had nearly an identical score (weighted score = 0.7513) to the most preferred candidate. The approximate wintering population size associated with the most preferred candidate is 617 thousand, compared to 545 thousand for the second-most preferred candidate. For both management units, the preferred targets represent about a 20% reduction from current values of breeding-season abundance. Despite limitations, the MCDA process as conducted was fully transparent and, importantly, clearly separated the application of science (the expert elicitation) from value-based policy decisions (the swing-weighting exercise). Nonetheless, we emphasize that the MCDA should not be perceived as dictating a preferred set of candidate targets; rather the MCDA narrows the range of candidates that may be worthy of further discussion, particularly if there are considerations not fully captured by the analysis.

Introduction

The range of the NW/SW European population of Greylag Geese includes Norway, Sweden, Finland, Denmark, Germany, Netherlands, Belgium, France and Spain. In 2018, at the EGM IWG3 that took place in Leeuwarden, the Netherlands, the EGMIWG approved MCDA as a framework for deliberations concerning the setting of management targets for this population. Widely used in natural resource management, MCDA combines scientific information with value-based objectives to identify a preferred decision alternative (Huang et al. 2011). The idea for Greylag Geese is to first consider fundamental management objectives described in the ISSMP (Powolny et al. 2018) and then use the best information available to predict the consequences of varying levels of goose abundance for each of those objectives. The best choice of a target for abundance is the one that maximizes the weighted sum of consequences across objectives, using objective weights provided by decision makers. MCDA explicitly recognizes multiple objectives and inherent tradeoffs, and relies on decision makers to determine the relative importance of various management objectives.

Phase I of the MCDA involved identification of the fundamental management objectives of the ISSMP and an assessment of the potential consequences of varying levels of Greylag Goose abundance (Fig. 1). Ideally, the potential consequences of various population sizes are based on empirically based models. Although population models for Greylag Geese are in development, they are not yet ready nor will they be sufficient to address all management objectives. Thus, we relied on expert opinion, which is widely used in the absence of empirical information and can be a valuable tool for decision-making if rigorous protocols are followed (Morgan 2014).

The expert elicitation was followed by phase II of the MCDA, in which members and permanent observers of the EGMIWG were asked to assign weights to the management objectives, reflecting their perceived importance of each objective. National Government Representatives (NGRs) and permanent observers of the EGMIWG participated in this exercise. Participants used a technique known as swing weighting (Gregory et al. 2012) to identify weights using the results of the expert elicitation described above. Swing weighting is an exercise in which decision makers are asked to rank the perceived importance of multiple objectives and then to identify acceptable tradeoffs among them.

In this report, we describe the methods used in each phase of the MCDA, provide the results of those two phases, and describe and discuss the results of the MCDA in terms of potential population targets.

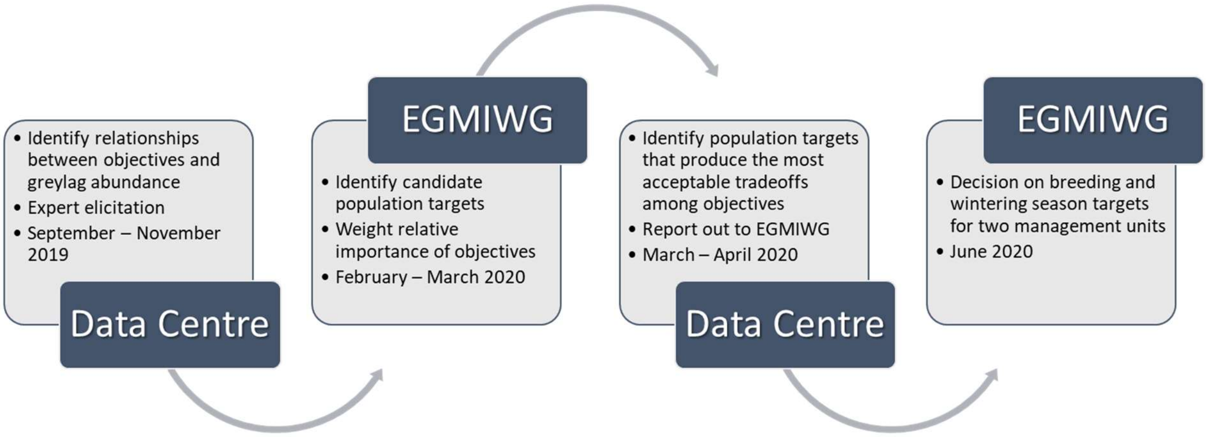

Figure. 1. Phases and timeline of the multi-criteria analysis used to help set population targets for the NW/SW European population of Greylag Geese.

Methods

The EGMIWG has chosen to manage the flyway population based on two breeding management units (MU):

MU 1 (migratory)
Breeding: Norway, Sweden, Denmark, Finland
Stopovers: Denmark, Germany, France
Wintering: Netherlands, Denmark, Sweden, Spain, France

MU 2 (sedentary)
Breeding: Netherlands, Belgium, NW Germany
Wintering: Netherlands, Belgium, NW Germany

We relied on the ISSMP (pages 15-17) for specification of fundamental management objectives. In some cases, we attempted to provide more specificity to the objectives so that it was clear to experts exactly what consequences were being elicited. In all cases except the objective related to sport hunting opportunity, we recognized that consequences might vary between breeding (roughly defined as April-August) and wintering (roughly defined as August-April) seasons. The objectives were defined as follows:

	Criterion	Objective
(1)	Maximize	Cultural and aesthetic values provided by Greylag Geese
(2)	Minimize	Agricultural damage (real or perceived loss of crop biomass) by Greylag Geese
(3)	Minimize	Government payments to mitigate agricultural damage by Greylag Geese
(4)	Minimize	Direct costs to government of culling and scaring Greylag Geese
(5)	Minimize	Indirect costs to government of public derogations of Greylag Geese
(6)	Minimize	Deleterious impacts to other species resulting from habitat modifcation by Greylag Geese
(7)	Maximize	Satisfaction with amount of sport hunting opportunity for Greylag Geese
(8)	Maximize	Public health (amenity fouling & disease transmission by Greylag Geese)
(9)	Maximize	Air safety (number of bird strikes by Greylag Geese)
Not listed	*Maximize*	*Probability that population size falls above the FRVs for Greylag Geese*
		(FRVs have not yet been established.
		Any candidate population target that is less than or equal to a
		FRV that is eventually established will be dropped from consideration)

Phase I: Expert Elicitation

For each of the nine management objectives, experts were asked to decide which of several candidate relationships they believed best characterized the true relationship between Greylag Goose abundance and the performance metric provided. Experts were asked to do this separately for the breeding season and for the wintering season in their respective country. We emphasized that it was the general shape of the relationship that was important, rather than the precise values of the x-y coordinates. Breeding-season relationships are management-unit specific (experts only received a form containing the management unit in which their country was a part), but the wintering season included Greylag Goose abundance arising from both management units. The current, approximate country-specific distributions of Greylag Geese for each season were provided as reference.

The candidate relationships provided to experts are shown below (Fig. 2), with the scaling of Greylag Goose abundance depending on the management unit and season. The x axis thus indicated varying levels of goose abundance and the y axis represented the consequence for the objective in question. For the candidate relationships (A, B, C, …), the x axis provided a range of possible abundance values of Greylag Geese, which included ±20% of current minimum and maximum values. To serve as a benchmark, the approximate, average current values were shown as vertical dashed lines on the graphs. Breeding season abundance was in number of breeding pairs, whereas the wintering population was absolute number of individuals (both in thousands). The y axis represented a relative score corresponding to varying levels of Greylag Goose abundance and for computational purposes, we allowed this score to range from zero to one. We note that the parabolic relationship for cultural and aesthetic values (candidate E) was available only for this objective because we reasoned that the relationships with other objectives should be monotonic (i.e., never decreasing). For this exercise we assumed that current estimates of Greylag Goose abundance are approximately correct. However, it is possible that current estimates of abundance are biased low. If that turns out to be the case, we will simply rescale the x axis and we will still be able to use the original responses from the experts.

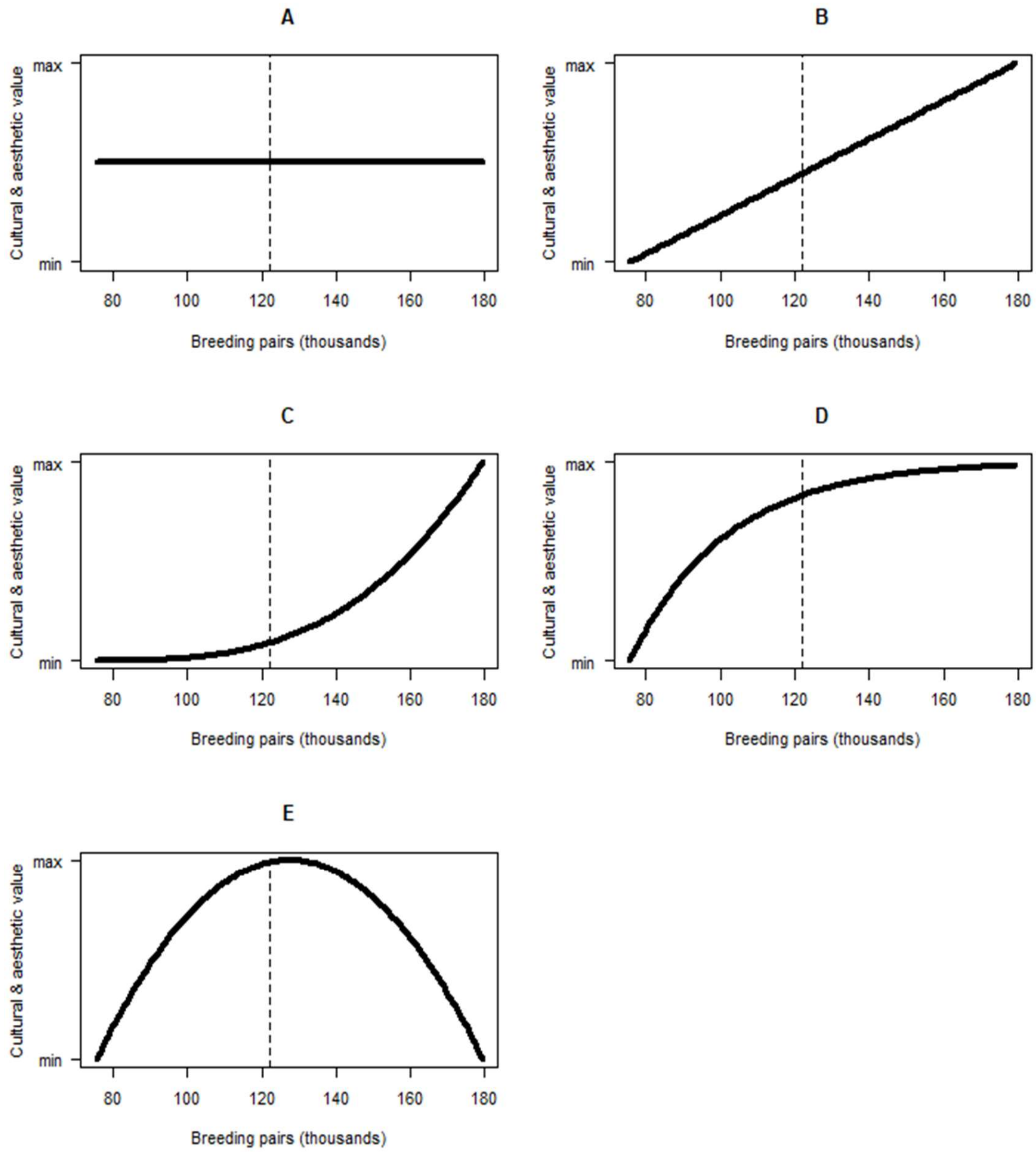

Figure 2. Possible relationships between Greylag Goose abundance and a management objective (cultural and aesthetic values in this case). The vertical, dashed line is current abundance in MU2 as provided in the ISSMP.

Once experts decided which relationships best characterized the true relationship in their country, they were asked to allocate 100 points among them. For example, for cultural and aesthetic values an expert may have decided that the relationship was most likely linear (B), but they also believe it could be asymptotic (D). Thus, they might have placed 75 points on (B) and 25 points on (D). Thus, the assigned points were meant to represent the experts' level of confidence in the candidate relationships. Notice that candidate (A) posits no relationship between goose abundance and the objective. This might be the case, e.g., where impacts occur at a very local level and any relationship with goose abundance may be largely absent at the country level. Experts were instructed not to feel compelled to respond to an objective or season if they did not feel qualified to do so, or if it was not applicable to their country (e.g., sport hunting in the Netherlands, agricultural damage payments in Norway).

Finally, we strongly emphasized to experts that their responses were intended to represent the best available information (i.e., empirical information or expert opinion) and that they should be as objective as possible. The expert elicitation was a modeling exercise and thus it would have been inappropriate to impart personal values or institutional agendas. Value-based judgements indicating the relative importance of the management objectives are the purview of decision makers and have been assessed in the phase II of the MCDA.

The EGMP Data Centre identified experts who were known for their scientific work on goose ecology and management in the Range States of the NW/SW European population of the Greylag Goose. Identified candidates were those who work with aspects of human-goose interactions and ecosystem services, including exploitation. The Data Centre contacted at least three experts in each participating Range State, and received responses from the following number of goose experts (Appendix):

Belgium: 2
Denmark: 3
Finland: 2
France: 2
Netherlands: 2
Norway: 3
Spain: 4
Sweden: 3

To summarize the relationships for each management unit we used the following protocol:

- Within a country, responses from experts were equally weighted using a simple average because there was no a priori reason to believe some experts were more qualified than others.
- Once breeding-season responses were averaged over experts for each Range State, they were combined for a management unit response using a weighted average, with weights based on the current estimate of breeding pairs in each country (as provided in the ISSMP).
- For wintering season responses, Range States were also combined using a weighted average, but with weights based on the approximate winter distribution of geese among Range States (as determined by neck collar observations).

Specification of candidate population targets is inherently arbitrary, but the goal was to select a range wide enough to encompass diverse stakeholder interests, and with increments that would reflect realistic management and monitoring capabilities. We next specified candidate population targets for the two management units in the following manner (all values in thousands):

MU1:

- Breeding-pair range reported in ISSMP: 81.6 – 92.0 (mean = 86.8)
- Reported range ± 20%: 65.3 – 110.4
- Five equally spaced values within the range (rounded): 65, 77, 88, 99, 110
- Candidates: 70, 80, 90, 100, 110

MU2:

- Breeding-pair range reported in ISSMP: 94.5 – 149.5 (mean = 122.0)
- Reported range ± 20%: 75.6 – 179.4
- Five equally spaced values within the range (rounded): 76, 102, 128, 153, 179
- Candidates: 80, 100, 120, 140, 160

Using the weighted curves described above, we constructed a table depicting the consequences of candidate targets for all nine objectives during both the breeding and wintering seasons. The candidate targets were specified as all possible pairs of the five candidates for each management unit. Thus, there were 25 total candidates, expressing possible targets for the two management units. As before, breeding-season and wintering-season consequences were weighted by the relative abundances of Greylag Geese in each Range State.

The resulting consequence table depicts scores for the 25 candidates on each of the nine objectives for each season. Thus, the table has 18 rows and 25 columns, making it difficult to assess the relative tradeoffs among objectives. For example, low targets generally score better on objectives like agricultural damage (objective #2), but worse on objectives like cultural and aesthetic values (objective #1) or the level of satisfaction with the amount of sport hunting (objective # 7). While these sorts of general patterns are apparent, the precise extent of the tradeoffs is difficult to assess because of so many objectives and so many candidate targets. Fortunately, there are two ways to simplify a consequence table so that the nature of the tradeoffs is more obvious (Hammond et al. 1999). The first is to determine if there are any irrelevant objectives; i.e. those that do not substantially help a decision maker distinguish among the candidate targets. The second is to determine if there are any dominated alternatives; i.e., those candidate targets that perform worse or no better than other targets across all objectives. We used both approaches to simplify the consequence table.

We first inspected the correlation between breeding and wintering season consequences for each of the nine objectives, reasoning that if there was a high correlation then the consequences for one of the two seasons were largely redundant. We observed the following Pearson correlation coefficients between the breeding and wintering-season consequences for each objective:

1) Cultural and aesthetic values: 0.85
2) Agricultural damage (real or perceived loss of crop biomass): 0.93
3) Government payments to mitigate agricultural damage: 0.98
4) Direct costs to government of culling and scaring: 0.96
5) Indirect costs to government of public derogations: 0.91
6) Deleterious impacts to other species resulting from habitat modification: 0.95
7) Satisfaction with amount of sport hunting opportunity: NA
8) Public health (amenity fouling & disease transmission): 0.93
9) Air safety (number of bird strikes): 0.72

We chose a correlation coefficient of 0.90 as a threshold, and eliminated the wintering-season consequences for any objective that had a coefficient greater than this. While we could have eliminated the breeding-season consequences instead, we chose to retain them because the focus is on establishing breeding-season targets for the two management units. For cultural and aesthetic values and for air safety, the correlation coefficients fell below the threshold of 0.9. For cultural and aesthetic values, we chose to retain only the wintering-season consequences because they were generally higher (better) than during the breeding season. We believe this is a logical outcome because geese are concentrated in flocks during the winter and the subject of considerable bird-watching. For air safety (bird strikes), the consequences were also generally higher (worse) during the winter season, again perhaps due to large concentrations of geese. For both objectives, we therefore retained consequences only for the wintering period. For sport hunting opportunity, we also only used the wintering-season consequences because there is no sport hunting during the breeding season.

Once we had reduced the consequence table to nine rows, one for each objective, we focused on those objectives related to government costs (objectives #3-5). Because both direct and indirect costs are on the same scale (0-1), we combined them for a total cost. In the expert elicitation, we distinguished among different type of costs because of the possibility that the relationships with Greylag Goose abundance might differ. However, once those different costs are tabulated for each of the candidate targets, it is possible to simply sum them for a total cost to government. The resulting consequence table now had seven objectives to use in evaluating the 25 candidate targets.

We next turned to identifying any dominated candidate targets. The following candidates did worse or no better than other candidates; i.e. they were "dominated" by other alternatives and thus could be eliminated from consideration. The dominated alternatives were (values are in thousands of breeding pairs for MU1/MU2): 90/80, 90/100, 90/120, 100/80, 100/100, 100/120, 100/140, 110/80, 110/100, 110/120, 110/140. The result was a greatly simplified consequence table consisting of seven objectives and 14 candidate targets. This reduced consequence table was provided to members of the EGMIWG in order to elicit the relative importance of management objectives.

Phase II: Weighting of Management Objectives

When a decision maker has more than just a few objectives, swing weighting is one of the easiest methods for determining their relative importance (Gregory et al. 2012). Swing-weighting involves a thought experiment where the participant is first asked to imagine a baseline alternative that has the worst consequences across all objectives. Then the participant is asked to identify their most important objective and to swing its (and only its) consequence from its worst value to its best to develop hypothetical alternative. That alternative is given a rank of 1 (the best). The participant repeats the process swinging one (and only one) consequence from its worst to its best, and ranks those hypothetical alternatives from the second best (2) to the worst (7, in this case). Then the participant assigns 100 points to the hypothetical alternative ranked number 1. They then assign points to the remaining hypothetical alternatives in accordance with how important they are relative to the top ranked one. Finally, the point values are normalized to provide a relative weight for each of the objectives.

Once objective weights were solicited, they were used to identify a preferred alternative (a set of management-unit population targets in this case). First, all consequence scores from the expert elicitation were normalized to the interval 0-1 (with 0 being the worst outcome and 1 being the best) for each objective. Then for each alternative, a weighted sum of the (normalized) consequence scores was calculated, using the objective weights established in the swing-weighting exercise. Because objective weights varied among members of the EGMIWG, we used the consensus-convergence model to identify a set of consensus weights (Regan et al. 2006). This method avoids many of the pitfalls of ad hoc methods of negotiation and consensus-building because it is inclusive of all group members, is blind to dominant personalities within the group, and is immune to the influence of powerful special interests. The consensus-convergence model has its foundations in the philosophy of negotiation, and the method is both transparent and repeatable. Basically, the method relies on the correlations in responses among participants. Higher correlations result in more weight on those participants. In other words, participants with more similar objective weights have more influence on the overall average. Extreme views (e.g., almost all of the weight on any one objective) have less influence on the overall average. By agreeing to the application of this method for creating consensus weights, all stakeholders are essentially agreeing to compromise their values to some extent by explicitly recognizing the different values of others in the group (which, of course, is the basis of any negotiated settlement).

We received objective weights from the national governments of Belgium, Denmark, Finland, France, the Netherlands, Norway, and Sweden (Germany is not participating in the implementation of the Greylag Goose ISSMP, and thus did not participate in this exercise) and from the following EGMIWG permanent observers: the International Council for Game and Wildlife Conservation (CIC), the Committee of Professional Agricultural Organisations-General Confederation of Agricultural Cooperatives (COPA-COGECA), BirdLife , the European Federation for Hunting and Conservation (FACE), the European Institute for the Management of Wild Birds and their Habitats (OMPO), Wetlands International, and the Wildfowl and Wetlands Trust (WWT) (Appendix).

Results

The following graphs (Figs. 3-11) depict responses elicited from experts concerning the consequences of varying goose abundance during breeding and wintering seasons, along with the weighted averages as described above. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets.

Across all objectives, there tended to be more agreement among goose experts in the shapes of the relationships with Greylag Goose abundance during the breeding season than during the winter. When weighted by country-specific abundance, most relationships were nearly linear, although the slopes of the curves varied among objectives. In particular, the curves were nearly flat for habitat impacts (objective #6) and public health (objective #8) during the winter, suggesting that Greylag Goose abundance had little influence on those objectives during the wintering period. For cultural and aesthetic values (objective #1), the weighted curves were parabolic, reflecting the view that maximization of this objective occurs in the mid-range of Greylag Goose abundance.

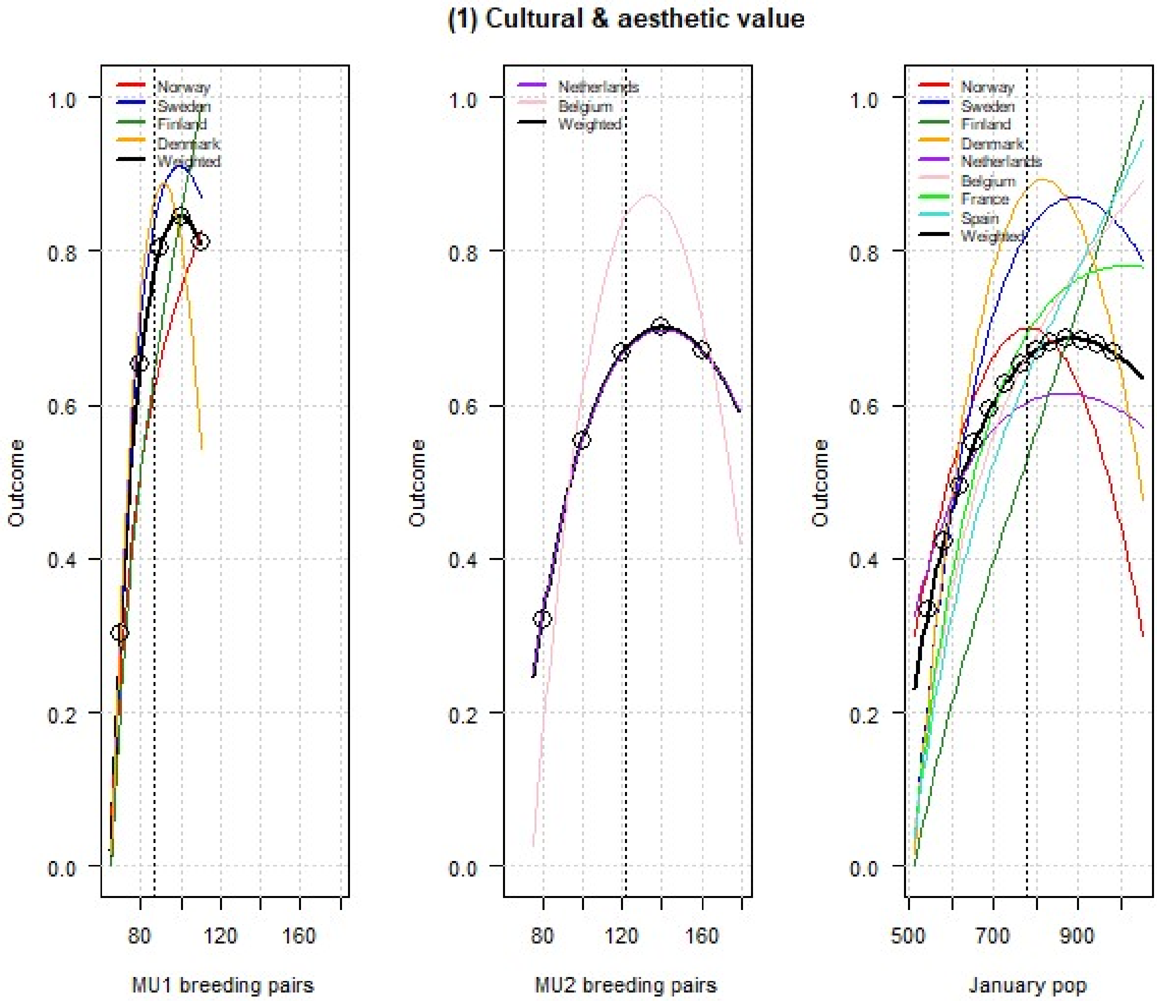

Figure 3. The relationships between Greylag Goose abundance and cultural and aesthetic values as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

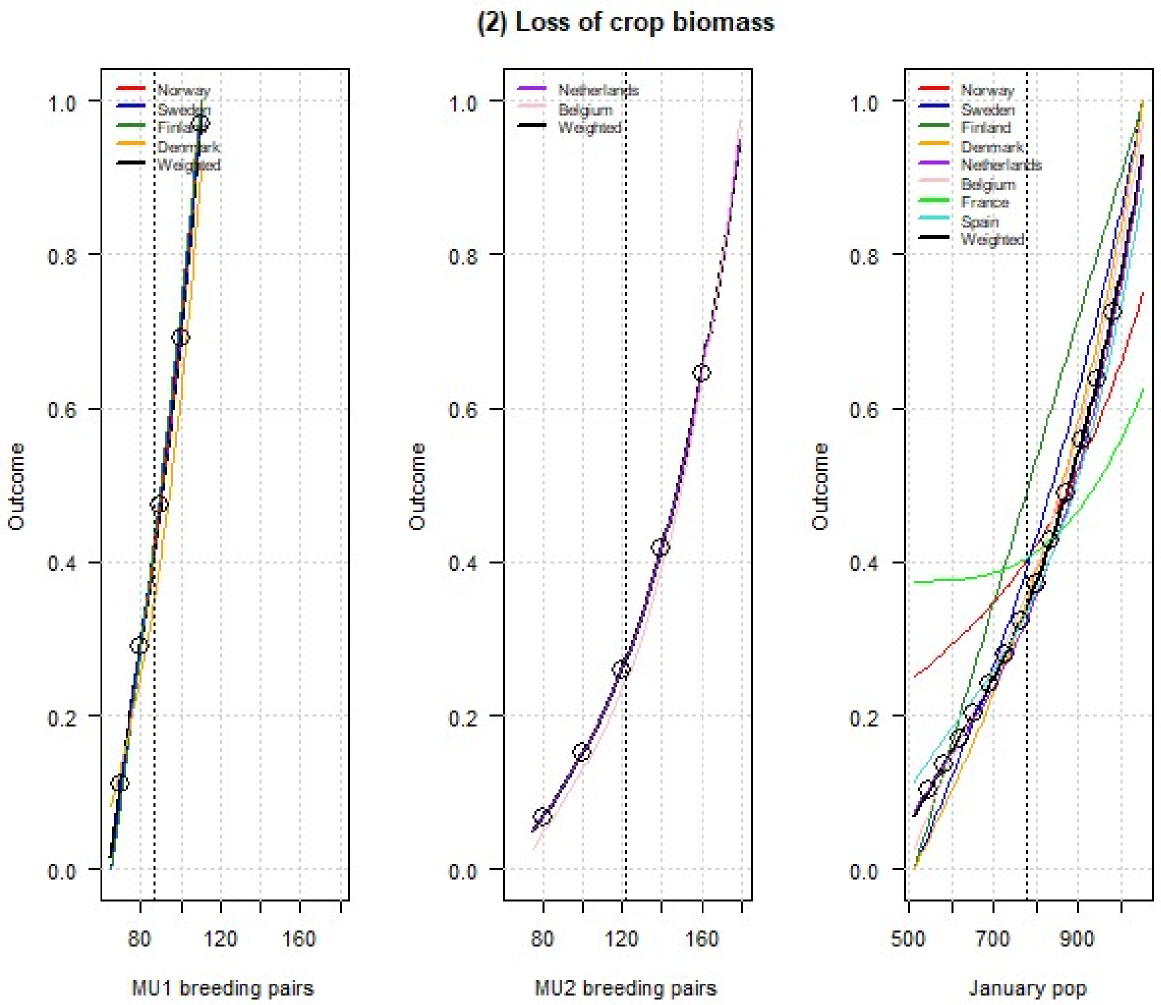

Figure 4. The relationships between Greylag Goose abundance and loss of crop biomass as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

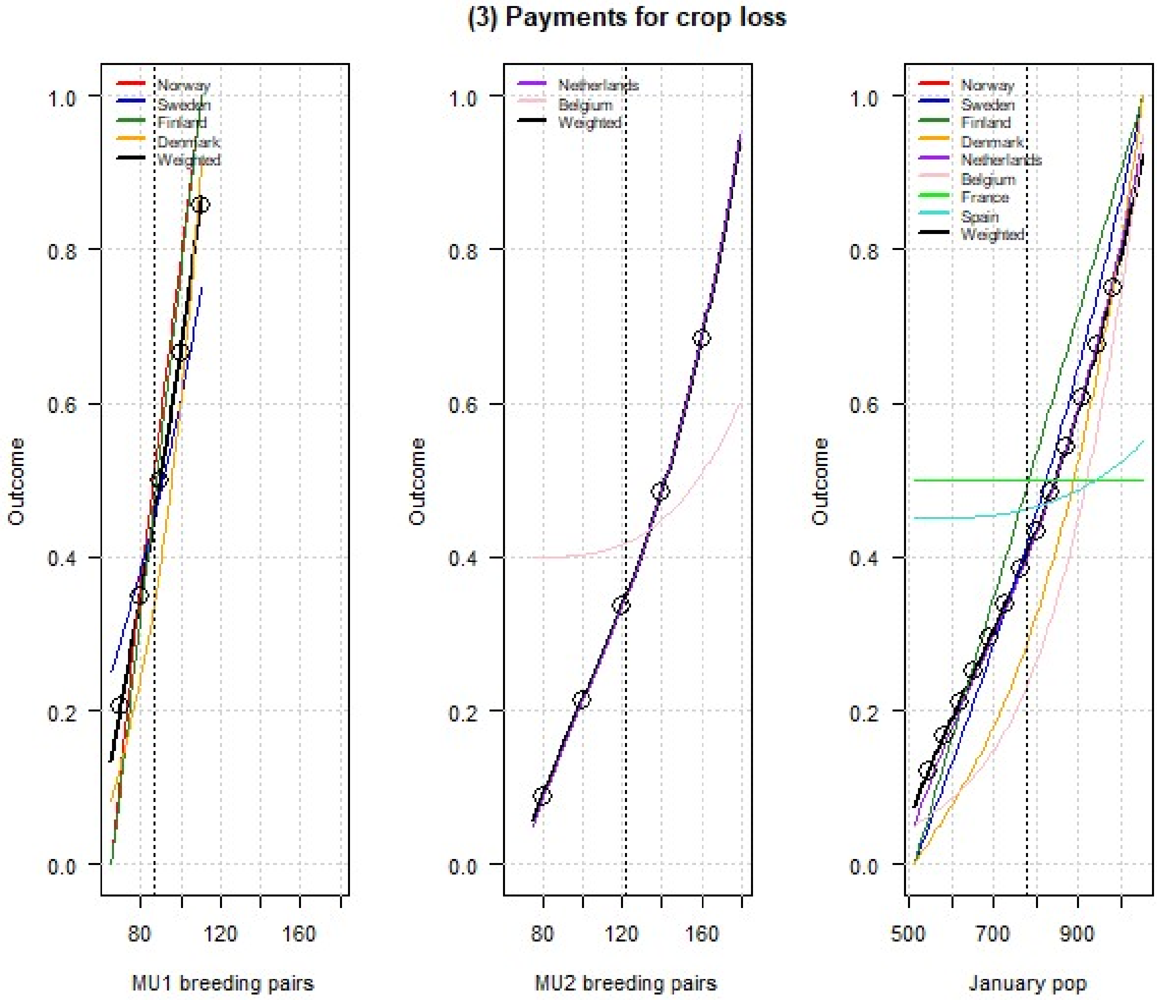

Figure 5. The relationships between Greylag Goose abundance and government payments to mitigate agricultural damage as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

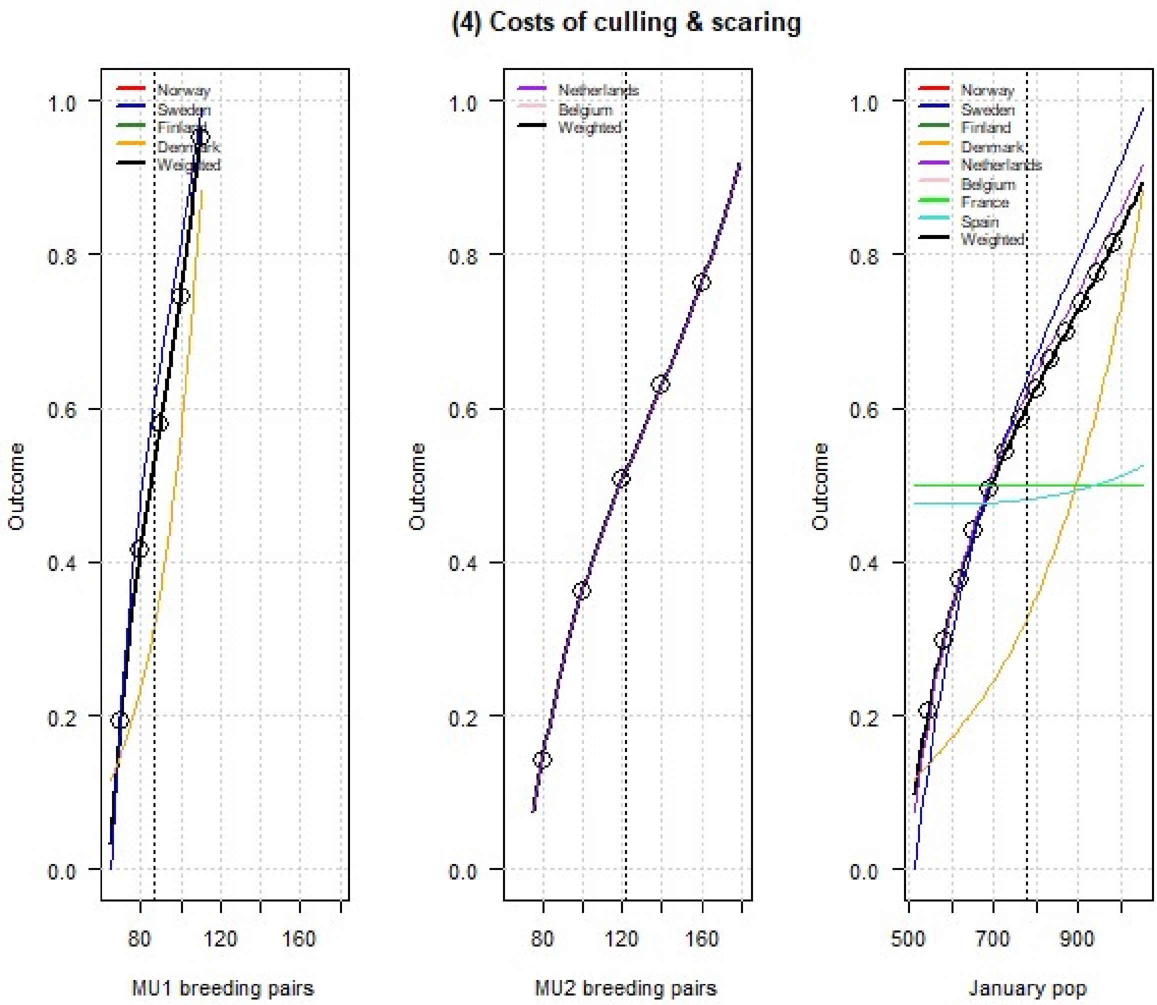

Figure 6. The relationships between Greylag Goose abundance and direct costs to governments of culling and scaring geese as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

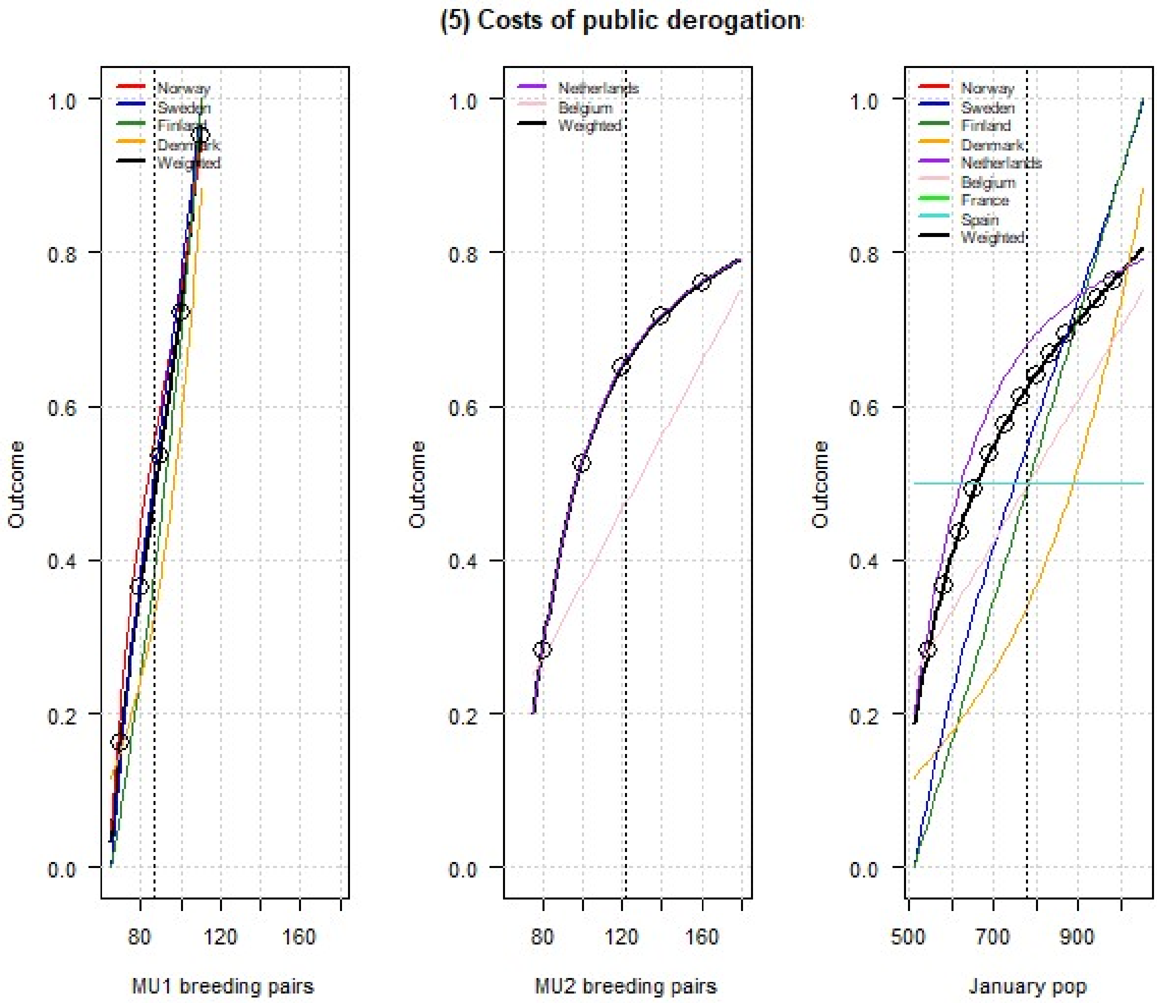

Figure 7. The relationships between Greylag Goose abundance and indirect costs of public derogations as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

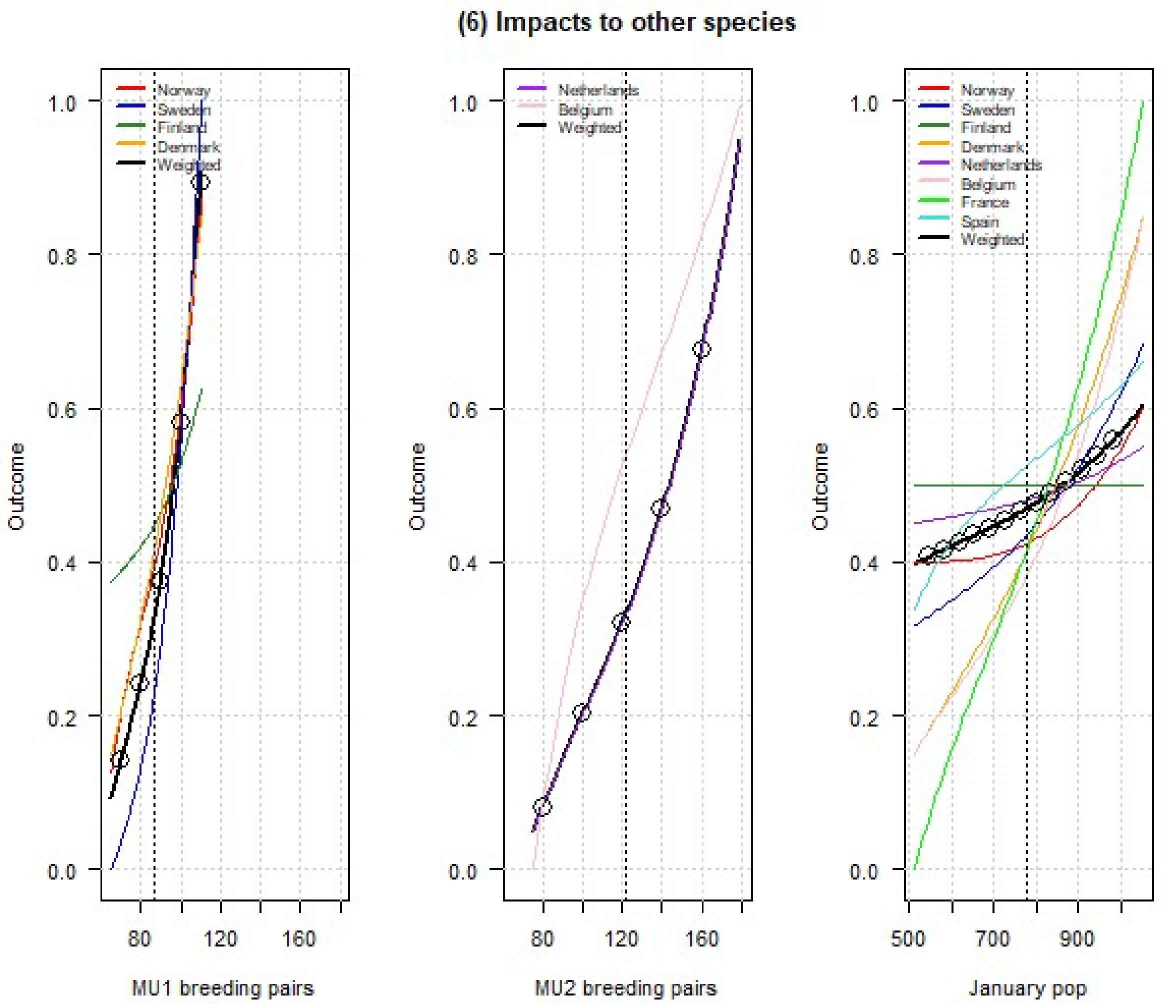

Figure 8. The relationships between Greylag Goose abundance and deletarious impacts to other species as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

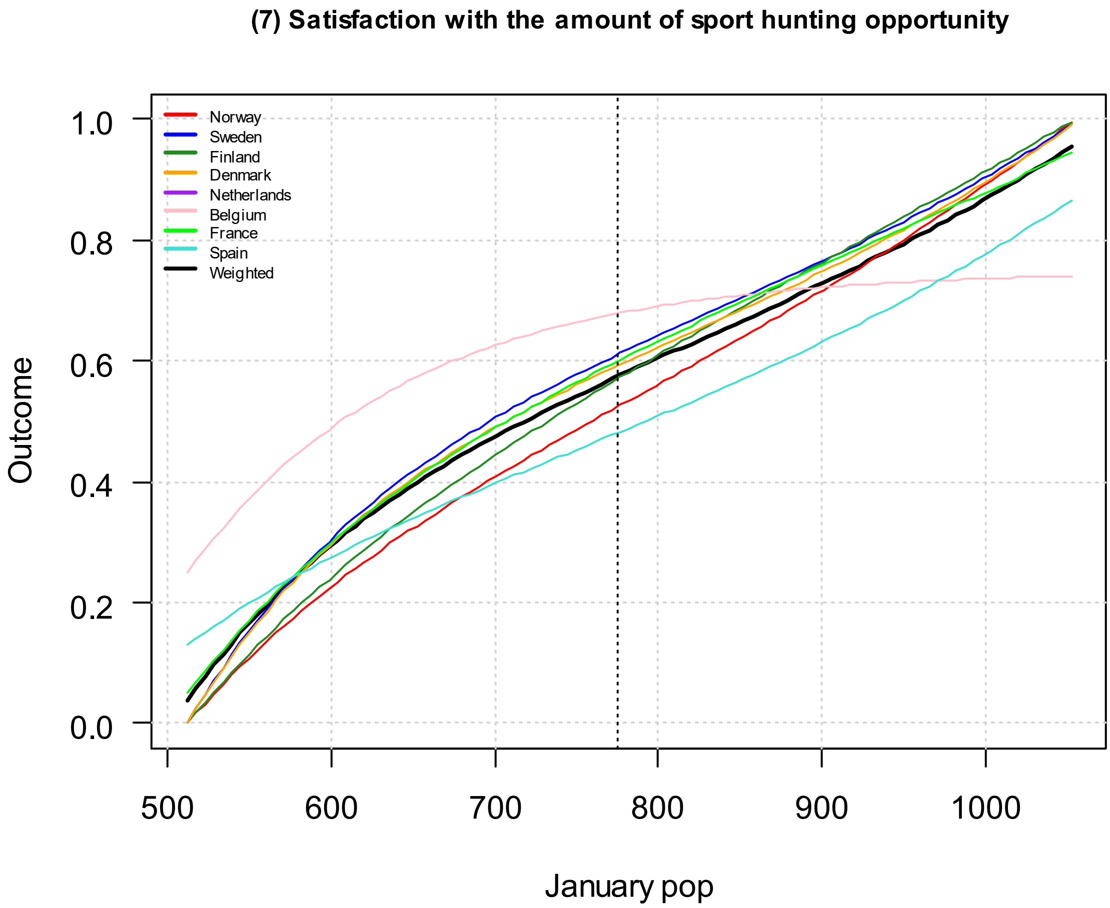

Figure 9. The relationships between Greylag Goose abundance and satisfaction with the amount of sport hunting as judged by goose experts in the Range States. The circles on the weighted-average (black) depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

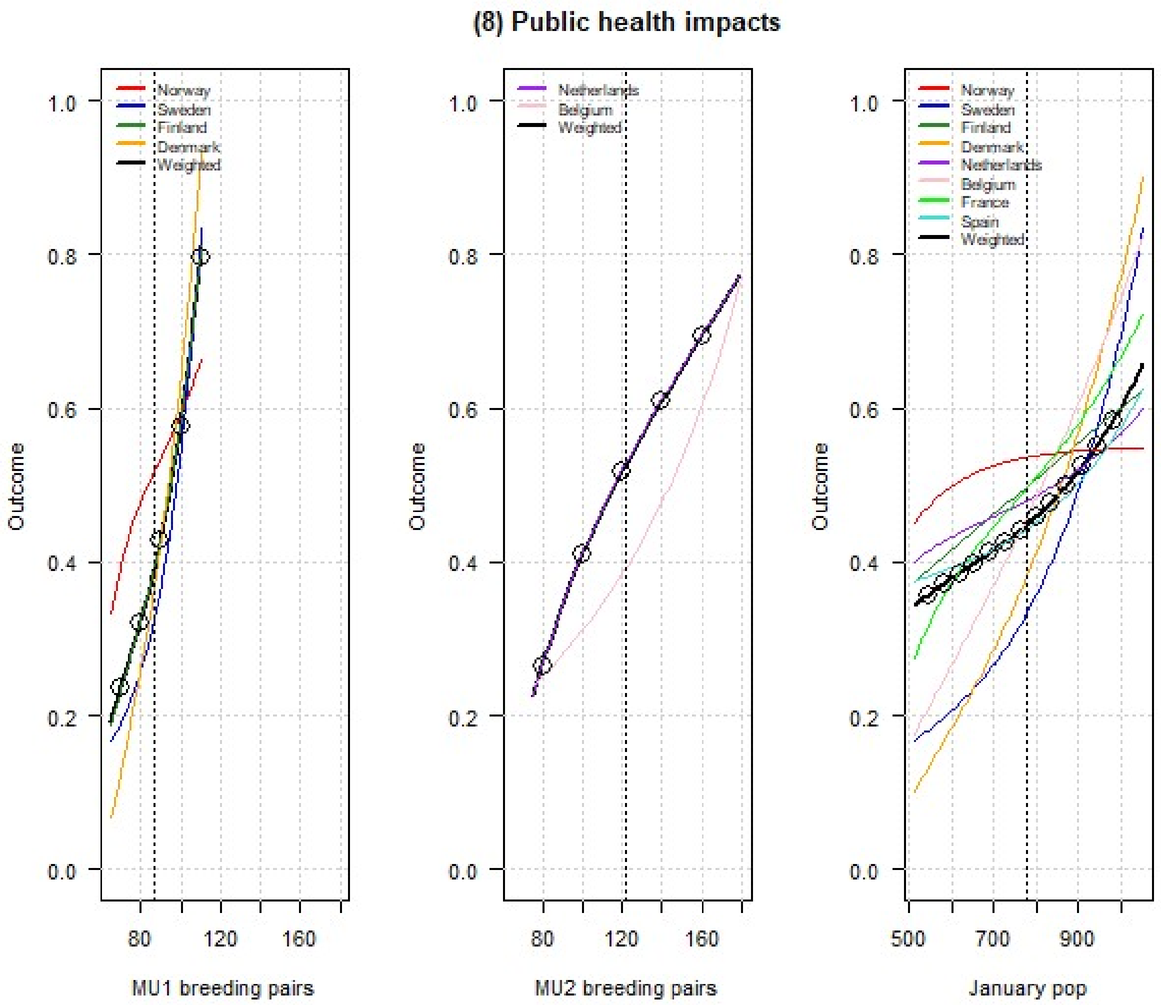

Figure 10. The relationships between Greylag Goose abundance and public health (amenity fouling and disease transmission) as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

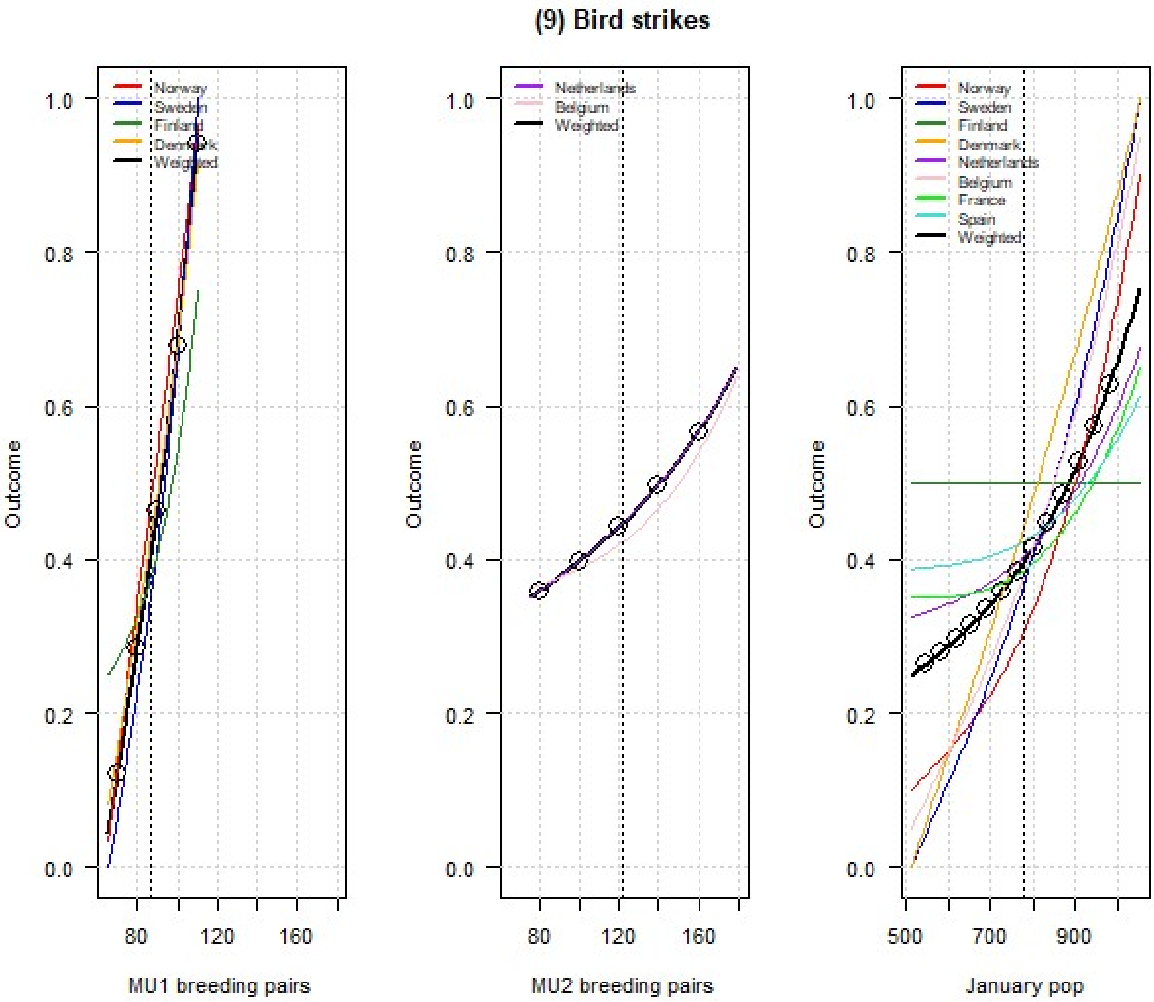

Figure 11. The relationships between Greylag Goose abundance and air saftey (number of bird strikes) as judged by goose experts in the Range States. The circles located on the weighted-average (black) curves for the breeding season depict candidate values for target population sizes for the two management units. The circles on the weighted-average (black) curve for the wintering season depict approximate wintering abundances arising from all possible combinations of the breeding-season candidate targets. Population sizes are in thousands.

Table 1 depicts the consequence table that was provided to the EGMIWG national governments and observers for assigning weights to the management objectives. Note that the goal is to minimize the consequence scores for all objectives except cultural and aesthetic values (objective #1) and sport hunting (objective #7), for which the goal is maximization. As specified in the ISSMP, the current abundance of breeding pairs is approximately 90 thousand and 120 thousand in MU1 and MU2, respectively. The tradeoffs between low and high goose abundance are readily apparent, suggesting that a compromise will be necessary for establishing population targets.

Table 1. Consequence scores associated with candidate population targets for two management units of Greylag Geese. Management objectives are to maximize cultural and aesthetic values (C&A), minimize agricultural damage (Crop), minimize management costs to governments (Cost), minimize deleterious impacts to habitats (Habitat), maximize satisfaction with the level of sport hunting (Hunting), minimize amenity fouling and disease transmission (Health), and minimize bird strikes to aircraft (Air). The green shaded cells are the best consequence for each objective and the red shaded cells the worst.

Mgmt Unit 1	70	70	70	70	70	80	80	80	80	80	90	90	100	110
Mgmt Unit 2	80	100	120	140	160	80	100	120	140	160	140	160	160	160
1. C&A	0.33	0.49	0.59	0.65	0.68	0.42	0.55	0.63	0.67	0.69	0.68	0.68	0.68	0.67
2. Crop	0.09	0.13	0.20	0.29	0.42	0.16	0.21	0.27	0.37	0.49	0.44	0.57	0.66	0.78
3-5. Cost	1.13	1.80	2.34	2.86	3.49	1.65	2.29	2.80	3.31	3.93	3.73	4.33	4.81	5.42
6. Habitat	0.10	0.18	0.25	0.33	0.46	0.15	0.22	0.29	0.37	0.50	0.43	0.55	0.64	0.77
7. Hunting	0.15	0.33	0.46	0.56	0.65	0.25	0.40	0.51	0.60	0.69	0.65	0.74	0.79	0.84
8. Health	0.26	0.34	0.40	0.46	0.50	0.29	0.37	0.44	0.49	0.54	0.54	0.58	0.64	0.74
9. Air	0.26	0.30	0.34	0.38	0.45	0.28	0.32	0.36	0.41	0.48	0.45	0.53	0.57	0.63

Based on responses to the swing-weighting exercise, management objectives to minimize crop damage, adverse habitat impacts, and bird strikes received the highest weights (Fig. 12). There were some minor differences in weights expressed by national governments and those by observers, especially in terms of cultural and aesthetic values, crop damage, and bird strikes.

Using all swing-weighting responses, consensus-convergence weights were highest for habitat impacts, agricultural damage, and bird strikes, intermediate for government costs, cultural and aesthetic values, and sport hunting, and lowest for amenity fouling and disease transmission (Fig. 13). Accordingly, the highest scoring candidates tended to be those with the lowest breeding and wintering abundances (Fig. 14). Based on the entire MCDA analysis, the preferred targets for units MU1 and MU2 are 70 thousand and 100 thousand breeding pairs, respectively (weighted score = 0.7514). However, targets of 70 thousand and 80 thousand breeding pairs for units MU1 and MU2, respectively, had nearly an identical score (weighted score = 0.7513) to the most preferred candidate. The approximate wintering population size associated with the most preferred candidate is 617 thousand, compared to 545 thousand for the second-most preferred candidate.

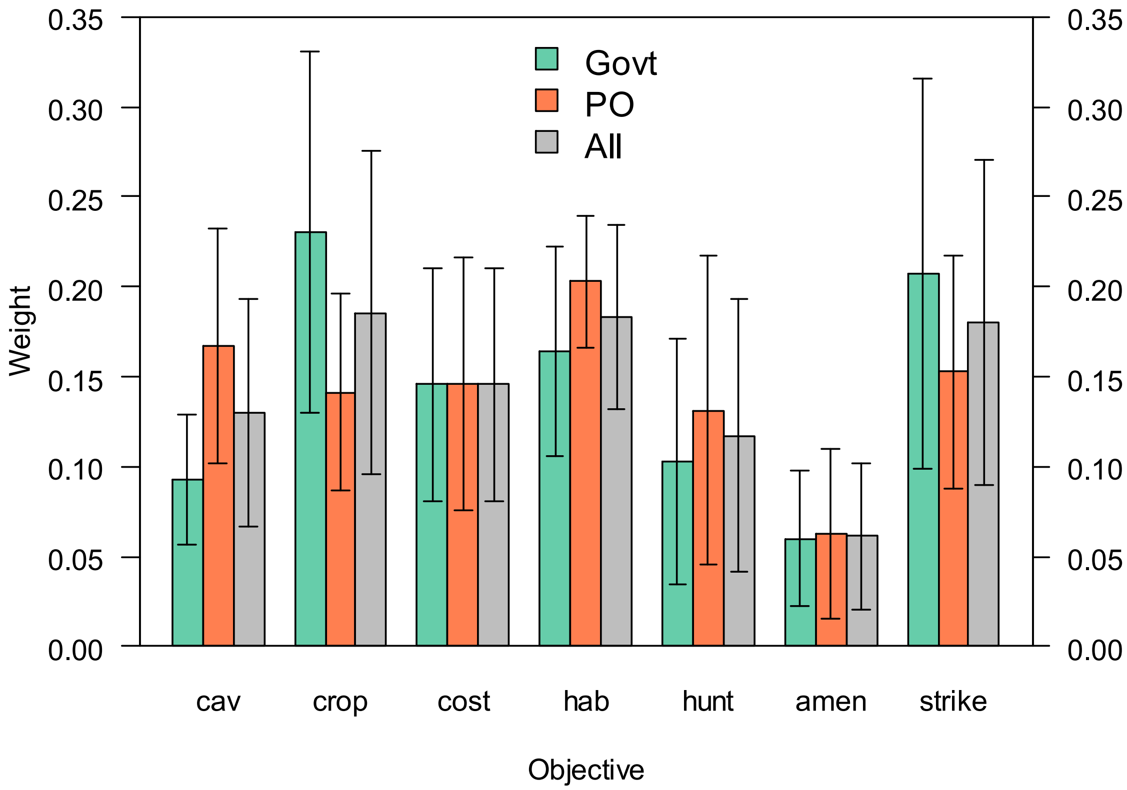

Figure 12. Means and standard errors of the weights assigned to Greylag Goose management objectives by national governments (Govt), by EWGIWG permanent observers (PO), and by all respondents. Management objectives are to maximize cultural and aesthetic values (cav), minimize agricultural damage (crop), minimize management costs to governments (cost), minimize deleterious impacts to habitats (hab), maximize satisfaction with the level of sport hunting (hunt), minimize amenity fouling and disease transmission (amen), and minimize bird strikes to aircraft (strike).

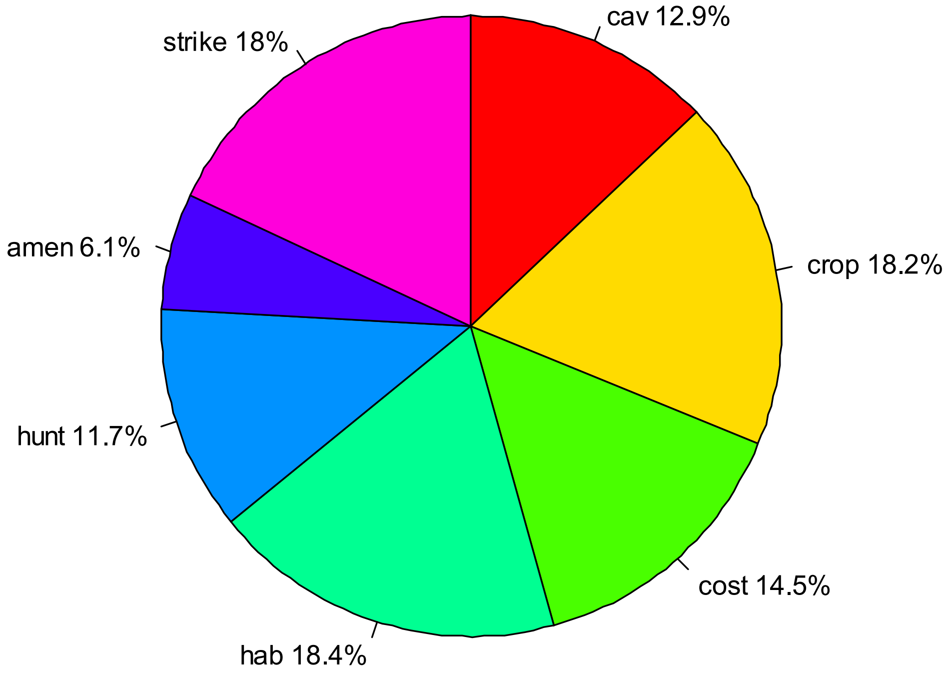

Figure 13. Consensus convergence weights for Greylag Goose management objectives derived from EGMIWG respondents. Management objectives are to maximize cultural and aesthetic values (cav), minimize agricultural damage (crop), minimize management costs to governments (cost), minimize deleterious impacts to habitats (hab), maximize satisfaction with the level of sport hunting (hunt), minimize amenity fouling and disease transmission (amen), and minimize bird strikes to aircraft (strike).

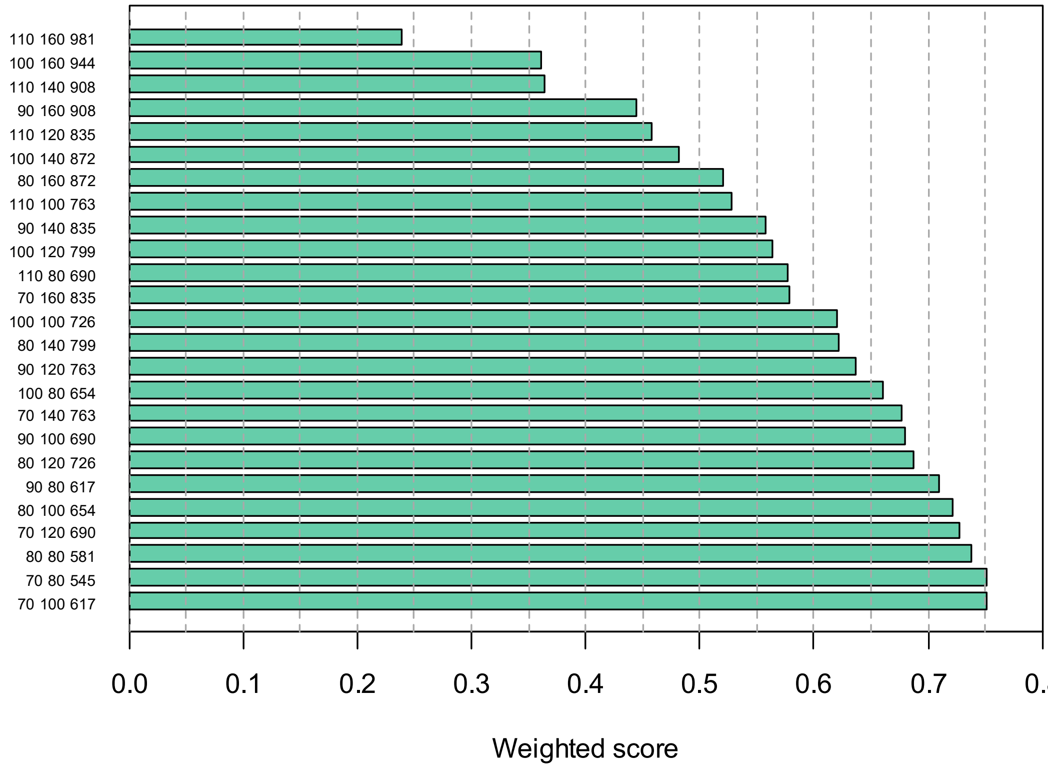

Figure 14. Scores for candidate population targets for Greylag Geese, weighted by the consensus convergence weights on management objectives. On the y axis are first the breeding-pair targets for management units MU1 and MU2, respectively, followed by the approximate number of wintering individuals (all values in thousands). Higher scores indicate higher preference.

Discussion

To our knowledge, this is the first time anywhere that multi-criteria decision analysis has been used to help set population targets for migratory birds. Accordingly, there have been a number of lessons learned. First and foremost, the lack of empirical models to predict the consequences of candidate targets relative to management objectives is an important limitation. Although expert opinion can be a valuable adjunct to empirical data, it is no substitute for direct monitoring of consequences in relation to varying levels of goose abundance. Nonetheless, our elicitation of consequences drew on the expertise of 21 goose specialists in Europe, with a minimum of two experts responding per Range State. The shapes of the relationships between objective consequences and goose abundance were remarkably similar among Range States, particularly during the breeding period, reflecting a high degree of consensus among experts.

Other shortcomings involved the assignment of weights to the management objectives of Greylag Geese. Ideally, this would involve a fully democratic process, with all members of society having the opportunity to express their opinions. A more practical alternative was to ask the National Governmental Representatives of the Range States and permanent observer organizations of the EGMIWG to best represent the perspectives of their respective stakeholders. Nonetheless, the available time for these parties to consult within their organizations was necessarily limited, and participants in the swing-weighting exercise sometimes expressed frustration at the difficulty of properly representing the diverse views of their constituencies. These limitations imply that the swing-weighting exercise is not repeatable in the sense that different objective weights would likely result if the exercise were conducted again. Nonetheless, limited sensitivity analysis of the objective weights suggest that the preferred population targets would change very little.

Despite limitations, the MCDA process as conducted was fully transparent and, importantly, clearly separated the application of science (the expert elicitation) from value-based policy decisions (the swing-weighting exercise). Science and policy issues are often conflated in environmental management, especially in controversial issues (Pielke 2007). The MCDA also identified the nature and extent of tradeoffs inherent in complex decisions, and demonstrated that compromise within and among stakeholder groups would be necessary to reach agreement on population targets for Greylag Geese. In this regard, use of the consensus-convergence model to identify a set of consensus weights avoided many of the pitfalls of ad hoc, face-to-face methods of negotiation and consensus-building. It is inclusive, repeatable, and transparent, and it is blind to dominant personalities and powerful special interests that can lead to one-sided agreements. It is notable, however, that the consensus-convergence weights differed little from simple averages among all participants in the swing-weighting exercise. This fact demonstrates that even special interests had a high regard for the interests of other parties.

Based on the MCDA results, there is near universal agreement that lowering the abundance of Greylag Geese would best meet a broad range of management objectives. For both management units, the preferred targets represent about a 20% reduction from current values of breeding-season abundance, which from a management perspective would require considerable effort above and beyond current population-control measures. Yet maintenance of the population at a lower abundance could result in substantial long-term cost savings to national governments and agricultural interests, and a significant decrease in the potential for aircraft bird strikes. Lower abundance of Greylag Geese would be accompanied by some sacrifice from those interested in cultural, aesthetic, and sport hunting values, of course, but even EGMIWG observer organizations acknowledged the importance of minimizing the adverse impacts of large numbers of geese.

Finally, we acknowledge that the MCDA necessarily represents a coarse-grain analysis, in the sense that we relied on expert opinion for objective consequences, we chose candidate population targets somewhat arbitrarily, and we used a representative rather than fully democratic process for weighting objectives. These facts imply that the weighted scores for the candidate population targets are not precise, in that small differences in scores among candidates are likely not meaningful. Moreover, the most preferred candidates all have values of population targets that are at are near the minimums considered. We therefore emphasize that the MCDA should not be perceived as dictating a preferred candidate (it is a policy decision after all); rather the MCDA narrows the range of candidates that may be worthy of further discussion, particularly if there are considerations not fully captured by the analysis (e.g., distribution of total breeding pairs among the two management units).

Acknowledgements

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Appendix

Elicited responses from European goose experts in phase I of the MCDA:

Link to Expert Elicitation

Objective weights expressed by National Governmental Representatives of the Range States and permanent observer organizations of the EGMIWG in phase II of the MCDA:

Link to Objective Weights

Annex 4. Population Models

Management of the NW/SW European Population of Greylag Geese: Decision Making under Deep Uncertainty

Prepared by the EGMP Data Centre:
Fred A. Johnson
Aarhus University, Denmark

Summary

The problem we address in this report is motivated by the desire to regulate the size of the NW/SW European Greylag Goose population to meet a number of management objectives, including providing sustainable harvests and minimizing agricultural damage and conflicts. Using simple models of population dynamics along with observed allometric relationships in birds, we have concluded that reported estimates of Greylag Goose population size and/or offtake at the flyway level are likely biased, perhaps severely so. Recognizing that resources are limited, we suggest that the most pressing need may be to investigate and strengthen monitoring protocols for Greylag Goose offtake. We describe a simple information-gap ("info-gap") decision model that could allow decision makers to make informed choices about the magnitude of offtake until such time that more reliable monitoring information is available for Greylag Geese. With the info-gap decision model we were compelled to use a management criterion based on the growth rate of the flyway-wide population because true levels of abundance and offtake on a management-unit basis are unknown. Moreover, we emphasize that in the face of deep uncertainty about Greylag Goose abundance and offtake, decisions concerning management of the population carry a very high risk of failing to meet conservation objectives, whatever they may be. While the info-gap analysis suggests an increase of offtake over the nominal level of 450 thousand is necessary to begin decreasing population size, we emphasize that we do not know the current level of offtake (i.e., whether it has changed from that reported in the ISSMP). Moreover, the info-gap analysis does not take into account special needs and population trajectories of the MUs and their different segments, and thus it carries a high risk of not meeting the MU-specific population targets if not replaced by a more reliable decision-making tool. Therefore, we conclude that info-gap decision analysis does not provide a sound basis for adaptive, dynamic decision-making, which ultimately will be necessary to reliably manage Greylag Goose abundance in accordance with population targets in the two management units. Only up-to-date, coordinated, and reliable monitoring data on abundance and offtake from throughout the flyway will allow us to realize that goal.

Introduction

The ISSMP for the NW/SW European population of Greylag Geese provides contemporary estimates of abundance of 900 – 1200 thousand individuals in midwinter and an offtake (sport harvest + derogations) of about 450 thousand individuals (Powolny et al. 2018). One or both estimates appear to be biased, perhaps severely so, based on arguments contained herein. The presence of bias in estimates of abundance and/or offtake make informed decisions concerning management of this goose population challenging at best.

Science-based population management requires at a minimum reliable estimates of population size during some part of the annual cycle, along with estimates of anthropogenic mortality. Even when detailed demographic information is limited or lacking, reliable estimates of population size and offtake can nonetheless provide a reasonable basis for making and evaluating management decisions (Johnson et al. 2018). Moreover, managers can sometimes cope with bias in estimates of population size or offtake if more detailed demographic information is available (Johnson et al. 2020). Unfortunately, none of these scenarios is currently applicable to the NW/SW European population of Greylag Geese.

Information gap decision theory ("info-gap") is designed for cases of "deep" uncertainty – those in which a stochastic (probabilistic) structure for uncertain consequences is either unreliable or unavailable (Ben-Haim 2001, Regan et al. 2005, van der Burg and Tyre 2011). It is similar to the concept of maxi-min (Polasky et al. 2011), in which a preferred management action is the one which maximizes the minimum level of management performance over all uncertain consequences. Info-gap decision analyses poses a slightly different question: "which management action is most likely to satisfy a specified management criterion for the largest range of uncertainty?"

The problem we address in this report is motivated by the desire to regulate the size of the Greylag Goose population to meet a number of management objectives, including providing sustainable harvests and minimizing agricultural damage and conflicts. In the following sections, we first provide evidence for bias in the estimates of abundance and/or offtake of Greylag Geese. We then describe a simple info-gap decision model that could allow decision makers to make informed choices about the magnitude of offtake until such time that more reliable monitoring information is available for Greylag Geese. Finally, we provide the relative risk of not meeting a management criterion so that decision makers can account for their risk attitude.

Intrinsic and Realized Growth Rates of the Greylag Goose Population

We used the methods of Johnson et al. (2012) and Niel and Lebreton (2005) to estimate the intrinsic population growth rate (i.e., no density dependence and no anthropogenic mortality) of Greylag Geese. From Johnson et al. (2012), adult survival under ideal conditions for birds ranging in mass from 12 to 8663g is estimated as:

(1) $\theta = p^{\frac{1}{(exp(3.22+0.24log(M)+e)-\alpha)}}$,

where p is the observed proportion of the population alive at the observed maximum lifespan with $p{\sim}beta(3.34{,}101.24)$, M is body mass in kg, α is age at first breeding, and e is the error in the model relating body mass to longevity with $e{\sim}Normal(0, \sigma^2 = 0.087)$. Using both female and male mean body masses of 3.108 kg (sd = 0.274) and 3.509 (sd = 0.321), respectively (Dunning Jr. 2008), and an assumed $\alpha = 3$, the median is $\theta = 0.889$ and 95% confidence interval is 0.785 – 0.943. This represents a maximum longevity of about 29 years, which agrees well with that of birds in captivity (e.g., Nigrelli 1954). Use of an age at first breeding of $2 < \alpha \leq 3$ (i.e., some portion of 2-year-olds can breed) causes only very minor differences in the value of θ.

Next, we used the values of $\theta = 0.889\ (0.785 - 0.943)$ and $\alpha = 3$ along with Equation (15) from Niel and Lebreton (2005) to estimate the intrinsic population growth rate as:

(2) $\lambda \approx \frac{(\theta\alpha-\theta+\alpha+1)+\sqrt{(\theta-\theta\alpha-\alpha-1)^2-4\theta\alpha^2}}{2\alpha} \approx 1.159 \quad (1.120 - 1.206)$.

The median is similar to empirical values for snow geese and barnacle geese provided by Niel and Lebreton (2005).

For the period (2004-2012) in which EGMP national midwinter counts are available from all flyway Range States (Sweden, Denmark, Germany, Netherlands, Belgium, France, Spain, and Portugal) (Appendix and Heldbjerg et al. 2020), we can estimate the realized mean growth rate using a log-linear regression model of counts, *N*:

(3) $$N_t = N_0\lambda^t$$

$$log(N_t) = log(N_0) + log(\lambda) \cdot t$$
$$log(N_t) = \beta_0 + \beta_1 t + e_t$$

$$e_t \sim \text{Normal}(0, \sigma)$$
$$\bar{\lambda} = exp\left(\beta_1 + \frac{\sigma^2}{2}\right)$$

The estimated mean growth rate for 2004-2012 was $\bar{\lambda} = 1.063\ (1.048 - 1.079)$ (Fig. 1). Note that this analysis assumes that whatever the bias in EGMP national totals may be, it is relatively constant over the period 2004-2012.

We note, however, that population growth may have slowed since 2012. EGMP national totals are available from all Range States from 2004 to 2016 (i.e., 4 additional years) except Spain (outside Donana) and Germany. If we use the observed growth rates in those two countries during 2004-2012 to extrapolate their respective counts through 2016, the growth rate of the flyway population was $\bar{\lambda} = 1.038\ (1.026 - 1.051)$ during 2004-2016. Counts of geese in the Netherlands and in Spain appear to be most responsible for the lower growth rate when compared to the 2004-2012 period.

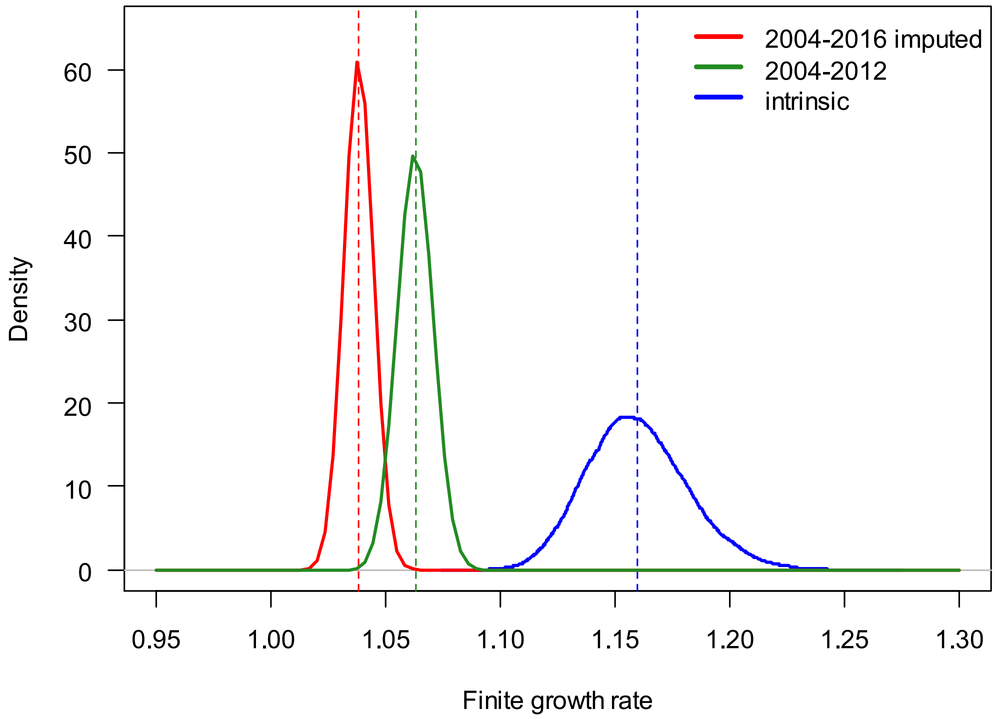


Figure 1. The intrinsic population growth rate of Greylag Geese as estimated using the methods of Johnson et al. (2012), and the realized growth rates based on EGMP national totals in the Range States of the NW/SW European population of Greylag Geese. Note that counts for Spain and Germany were imputed for 2013-2016 (see text). Dashed, vertical lines represent the means.

Magnitude of Bias in Abundance and/or Offtake

We can use the estimated intrinsic and realized population growth rates to investigate the potential magnitude of bias in abundance and/or offtake of Greylag Geese. To do so, we must assume that (1) the population is not subject to any significant density dependence; (2) all anthropogenic mortality is due to sport hunting or to take under derogations; and (3) offtake is additive to other sources of mortality. While all of these assumptions are unlikely to be true, we believe they represent a reasonable starting point. Under these assumptions:

(4) $\bar{\lambda} \approx \lambda\left(1 - \frac{\beta H}{\alpha N}\right)$

where $\bar{\lambda}$ is the realized growth rate, λ is the intrinsic growth rate, *H* and *N* are the estimated size of the offtake and the post-breeding population, respectively, and $\alpha$and β are bias coefficients. If the (approximate) equality in Equation (4) is satisfied for $\alpha = \beta = 1$, then there is no apparent bias in estimates of abundance or offtake.

We can find the combinations of and that satisfy the equality in Equation (4) for nominal values of H and *N*. We use the estimates of abundance of 900 – 1200 thousand individuals in midwinter and an offtake (sport harvest + derogations) of about 450 thousand individuals reported in the ISSMP for comparable time periods (Powolny et al. 2018). We thus specify the following nominal values:

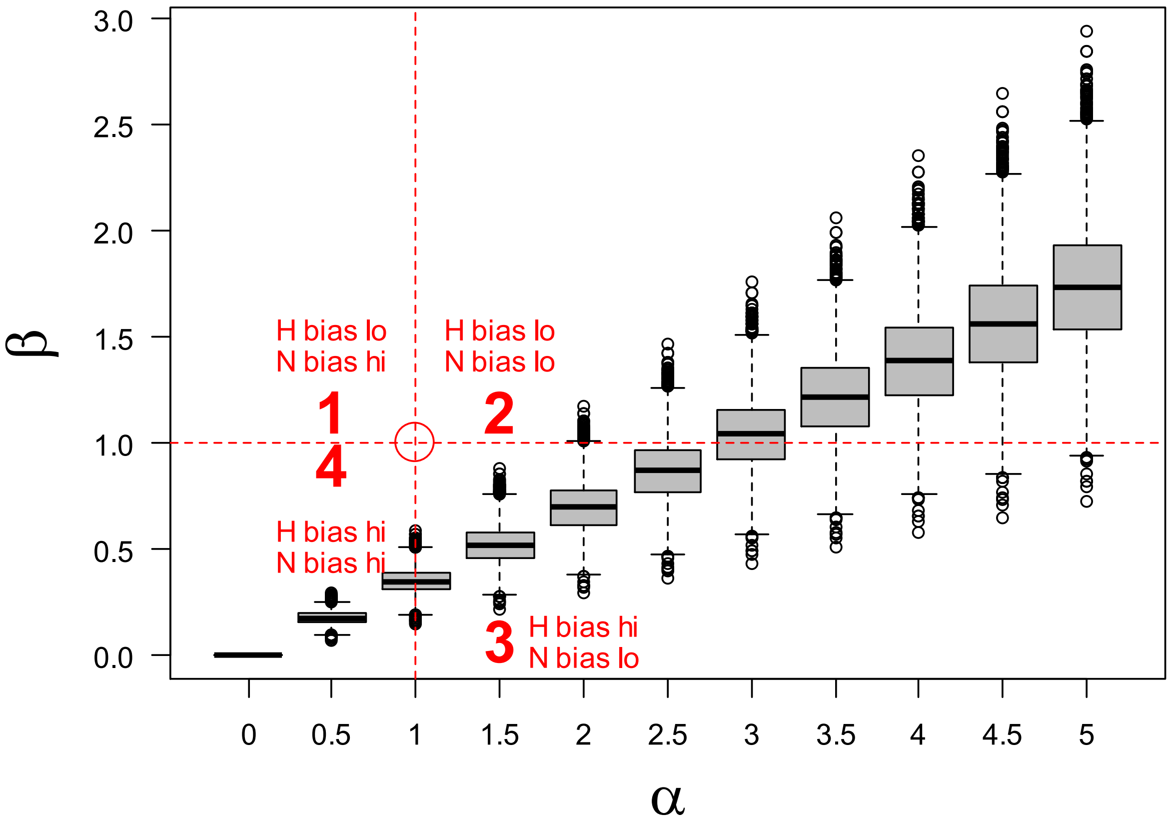
$$H = 450k$$
$$N = \frac{900k + 1200k}{2} + H = 1500k$$

We choose to use the estimated growth rate during 2004-2016 (i.e., with four years of imputed values for Germany and Spain) for this exercise because it better aligns with the period of the information provided about offtake in the ISSMP. Using five thousand samples from the distributions for $\bar{\lambda}$ and λ (Fig. 1), we solved Equation (4) for β for a range of values in α. A plot of the resulting values of β against α can be divided into four quadrants, representing cases where: (1) *H* is biased low $(\beta > 1)$and *N* is biased high $(\alpha < 1)$; (2) *H* is biased low $(\beta > 1)$and *N* is biased low $(\alpha > 1)$; (3) *H* is biased high $(\beta < 1)$and *N* is biased low $(\alpha > 1)$; and (4) *H* is biased high $(\beta < 1)$and *N* is biased high $(\alpha < 1)$ (Fig. 2). If we were to assume that the nominal estimate of offtake is unbiased (horizontal dashed line in Fig. 3), abundance would be underestimated by a factor of about 2.5 – 3. On the other hand, if we assume that the nominal estimate of abundance is unbiased (vertical dashed line in Fig. 3), offtake would be overestimated by a factor of almost 3. If one were to assume that actual goose abundance is unlikely to be more than 3 times the nominal abundance, then a robust conclusion is that the nominal estimate of offtake is biased high, perhaps severely so.

The conclusion that reported offtake is biased high is further supported if we consider the possibility that the intrinsic growth rate is a maximum that may not be realized in a variable environment, or that density-dependent mechanisms are acting to reduce it. Consider the following modification to Equation (4):

(5) $\bar{\lambda} \approx p\lambda\left(1 - \frac{\beta H}{\alpha N}\right)$

where $p < 1$ represents a potential reduction in the intrinsic growth rate. For any values $p < 1$, the combinations of α and β that satisfy the equality in Equation (5) even more strongly suggest a positive bias in reported offtake.



Combinations of α and β that satisfy the equality in Equation (4) for nominal values of abundance and offtake of the NW/SW European population of Greylag Geese that were reported in the ISSMP. The horizontal dashed line represents an unbiased nominal estimate of offtake, and the vertical dashed line represents an unbiased nominal estimate of goose abundance.

A similar problem of monitoring bias exists for Greylag Geese breeding in Iceland (Frederiksen et al. 2004) and has been recognized at a regional level in Europe (although that report has not been publicly released). The source of the bias in Greylag Goose monitoring protocols is not easily identified, as other sources of corroborating information are lacking. However, IWC counts and estimates of the number of breeding pairs (which may have their own problems) seem to suggest that EGMP national totals may be roughly of the correct magnitude. Corroborating estimates of sport and derogation harvest are completely lacking, but we note that Padding and Royle (2012) found that hunter-reported goose harvests in the U.S. were 49-64% higher than the actual harvests (e.g., hunters potentially exaggerated their harvest).

It is also possible that reported population sizes and offtake for Greylag Geese are approximately correct, but this would demand much higher survival and fecundity than is typical in arctic and subarctic breeding geese. In fact, the proportion of young prior to hunting would have to be ≥30% (the minimum value of 30% would only be possible if there was no mortality other than harvest). Based on allometric relationships (Niel and Lebreton 2005, Johnson et al. 2012), we would expect about 23% young under ideal conditions. However, Greylag Geese breeding in more temperate latitudes do so under exceedingly favorable environmental conditions and such high values of reproductive success cannot be completely discounted (A. Fox, Aarhus University, personal communication).

Information-Gap Decision Analysis

Methods and an Example

The existence of bias of unknown magnitude in Greylag Goose monitoring renders traditional approaches to modeling population dynamics and decision analysis inappropriate. However, in an effort to help guide decision making, we explored an info-gap approach, which poses the question: "which management action will most likely satisfy a management criterion for the largest range of uncertainty?" In our case, the deep uncertainty concerns the true values of α and β, expressing the degree of bias in estimates of abundance and offtake, respectively. Thus, we would like to choose a management action, in this case a level of offtake, *H*, that would meet some management criteria for a larger range of uncertainty in α and β than any other potential level of offtake.

Ultimately, the management criterion will be represented by a target population size for each of the two management units defined for Greylag Geese (https://egmp.aewa.info/sites/default/files/meeting_files/reports/AEWA_EGM_IWG_4_final_report.pdf). These targets are in the process of being specified using multi-criteria decision analysis to determine the appropriate tradeoff among a variety of management objectives. However, even if targets were available, they would not be useful as criteria in this situation because it is abundance itself that is uncertain. Nor can we use a criterion for each management unit because the derivation of the total harvest (i.e., the portion of the total harvest derived from each management unit) is unknown. However, we can establish a management criterion based on the predicted growth rate of the NW/SW European population using Equation (4). In other words, we can determine the nominal level of total offtake that would meet a growth-rate criterion for the largest possible range in values of α and β.

For example, suppose that the decision maker wishes to stabilize population growth. Population growth based on EGMP national totals (with imputation for Spain and Germany for four years) during 2004-2016 was $\bar{\lambda} = 1.038\ (1.026 - 1.051)$ amid growing concern about the adverse impacts of population size. The decision maker knows (s)he is unlikely to meet the criterion of a realized growth rate $\bar{\lambda} = 1$ precisely, but would like to get as close as possible to a stable population. The info-gap decision problem then is: "what nominal level of offtake will meet a performance criterion of $|\bar{\lambda} - 1| \leq C$, where *C* is some critical threshold, for as large a range in α and β as possible?"

We first establish a range of uncertainty in α and β to examine. Based on previous arguments, it is likely that estimated offtake is biased high as long as true abundance exceeds nominal abundance by a factor <3.5. Thus, we somewhat arbitrarily set $\alpha \sim \text{uniform}(0.5{,}3.5)$ and $\beta \sim \text{uniform}(0.2{,}1.0)$. We then examined a range of nominal values of offtake and, for each combination of α and β predicted $|\bar{\lambda} - 1|$ using Equation (4). For this example, we simply look at two levels of offtake: (a) no increase; and (b) a 40% increase in the level of offtake.

While the info-gap analysis relies only on the estimated intrinsic growth rate (and *not* on an observed growth rate), it is nonetheless sensitive to nominal values of abundance and offtake. As with the investigation of bias, we used imputed, total winter counts from the IWC, but used an average of the three most recent years available (2016-2018) (Heldbjerg et al. 2020). Importantly, we continued to assume that the nominal level of offtake is currently 450 thousand because we have no more recent information that would allow us to do otherwise. Thus, nominal offtake and post-breeding abundance was assumed to be:

$$H = 450k$$

$$N = \frac{709k + 775k + 751k}{3} + H$$

$$N = 745k + 450k = 1195k$$

Fig. 3 depicts contours of $|\bar{\lambda} - 1|$for the ranges of α and β, and for the levels of offtake described. One can see from the contour plots that less restrictive management criteria can be achieved under a wider range of uncertainty in α and β than with more restrictive criteria. For example, a criterion of $|\bar{\lambda} - 1| \leq 0.10$ encompasses many more possible combinations of α and β than a criterion of $|\bar{\lambda} - 1| \leq 0.05$. This follows from the intuitive notion that the more stringent the management criteria, the less uncertainty that can be tolerated.

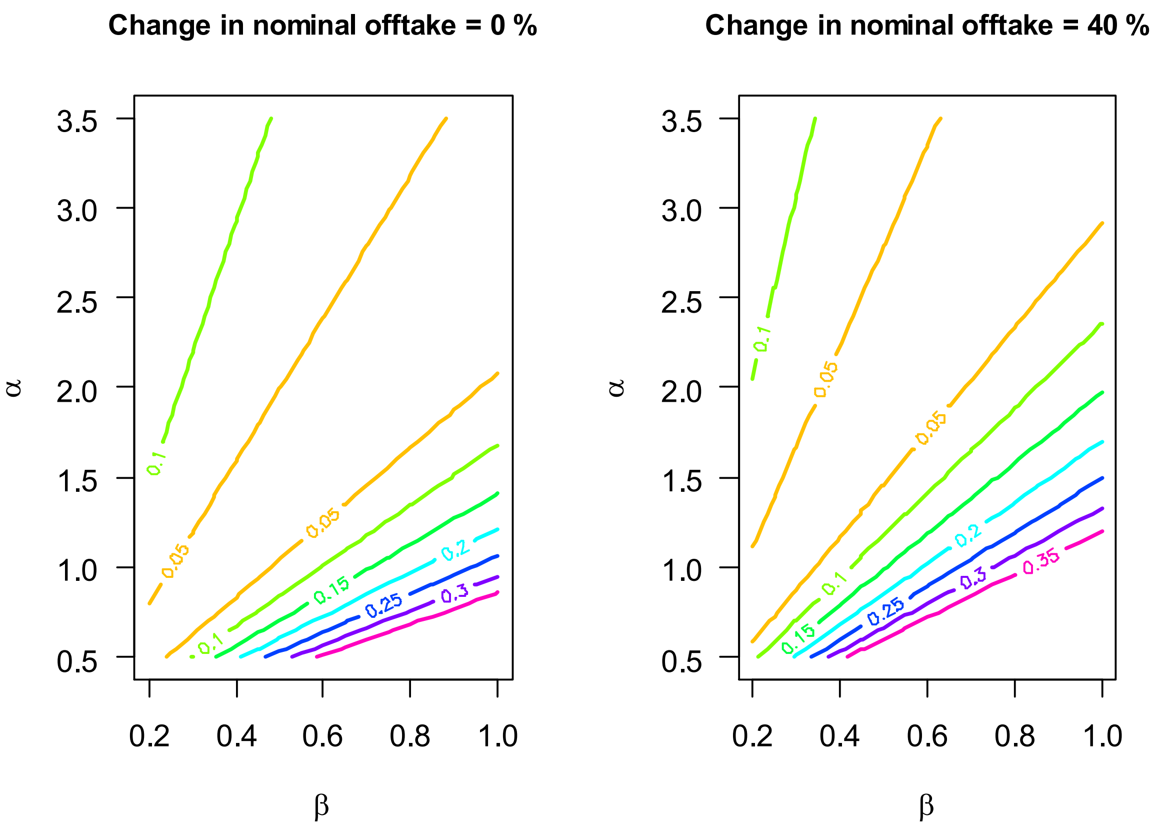


Figure 3. Contour plots of the predicted, absolute deviation from a stable growth rate, $|\bar{\lambda} - 1|$, for two proportional changes in the nominal level of offtake, and for varying degrees of bias in estimates of abundance, α, and offtake, β, for the NW/SW European population of Greylag Geese. The intrinsic growth rate is assumed to be $\lambda = 1.159$ with no error.

The calculations used to generate Fig. 3 were based on the median of the intrinsic growth rate and do not account for uncertainty in $\lambda = 1.159 \quad (1.120 - 1.206)$. Yet this uncertainty is not "deep", in the sense that it has a stochastic structure; e.g., we can be 95% confident that the true value lies between 1.120 and 1.206. We can account for this stochastic structure by running the previous analysis many times, using random samples from the empirical distribution of λ.

Proposed Info-Gap Decision Analysis

We start by acknowledging that population targets will likely to be at least 20% less than current population sizes, and that the Adaptive Flyway Management Plan has a 6-year time horizon. In the face of deep uncertainty about current levels of offtake and abundance, we suggest a precautionary approach of seeking to reduce population size by 15% over 10 years. Thus, we seek an annual growth rate of lambda = 0.98. We are unlikely to meet this criterion precisely, so we might consider 0.96 < lambda < 1.00 as acceptable (i.e., population size decreasing by less than 4%/year). Accordingly, an increasing population, or a population declining more than 4% per year, would be considered unacceptable. The lower limit of 0.96 could be anything, and here simply note that an annual lambda = 0.96, if realized, would reduce population size by 34% in 10 years.

The probabilities of meeting this management criterion for an expanded range of potential levels of offtake are shown in Fig. 4. Notice that all probabilities are low (<20%), reflecting the challenge of meeting the restrictive criterion of $0.96 \leq \bar{\lambda} \leq 1.00$ in the face of deep uncertainty concerning the true values of bias, α and β. A nominal level of offtake of 40% higher than that reported in the ISSMP is expected to achieve the management criterion for a wider range in α and β than any other alternative. But we emphasize that this decision would be accompanied by an 86% chance that the criterion would *not* be met (assuming all examined values of α and β are considered equally plausible). In other words, there would be an 86% chance that abundance could either increase or decline by more the 4% annually. Finally, we note a very broad range of changes in offtake had nearly identical (mean) probabilities of meeting the management criterion, and indeed are not statistically distinguishable from each other.

Moreover, the info-gap analysis suggests that an increase in offtake may be needed to merely *stabilize* population size. Yet recent IWC counts and EGMP national totals suggest that the flyway population is no longer increasing (Heldbjerg et al. 2020). Assuming this recent population trend is real, there are at least three possible reasons for the contradictory conclusions arising from the info-gap analysis: (1) the current, nominal winter abundance is lower than the value we used; (b) the current, nominal offtake is higher than the value we used (i.e., it has increased in recent years); or there are factors beyond offtake (e.g., density dependence) acting to lower the intrinsic growth rate. Indeed, all three reasons might be operative.

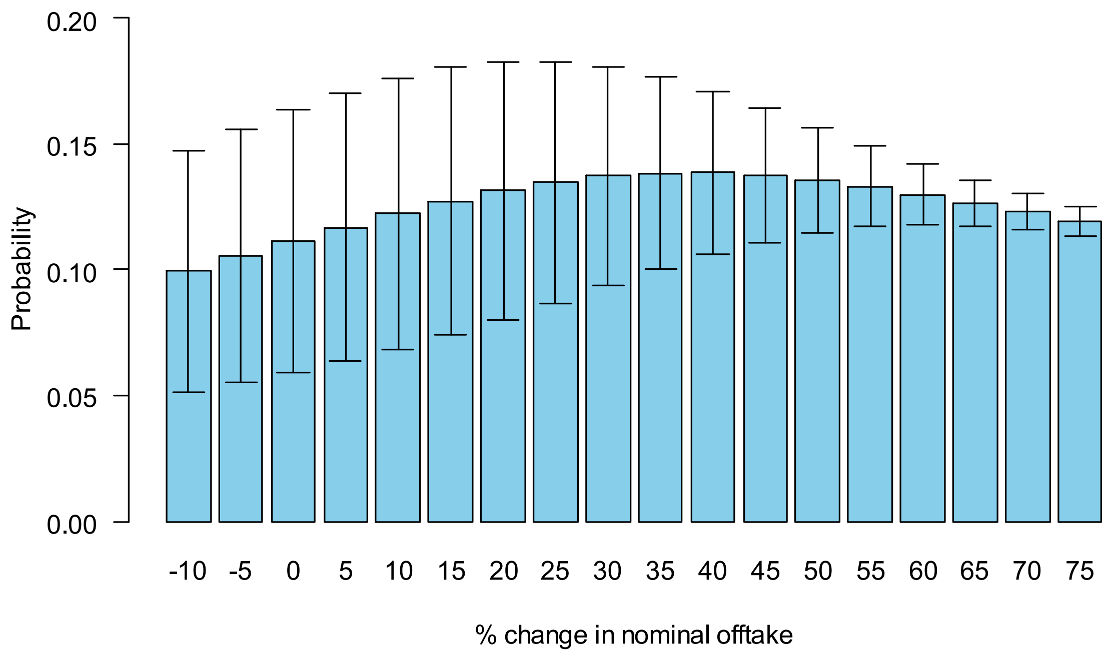


Figure 4. Probabilities of achieving a population growth rate of $0.96 \leq \bar{\lambda} \leq 1.00$ for varying levels of offtake (relative to the nominal value of 450 thousand reported in the ISSMP) for NW/SW European population of Greylag Geese in the face of deep uncertainty about bias in estimates of abundance and offtake. Error bars represent 95% confidence limits, which account for uncertainty in the intrinsic growth rate of Greylag Geese.

Discussion

Using simple models of population dynamics along with observed allometric relationships in birds, we have inferred that reported estimates of Greylag Goose population size and/or offtake at the flyway level are likely biased, perhaps severely so. Recognizing that resources are limited, we suggest that the most pressing need may be to investigate and strengthen monitoring protocols for Greylag Goose offtake. While population counts have been largely coordinated among countries, offtake reporting has been rather haphazard. For example, reporting is sometimes not required nor solicited, reported offtakes are occasionally an unknown mix of sport harvest and derogations, data are sometimes not routinely compiled on a national basis, and monitoring protocols are sometimes changed without maintaining adequate documentation of the changes. If Greylag Geese are to be managed as a shared resource, more international coordination will be essential for establishing rigorous and standardized protocols for data collection and archiving.

In the face of deep uncertainty about estimates of Greylag Goose abundance and offtake, decisions concerning management of this population carry a high risk of failing to meet conservation objectives, whatever they may be. If such decisions must be made, however, information-gap decision analysis offers perhaps the most robust choice of decision-analytic tools. Info-gap analysis seeks a decision among all possible choices that has the best chance of meeting a management criterion for the largest range of uncertainty. In the case of Greylag Geese, however, simplifying assumptions about population dynamics must be made, and only a management criterion based on the rate of flyway population growth is plausible, as almost any other objectives would likely be related in some way to population size or offtake, both of which are unknown. Even a management criterion based on a population growth rate is feasible only if we assume that the bias in abundance and offtake, whatever their magnitude, are relatively constant over time.

While the info-gap analysis suggests an increase of offtake over the nominal level of 450 thousand is necessary to begin decreasing population size, we emphasize that we do not know the current level of offtake (i.e., whether it has changed from that reported in the ISSMP). Moreover, the info-gap analysis does not take into account special needs and population trajectories of the MUs and their different segments, and thus it carries a high risk of not meeting the MU-specific population targets if not replaced by a more reliable decision-making tool. We conclude that info-gap decision analysis does not provide a sound basis for adaptive, dynamic decision-making, which ultimately will be necessary to reliably manage Greylag Goose abundance in accordance with population targets in the two management units. Only up-to-date, coordinated, and reliable monitoring data on abundance and offtake from throughout the flyway will allow us to realize that goal.

Acknowledgements

EGMP Data Centre colleagues Henning Heldbjerg and Gitte Jensen provided data and helped with the analyses. Szabolcs Nagy and Tom Langendoen with Wetlands International provided recent IWC estimates of abundance. We also acknowledge the efforts of the national IWC coordinators and observers in providing IWC count data. Finally, we thank Dr. Guthrie Zimmerman, United States Fish and Wildlife Service, for providing a technical review of an earlier draft of this report and for providing helpful suggestions.

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Appendix

EGMP national totals (in thousands) used to investigate Greylag Goose population growth rates. Highlighted values are imputed (see text).

Year	Sweden	Denmark	Germany	Netherlands	Belgium	France	Spain	Portugal
2004	6.989	31.934	51.137	226.502	12.981	13.987	96.458	1.828
2005	23.380	40.096	68.704	227.401	9.472	14.313	125.632	2.332
2006	5.847	51.669	82.390	295.162	15.746	15.730	132.190	2.840
2007	39.300	75.092	63.846	254.874	10.649	13.879	119.456	2.734
2008	49.592	75.671	86.800	276.832	10.578	14.356	130.786	2.391
2009	35.631	91.057	81.451	325.987	11.950	15.558	119.000	2.673
2010	30.260	71.974	61.597	393.662	10.130	20.173	114.642	2.322
2011	12.510	61.353	65.040	448.419	13.893	28.284	93.775	3.163
2012	40.033	133.453	106.083	381.774	12.941	19.612	57.532	2.576
2013	19.849	91.185	110.442	437.290	14.031	20.081	54.514	5.128
2014	31.382	87.095	114.980	407.525	14.530	15.898	51.654	2.959
2015	37.907	81.268	119.705	414.557	13.863	18.755	48.944	2.439
2016	29.749	106.295	124.624	401.236	13.100	17.756	46.376	1.597

Annex 5. Impact Models

According to the ISSMPs for the Greylag Goose and the Barnacle Goose Range States are mandated to investigate if there is a relationship between goose abundances and the amount of damage caused by the species to agricultural crops, risks to air safety or other sensitive flora and fauna.

In order to scale up an assessment of the extent of damage or risks to regional, national or even flyway levels, it is necessary to apply either a retrospective time series, statistical analysis or a predictive simulation approach. With regard to agricultural damage, some first indicative examples of national time series analyses were provided in the respective ISSMPs based on compensation payments to farmers in relationship to annual abundances of geese. For Sweden this analysis has been extended and validated (Montràz-Janer et al. 2019). In case of Denmark, where compensation or subsidies are not used to support crop damage management, derogation was used as a proxy of the intensity of crop loss. At national level, there was a relationship between Barnacle Goose numbers and licenses granted for derogation shooting (Clausen et al. 2020). In the Netherlands, retrospective analyses are also in progress (to be reported in 2021).

Predictive models to assess the relationship have so far been developed at regional levels in Norway (Baveco et al. 2017). Work is in progress in the Netherlands and Denmark (at regional level), using individual-based models and agent-based simulations, respectively (to be reported in 2021). The process of building, parameterisation and testing such models is resource demanding and cannot be rolled out easily to all Range States. Hence, at least for the foreseeable future, such models can realistically only be used for selected regions.

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Annex 6. Indicator factsheets

I.1. Population size compared to the target population size

Rationale

This indicator measures the progress towards the Fundamental Objective I. Maintain the population at a satisfactory level.

The target population sizes have been identified above the Favourable Reference Population (FRP, see Chapter 4) at both population and management unit levels using the MCDA methodology (see Annex 3).

These target population levels can be considered satisfactory in the context of Article 2 of the Birds Directive because (i) they exceed the Favourable Reference Populations. This ensures that the population is not reduced below what is considered being ecologically functional in the long-term in individual Range States, Management Units and at the population level. This corresponds to the ecological requirements part of Article

2. However, satisfactory levels also take into account (ii) economical and recreational requirements (i.e. the second part of Article 2).

Indicator definition

Individuals belonging to the two management units partially mix during the passage and wintering seasons. Therefore, this indicator includes two sub-indicators:

1. Number of wintering individuals;
2. Number of breeding pairs.

Methodology

Data collection

Data collected for both sub-indicators at national level.

- Number of wintering individuals is estimated based on January counts (IWC counts and complementary goose counts) annually (see Chapter 6).
- Number of breeding pairs is also to be estimated annually because this is a precondition of the adaptive, dynamic harvest management of the population at MU level (see Chapter 6). National population sizes in the 2003-2018 round of the EU Birds Directive Article 12 reporting, or in the ISSMP for Norway, will represent the baseline.

Data flow
The dataflow is described in Chapter 6 of this AFMP.

Methodology for indicator calculation
Methodology is described in Chapter 6 of this AFMP.

Methodology for gap filling
Methodology for gap filling is to be agreed in 2020.

Methodology uncertainty
Incomplete coverage of breeding and wintering areas. Methodology guidelines are to be developed by the EGMP Data Centre in 2020.

I.2 Range extent compared to the Favourable Reference Range (FRR)

Rationale

This indicator measures the progress towards the Fundamental Objective I. Maintain the population at a satisfactory level.

The population is considered to be maintained at a satisfactory level if the range is maintained at or above the level of the Favourable Reference Range, which is set (for most Range States) in Table 2 of the AFMP at the level of the 2003-2018 period.

Indicator definition

This indicator consists of two sub-indicators:

- Actual breeding range in proportion of the breeding FRR;
- Actual non-breeding (staging and wintering range) in proportion of the non-breeding FRR.

The breeding range includes the areas where nesting and brood rearing before fledging takes place.

According to the CMS definition, the non-breeding range includes any areas the migratory species stays in temporarily, crosses or overflies during its normal migration. Hence, the range is not restricted to key sites only, but includes all areas where the species regularly (although not necessarily) occurs annually.

Methodology

Data collection
Data for the breeding range will be collected once in every six years linked to the reporting under Article 12 of the EU Birds Directive and to the AEWA national population status reporting. Range States shall map the breeding distribution of the species following the standards set for the reporting under Article 12 of the EU Birds Directive and use the range method described in DG Environment (2017, pp. 124-128). Data for the non-breeding range will be collected at the same time as for breeding range data is collected reporting under Article 12 of the EU Birds Directive and to the AEWA national population status reporting. Range States are recommended to use the Range Tool[11] developed for the reporting under Article 17 of the Habitats Directive to determine the range. The recommended gap distance for Greylag Goose is 190 km based on Box 3.2 in Bijlsma (2019, p. 40) using a body mass value of 3.14 kg. Information on non-breeding distribution can be obtained from the national IWC scheme and online observation reporting portals active in the Range States.

Data flow
Range States should calculate the range based on their distribution mapping and report to the EGMP Data Centre at the same year they report to the EU and AEWA on the breeding distribution of Greylag Goose.

Methodology for indicator calculation
For both sub-indicators the actual range will be compared to the national, MU and flyway level FRRs.

Methodology for gap filling
No need for gap filling is foreseen in the Range States.

Methodology uncertainty
The methodology is sensitive to changes on the edges of the range. Currently, the range method was not applied by all Range States. Several

References

Bijlsma, R., Agrillo, E., Attorre, F., Boitani, L., Brunner, A., Evans, P., . . . van Kleunen, A. (2019). *Defining and applying the concept of Favourable Reference Values for species and habitats under the EU Birds and Habitats Directives*. Retrieved from https://edepot.wur.nl/469035

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II.1. Relative change in damage payments

Rationale

This indicator measures the progress towards the Fundamental Objective II. Minimize agricultural damage and conflicts. The most direct indicator would be the loss of yield of a given crop type caused by Greylag Geese, cumulated from local to national and international levels; however, such measurements would be extremely costly and models for upscaling do not exist. Therefore, it is necessary to resort to measurable proxy indicators,

[11] http://cdr.eionet.europa.eu/help/habitats_art17/Reporting2019/Guidelines_for_EEA_range_tool_README_.pdf

such as (1) compensation payments or (2) subsidies, or management actions taken to prevent agricultural damage, such as (3) offtake under derogation.

Indicator definition

This indicator includes three sub-indicators (for definition and current use in the EGMP Range States, see Tombre et al. (2019)[12]:

1. Monetary compensation payments for crop damages cause by Greylag Geese, under which farmers eligible for compensation receive public money to counterbalance for the lost crop.
2. Subsidy payments, i.e. farmers receiving public funds in order to allow goose grazing on their properties. Subsidies are usually paid in advance and may hence not directly reflect the level of damage.
3. Offtake under derogation, referring to the culling of flight-less geese (adults and young), removing of nests or eggs during summer, or geese shot outside the hunting season to protect crops.

Because the three sub-indicators are used slightly differently among Range States and do not all use a monetary currency, they will be used on a relative scale to evaluate trends in damage.

Methodology

Data collection
Data collected for the three sub-indicators at national level, species-specific and annually. Compensation payments, subsidies paid, and numbers of Greylag Geese killed under derogation will be compiled from the national statutory authorities, who are also responsible for the quality check of the information provided. The authorities will also be asked to report any change in policies, regulations or management practices, which may influence payments or use of derogation.

Data flow
Data for each year from the period of 2020 – 2024 is to be reported to the EGMP Data Centre by 31 December 2025. Data collection shall continue also in 2025 – 2026.

Methodology for indicator calculation
The national payments and derogation information will be entered into a common database. The starting year will be set at an index of 100 for each country, and subsequent data will be indexed relatively to the starting year, taking into account the national inflation rate. An overview for all range states and the three relative sub-indicators will be updated annually.

Methodology for gap filling
No gap filling.

Methodology uncertainty
The sub-indicators are sensitive to changes in management policies, regulations and practises. A meta-database will document all the reported changes. Some countries do not have species-specific reporting of damage and can only give a rough estimate of the damage caused by Greylag Geese. A system will have to be set up to assess the uncertainties in the reporting.

[12] https://egmp.aewa.info/sites/default/files/download/population_status_reports/EGMP_010_Management_measures_for_geese.pdf

III.1 Risk of zoonotic influenza transmission to the general public

Rationale

This indicator measures the progress towards the public health component of Fundamental Objective III. Minimise the risk to public health and air safety.

Migratory geese can act as a vectors of various diseases harmful to humans and poultry (Buij *et al.*, 2017) although the general risk was considered being low both in the ISSMP (Polowny et al., 2018) and in the MCDA process (Johnson, 2020). Risk of zoonotic influenza transmissions has been selected to as an indicator because (i) its high relevance for human health, (ii) there is an ongoing surveillance programme in the EU with quarterly reports[13]. Hence, monitoring zoonotic influenza does not require additional resources from the EGM Range States. (iii) This indicator represents not only the prevalence of the virus, but also the preparedness to avoid transmissions.

Indicator definition

Number of human cases of zoonotic influenza per year in the flyway that can be attributed to Greylag Goose.

Methodology

Data collection
No direct reporting is required by the Range States.

Data flow
Data will be obtained by the EGMP Data Centre from the Avian Influenza overview reports published quarterly by the European Food Safety Authority (EFSA), the European Centre for Disease Prevention and Control (ECDC) and the European Union Reference Laboratory for Avian influenza (EURL).

Methodology for indicator calculation
Number of cases per year.

Methodology for gap filling
No need for gap filling is foreseen in the Range States.

Methodology uncertainty
Attribution of the source of infection might be problematic in some cases.

References

Buij, R., Melman, T. C., Loonen, M. J., & Fox, A. D. (2017). Balancing ecosystem function, services and disservices resulting from expanding goose populations. *Ambio, 46*(2), 301-318.

Polowny, T., Jensen, G. H., Nagy, S., Czajkowski, A., Fox, A. D., Lewis, M., & Madsen, J. (2018). *AEWA international single species management plan for the greylag goose (Anser anser): Northwest/Southwest European population.*

III.2. Number of bird strikes with aircrafts caused by Greylag Goose

Rationale

This indicator measures the progress towards the Fundamental Objective III. Minimize the risk to public health and air safety. The frequency of bird strikes with Greylag Goose is the direct indicator for the development in

[13] https://www.ecdc.europa.eu/en/avian-influenza-humans/surveillance-and-disease-data/avian-influenza-overview

incidents, cumulated from local airports to national and international levels. The risk is likely to increase with the number of Greylag Geese passing over airports (see Indicator III.3).

Indicator definition

The indicator is the number of bird strikes caused by Greylag Geese in commercial airports in the Range States.

Methodology

Data collection
Data collected at airport and national level, species-specific and annually. This indicator is reported as a standard in all commercial civil airports and the airport authorities attempt to make an identification of the species causing the bird strike. Airports will be asked to report:

a. Date, time of bird strike;
b. Species, flock size, number struck;
c. Aircraft model;
d. Phase of flight (takeoff, landing, descent, climb, *en route*).

Bird strike data will be compiled from the national statutory authorities. The authorities will also be asked to report any change in reporting practices, which may influence the indicator.

Data flow
Data for each year from the period of 2020 – 2024 is to be reported to the EGMP Data Centre by 31 December 2025. Data collection shall continue also in 2025 – 2026.

Methodology for indicator calculation
Range States will be asked to select at least three high-risk civil commercial airports within the national range of the Greylag Goose for reporting. The frequency of bird strikes will be listed per airport and per country. An overview for all range states will be updated annually.

Methodology for gap filling
No gap filling.

Methodology uncertainty
The frequency of bird strikes with Greylag Goose is low in most airports. Therefore, the indicator has to be combined with III.3 to give a more reliable indication of the risk.

III.3. Number of Greylag Geese passing over commercial airports

Rationale

This indicator measures the progress towards the Fundamental Objective III. Minimize the risk to public health and air safety. The number of Greylag Geese passing over an airport indicates the risk of bird strikes in a given airport (Indicator III.2) and can be related to the national and international levels.

Indicator definition

The indicator is the cumulative number of Greylag Geese passing over civil commercial airports per year in the range of the Greylag Goose, using the same airports as in III.2.

Methodology

Data collection
Data collected at airport and national level, species-specific and annually. This indicator is reported as a standard in commercial civil airports and the airport authorities attempt to make an identification of the species passing (or landing in the airport). Airports will be asked to report:

a) Date, time of passage,
b) Species, flock size.

Greylag Goose passage data will be compiled from the national statutory authorities. The authorities will also be asked to report any change in reporting practices, which may influence the indicator.

Data flow
Data for each year from the period of 2020 – 2024 is to be reported to the EGMP Data Centre by 31 December 2025. Data collection shall continue also in 2025 – 2026.

Methodology for indicator calculation
Range States will be asked to select at least three high-risk civil commercial airports within the national range of the Greylag Goose for reporting. The cumulative number of Greylag Geese passing per year will be calculated per airport. A national trend index will be calculated. The starting year will be set at an index of 100, and subsequent data will be indexed relatively to the starting year. An overview for all range states (average national indexes and relative change) will be updated annually.

Methodology for gap filling
No gap filling.

Methodology uncertainty
The ability of species identification by bird control employees has to be checked. If some airports use radar for identification, standards for species identifications have to be defined.

IV.1 Area of natural habitat or habitat of threatened species negatively affected by Greylag Goose

Rationale

This indicator measures the progress towards Fundamental Objective IV. Minimize the risk to other flora and fauna. The risk to other flora and fauna can be induced mainly via (1) grazing of plants, e.g. reed, with possible knock-on consequences for reed-nesting birds or (2) eutrophication of oligotrophic lake ecosystems by goose droppings transferred from foraging grounds to roosts. However, grazing and nutrient transport is amongst the ecological functions of geese and not necessarily a damage. Therefore, it should be assessed on a case-by-case basis and considered being a damage if it conflicts with the conservation objectives of a site.

Indicator definition

Area of natural habitat or habitat of threatened species negatively affected by Greylag Goose. This indicator considers the natural habitats of conservation interest, which includes natural habitats listed on Annex I of the EU Habitats Directive or any other natural habitats that are of conservation interest at national level. It also includes the habitat for threatened species regardless whether the habitat is of natural origin or not. In case of such habitats the important factor is the presence and dependence of a threatened species on the habitat, and the structure and other characteristics of the habitat. In this context threatened species include species that are listed on Annex I of the Birds Directive or on Annexes II or IV of the Habitat Directive or listed as threatened on a European or national Red List.

Methodology

Data collection
Range States will need to collect information from the organisations responsible for managing conservation areas on the damage caused by Greylag Goose two times during the lifetime of this AFMP. As the damage can affect a wide range of species the extent of the habitat damaged will be used as the measurement of the damage. Site management organisations should be asked to report:

a) the threatened species or habitats affected negatively by Greylag Goose during the reporting period;
b) the location, the nature of the damage and the extent of area affected.

Data flow
Data for each year from the period of 2020 – 2024 is to be reported to the EGMP Data Centre by 31 December 2025. Data collection shall continue also in 2025 – 2026.

Methodology for indicator calculation
The EGMP Data Centre will report the total area affected and also areas by habitat types or species.

Methodology for gap filling
No need for gap filling is foreseen.

Methodology uncertainty
This indicator is dependent on the judgement of the site management organisations.

V.1 Number of people enjoying watching geese

Rationale

This indicator measures the progress towards the cultural/recreational component of Fundamental Objective V. Maximise ecosystem services.

Watching geese represents an important cultural/recreational service for many people (Buij *et al.*, 2017) and the MCDA process (Johnson, 2020) has identified that several stakeholder groups valued this highly. Unfortunately, it is highly difficult to monitor the change in the recreational value of geese. Repeated socio-economic surveys would be rather expensive. Therefore, it is suggested to use the number of people submitting Greylag Goose observations to online observation recording portals. These portals target the general public and a very high proportion of people interested in watching birds keep records of their observations on these platforms. The main observation portals in the region all contribute to the EuroBirdPortal. This would allow obtaining data at a very low cost. Even if the indicator would probably underestimate the number of people enjoy watching geese, it is assumed it would correlate closely with the total number of people. It is proposed to focus on the number of people rather than the number of man-days because the latter would require a different level of engagement than simple enjoyment.

Indicator definition

Change in the annual number of people submitting Greylag Goose observations to an online portal that contributes data to the EuroBirdPortal.

Methodology

Data collection
No direct reporting is required by the Range States.

Data flow
Data will be obtained by the EGMP Data Centre from EuroBirdPortal

Methodology for indicator calculation
An annual index of the number of people submitting goose observations to the online portals will be calculated for each country and aggregated at MU and flyway level.

Methodology for gap filling
No need for gap filling is foreseen in the Range States.

Methodology uncertainty
The index might also change if the number of users is changing and it should be tested whether this has any influence on the index.

References

Buij, R., Melman, T. C., Loonen, M. J., & Fox, A. D. (2017). Balancing ecosystem function, services and disservices resulting from expanding goose populations. *Ambio, 46*(2), 301-318.

V.2. Number of recreational Greylag Goose hunters

Rationale

This indicator measures the progress towards the Fundamental Objective V. Maximise ecosystem services. Throughout the flyway shooting of Greylag Geese constitutes a cultural service to recreational hunters, who enjoy the hunt for geese and the goose meat as a culinary food resource. Furthermore, waterfowl hunters often pay landowners for hunting rights and they spend considerable amounts of money on their equipment (see Buij at al. 2017). The number of active Greylag Goose hunters is an indicator of this cultural service, cumulated from national and international levels.

Indicator definition

This indicator is defined as the number of active Greylag Goose hunters, i.e. hunters who have reported shooting at least one Greylag Goose in the last year of reported harvest, per Range State and along the flyway as a total.

Methodology

Data collection
The number of active Greylag Goose hunters is derived from the national bag statistics, which are mandatory in some countries while based on questionnaires in other countries and for some countries at rather long intervals. Data collected at national level, species-specific and annually using the most up-to-date bag statistics available.

Data flow
Data for each year from the period of 2020 – 2024 is to be reported to the EGMP Data Centre by 31 December 2025. Data collection shall continue also in 2025 – 2026.

Methodology for indicator calculation
The number of active Greylag Goose hunters will be estimated per Range State and as a total for the flyway.

Methodology for gap filling
No gap filling.

Methodology uncertainty
The quality of the reports will depend on the national harvest reporting systems and the frequency of reporting. A system will have to be set up to assess the uncertainties in the reporting.

References

Buij, R., Melman, T. C., Loonen, M. J., & Fox, A. D. (2017). Balancing ecosystem function, services and disservices resulting from expanding goose populations. *Ambio, 46*(2), 301-318.

V.3. Number of Greylag Goose killed and used

Rationale

This indicator measures the progress towards the Fundamental Objective V. Maximise ecosystem services. Throughout the flyway shooting of Greylag Geese constitutes a cultural service to recreational hunters, who enjoy the hunt for geese and the goose meat as a culinary food resource (see V.2). Furthermore, waterfowl hunters often pay landowners for hunting rights and they spend considerable amounts of money on their equipment (see Buij *et al.*, 2017). In certain countries, Greylag Geese can be sold at the market, and in countries performing large-scale derogation culling, the goose meat is provided to public kitchens. Hence, the goose hunting is also a provisioning service. The number of Greylag Geese killed is an indicator of this provisioning ecosystem service, cumulated from national and international levels.

Indicator definition

This indicator is defined as the number of Greylag Geese reported shot and live birds culled or shot under derogation annually. These numbers will be reported per Range State and along the flyway as a total.

Methodology

Data collection
The number of Greylag Geese shot by hunters will be derived from the bag statistics, which are mandatory in some countries while based on questionnaires in other countries and for some countries at rather long intervals. Data collected at national level, species-specific and annually, using the most up-to-date bag statistics available. Offtake under derogation will be derived from the annual reporting to the EGMP. At a 6-year interval, a questionnaire concerning the use of the meat will be send out to national authorities.

Data flow
Data is to be reported to the EGMP Data Centre every 6 years (the same years as the deadlines for reporting on harvest of Annex II species under Article 12 of the Birds Directive), with a documentation of the year of reporting, type of reporting and geographical coverage.

Methodology for indicator calculation
The offtake of Greylag Geese by hunting or under derogation will be recorded per Range State and as a total for the flyway.

Methodology for gap filling
No gap filling.

Methodology uncertainty
The quality of the reports will depend on the national bag statistics and derogation reporting systems and the frequency of reporting. A system will have to be set up to assess the uncertainties in the reporting.

References

Buij, R., Melman, T. C., Loonen, M. J., & Fox, A. D. (2017). Balancing ecosystem function, services and disservices resulting from expanding goose populations. *Ambio, 46*(2), 301-318.

VI.1 Relative change in cost of goose management

Rationale

This indicator measures the progress towards the Fundamental Objective VI. Minimize costs of goose management. An indicator for the successful fulfilment of this objective is that the measurable administrative costs for dealing with the many facets of goose related management and conflict are reduced with the progressive implementation of the ISSMP for the Greylag Goose (and other EGMP species management plans?).

Indicator definition

This indicator is defined by the number of administrative man-years spent on goose management in the Range States, including program management, communication with users, number of field assessments made, reporting (from local to international levels).

Methodology

Data collection
The EGMP Data Centre will send out a questionnaire to each Range State asking for administrative costs spent on goose management activities at various governance levels (local, regional, national).

Data flow
Data for each year from the period of 2020 – 2024 is to be reported to the EGMP Data Centre by 31 December 2025. Data collection shall continue also in 2025 – 2026.

Methodology for indicator calculation
The number of man-hours divided into different levels of governance and tasks will be amalgamated for each country and be presented in an international overview at 6- year intervals.

Methodology for gap filling
No gap filling.

Methodology uncertainty
It is important to standardize the questionnaires, but due to differences in national organisation of goose management, they will have to be tailored specifically. For some countries it may be difficult to make a quantitative assessment, and it may be necessary to resort to a qualitative assessment (increase, stable, decrease).

VII.1 Available sustainable hunting quota

Rationale

This indicator measures the progress towards the Fundamental Objective VII. Provide hunting opportunities that are consistent with maintaining the population at a satisfactory level. An indicator for the successful fulfilment of this objective is that sustainable hunting quotas are available to the Range States, which want to have a quota. The annual quotas will depend on the status of the population in relation to the population size target, the harvest strategy decided by the Range States for the two Management Units as well as the controllability of the harvest regulations and quotas in the individual Range States.

Indicator definition

The indicator will reflect the available hunting quota defined by the EGM IWG based on the status report and the harvest recommendations produced by the EGMP Data Centre taking into account the agreed management objective.

Methodology

Data collection
The available harvest quota decision will be available in the EGM IWG meeting minutes annually.

Data flow
No additional data collection will be necessary.

Methodology for indicator calculation
Absolute annual values of the available harvest quota.

Methodology for gap filling
No gap filling is needed.

Methodology uncertainty
Due to the deep uncertainties of both of the offtake and the population size, proposing a sustainable harvest quota will be possible only in 2023 if the monitoring activities outlined in Chapter 6 are implemented.

Annex 7. Protocols for the iterative phase

Monitoring, assessment and decision-making protocols will be developed by the EGMP Data Centre after the adoption of the AFMP.