Doc. AEWA/EGMIWG/Inf.814
Date: 12 May 2023

AEWA EUROPEAN GOOSE MANAGEMENT PLATFORM

8th MEETING OF THE
AEWA EUROPEAN GOOSE MANAGEMENT
INTERNATIONAL WORKING GROUP

20-22 June 2023, Bonn, Germany

PROGRESS REPORT ON MODELING PROCESS FOR NW/SW EUROPEAN POPULATION OF GREYLAG GOOSE

Aarhus University

Coordinating Offtake of the NW/SW European Population of Greylag Geese

Progress Report

21 January 2023 v2

Fred A. Johnson, EGMP Data Centre, Aarhus University

Executive Summary

This report describes progress in building a flyway-level population model for assessing the implications of varying levels of sport harvest and derogation shooting for meeting population targets of Greylag Geese in western Europe. There are two breeding management units for this population: MU1, which is centered in Scandinavia and is migratory, and MU2, which is centered in the Netherlands and neighboring countries and is largely sedentary. Birds from the two breeding units mix during the wintering season and we defined two wintering areas: one in the North, centered on the Netherlands, that harbors birds from MU1 and MU2, and one in the South, centered on France and Spain, that harbors mostly MU1 birds. We constructed a post-breeding matrix model that recognizes three age classes (young, juveniles, and adults), accounts for the spatial and temporal distribution of birds from the two management units, and allows for offtake during both the breeding and wintering periods. The model was parameterized using basic life history information, although parameters can be updated as reliable monitoring data become available. We also develop a utility model to evaluate various offtake strategies in terms of their ability to meet population targets. This utility model was based on asking participants in the European Goose Management Platform (EGMP) how their levels of satisfaction would change as the number of breeding pairs deviate from their targets. Utilities were scaled $0 \leq U \leq 1$, with 1 = maximum satisfaction. We then simulated a large number (14,641) of offtake strategies, by varying offtake rates independently in the two breeding areas and two wintering areas. Only 31 strategies of the thousands examined had an overall utility of $U > 0.9$ for the number of breeding pairs after 8 years. The best strategies tended to have either high levels of offtake during the breeding season or high levels of offtake during the wintering season. Among the best offtake strategies, mean offtake levels for the South wintering area were uniformly small.

Introduction

The NW/SW European population of Greylag Geese has increased more than seven-fold since the 1980s, resulting in substantial conflicts with agricultural and public safety. The International Single Species Management Plan for the Greylag Goose (*Anser anser*) (ISSMP) mandated the development of an Adaptive Flyway Management Programme (AFMP) to help address the growing socio-economic concerns associated with this population and to provide for sustainable hunting opportunities (Powolny et al. 2018). This project addresses a key element of the AFMP, which is to "establish an internationally coordinated population management programme for both [management units], including offtake under hunting and, if necessary, under derogations, encompassing monitoring, assessment and decision-making protocols" (Nagy et al. 2021) There are two breeding management units for this population: MU1, which is centered in Scandinavia and is migratory, and MU2, which is centered in the Netherlands and neighboring countries and is largely sedentary (*Figure 1*).

Herein, we describe a utility model for Greylag Geese, which describes the relative level of satisfaction among stakeholders as the number of breeding pairs deviate from their agreed-upon targets. This utility model is used to evaluate various offtake strategies in terms of their ability to meet population targets. We also describe the structure of a flyway population model, which characterizes the dynamics of both breeding segments (MU1 and MU2) and accounts for the mixing of the two segments during autumn and winter. We initially parameterize this model using basic life history characteristics and allometric relationships. The demographic parameters of the model can be updated as more monitoring data become available. The structure and parameterization of the flyway model is provisional and subject to review by the relevant range states.

Spatial and Temporal Scales of Population Management

In addition to the two breeding management units, we define two wintering areas (*Figure 1*). In the northern unit there is broad overlap in the wintering distributions of the two breeding units. The southern unit is largely comprised of MU1 birds and is of special interest because of concern about the status of those birds. We also divide the annual cycle of Greylag Geese into a breeding season (April – July) and a wintering season (August – March) (*Figure 2*).

Breeding units (April – July)

(1) MU 1 (migratory): Denmark, Finland, Norway, Sweden

(2) MU 2 (sedentary): Belgium, France, Germany, Netherlands

Wintering units (August – March)

(1) North: Belgium, Denmark, Germany, Netherlands, Sweden

(2) South: France, Portugal, Spain

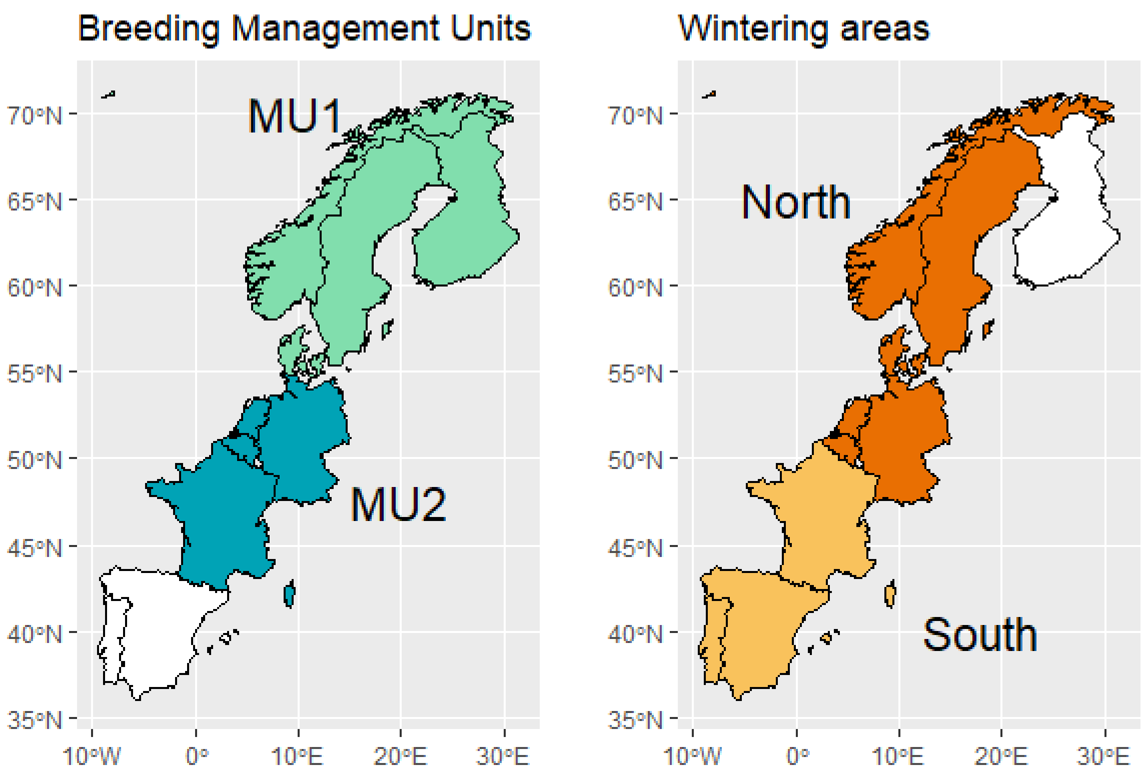

Figure 1. Breeding management units and wintering units for the NW/SW European population of Greylag Geese.

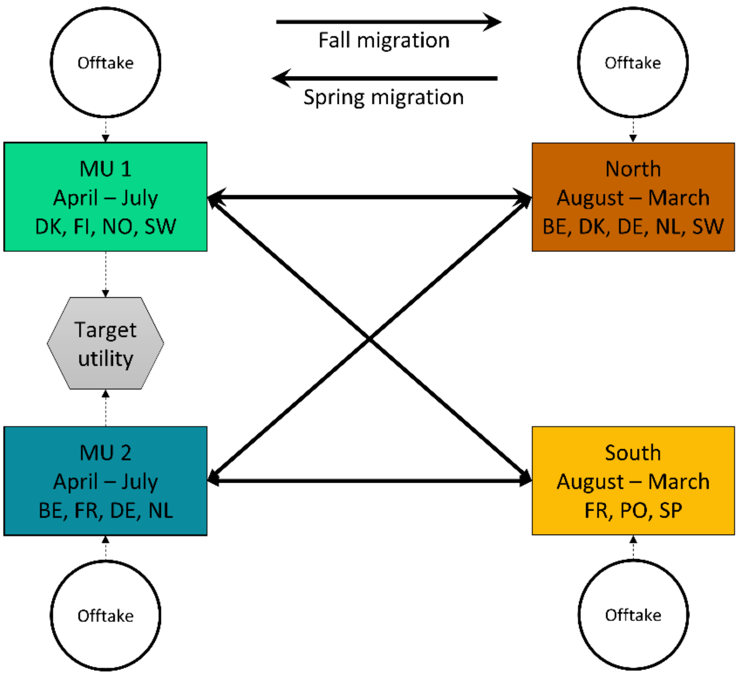

Figure 2. Diagrammatic representation of the model for the annual cycle of the NW/SW European population of Greylag Goose.

Management Objectives

The initial phase of the effort to better coordinate the offtake of Greylag Geese involved specifying objectives and their relative importance in managing the abundance of Greylag Geese. Beyond an objective to maintain the population in a favourable conservation status, the objectives specified by the ISSMP are depicted in *Figure 3.* The ISSMP did not prioritize these objectives, however, and so the International Working Group of the European Goose Management Platform (EGMP) was asked to specify their relative importance (also shown in *Figure 3*). The objectives to minimize agricultural damage, deleterious impacts to natural habitats, and bird strikes to aircraft were regarded as the most important. These objectives and their weights were used to specify population targets of 70 and 80 thousand breeding pairs for MU1 and MU2, respectively (Johnson et al. 2021) (article available here). For comparison, the Favourable Reference Values (FRP) are 31 and 73 thousand breeding pairs for MU1 and MU2, respectively.

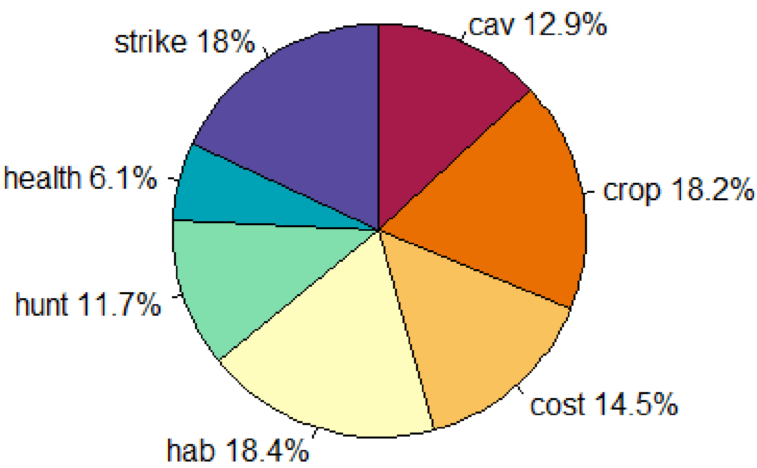

Figure 3. Relative importance of seven objectives for managing the offtake of the NW/SW European population of Greylag Geese. Management objectives are to maximize cultural and aesthetic values (cav), minimize agricultural damage (crop), minimize management costs to governments (cost), minimize deleterious impacts to habitats (hab), maximize satisfaction with the level of recreational hunting (hunt), minimize amenity fouling and disease transmission (health), and minimize bird strikes to aircraft (strike).

Utility Model

Participants in the EGMP were recently asked to express their levels of satisfaction with varying levels of Greylag Goose abundance relative to their targets. Respondents were asked to state their relative level of satisfaction if the population were at its FRP, between the FRP and target, at or near the target, 25% above the target, 50% above the target, and twice the target. For each population level, the respondents could register their level of satisfaction as completely unsatisfied, moderately unsatisfied, neither satisfied nor unsatisfied, moderately satisfied, or completely satisfied. Respondents could register responses for one or both breeding management units. A summary of questionnaire responses is available at: Greylag Goose questionnaire results.

To convert the levels of satisfaction to an ordinal scale, we first eliminated responses with missing values for a level of satisfaction and those in which the level of satisfaction did not vary with population level. This resulted in 17 usable responses for each management unit. We then arbitrarily assigned ordinal scores as: completely unsatisfied = 0, moderately unsatisfied = 0.25, neither satisfied nor unsatisfied = 0.50, moderately satisfied = 0.75, and completely satisfied = 1.0. The distributions of scores for each management unit are provided in *Figure 4*.

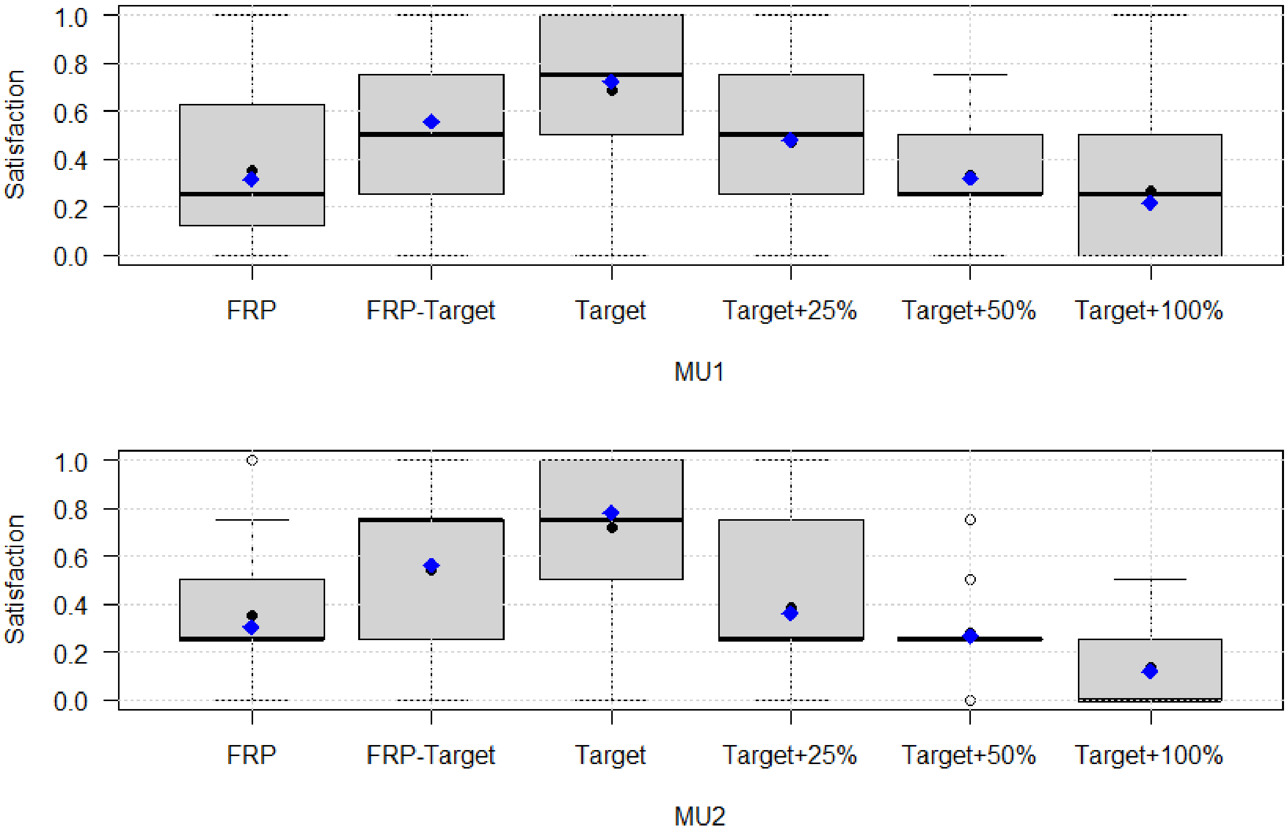

Figure 4. Relative levels of satisfaction with the number of breeding pairs of the NW/SW European population of Greylag Geese relative to their targets for MU1 and MU2, as solicited from participants in the European Goose Management Platform. FRP stands for Favourable Reference Value. The targets are 70 and 80 thousand for MU1 and MU2, respectively. The horizontal lines in the boxes represent median values, the boxes represent the interquartile ranges, the whiskers represent the approximate 95% confidence limits, and the open circles represent outliers. The solid black dots represent the means, and the blue diamonds represent the consensus-convergence values.

To represent the opinion of the EGMP as a group, we used a consensus-convergence model (Regan et al. 2006) to determine the relative level of satisfaction with varying population levels. 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 have less influence on the overall average. The resulting consensus values were then re-scaled so that $0 \leq u \leq 1$ for each management unit. Populations < FRP were assigned 0 utilities and populations > twice the target were assigned the same utility as that for twice the target Utilities for intermediate population levels were interpolated based on piecewise linear functions (*Figure 5*). It is apparent from *Figure 5* that there is more tolerance for the MU1 population being above the target than that for MU2.

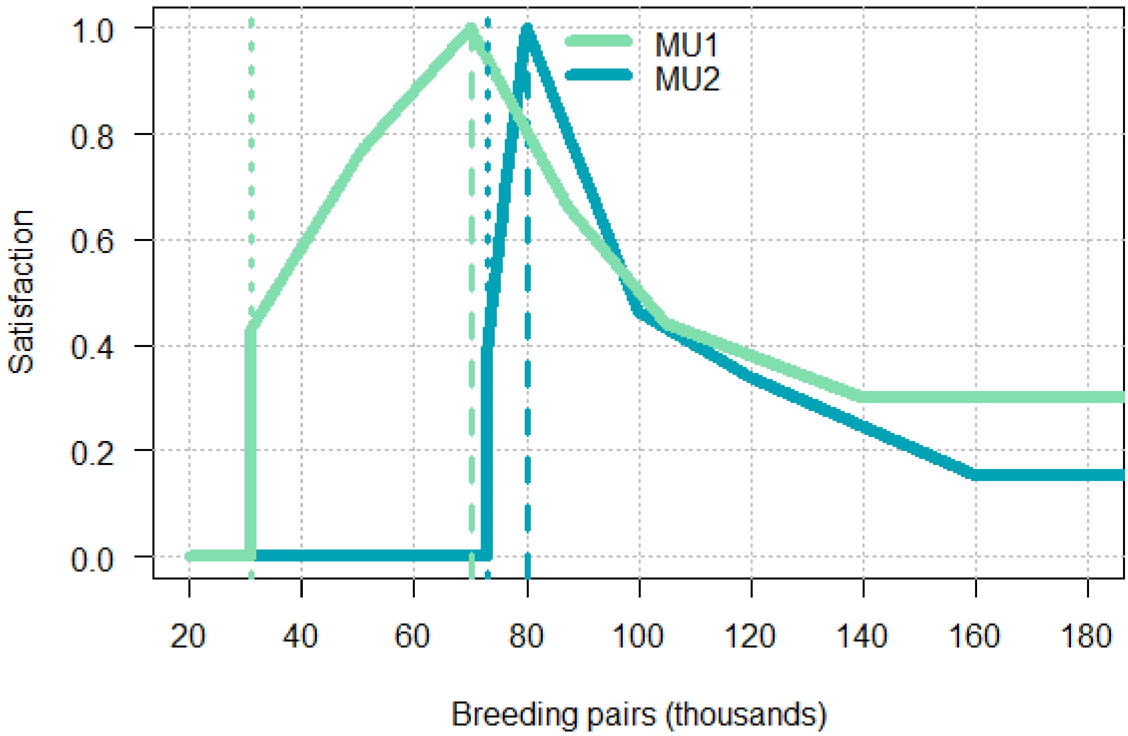

Figure 5. Utility functions for the two management units of the NW/SW European population of Greylag Geese. The dashed vertical lines represent the targets for the two management units and the dotted vertical lines represent their respective FRPs.

Finally, we required a multi-attribute utility function that expresses overall satisfaction for both populations relative to their targets. We reasoned that overall utility should be high only if populations in both management units were near their target, a situation referred to as complementarity (Keeney and Raiffa 1993). Thus, the overall utility function is $U(p_1, p_2) = u(p_1) * u(p_2)$, where p_1 and p_2 are the number of breeding pairs (in thousands) in management units MU1 and MU2, respectively (*Figure 6*).

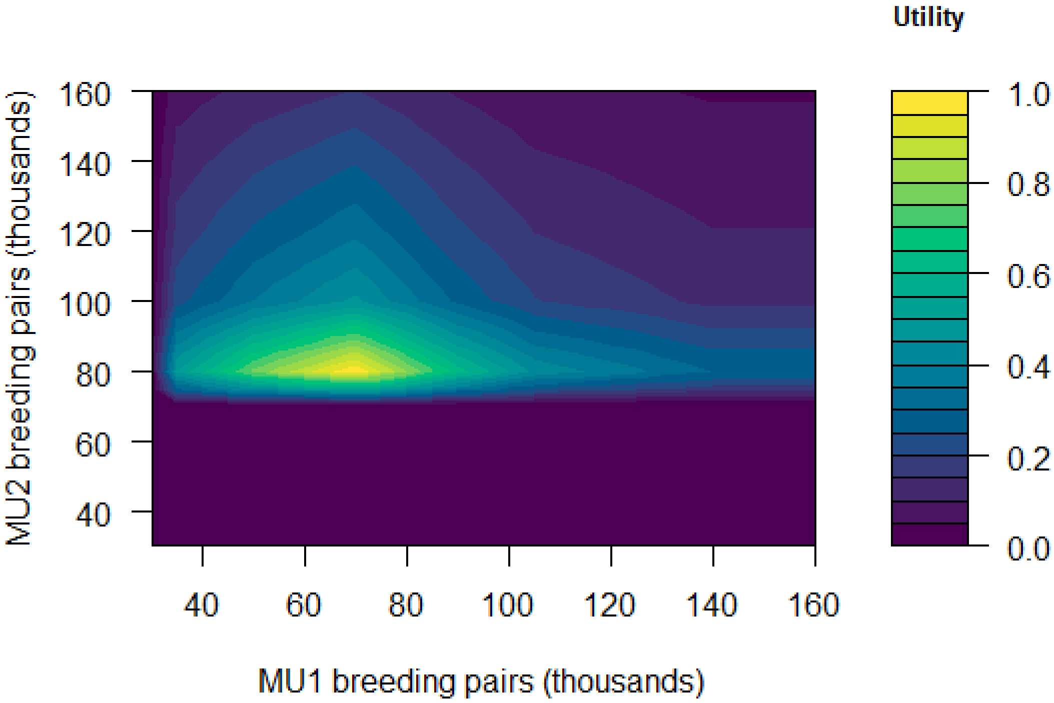

Figure 6. Multi-attribute utility function for the number of breeding pairs in management units MU1 and MU2 of the NW/SW European population of Greylag Geese.

Aarhus University

Population Model

We use a post-breeding projection matrix with an anniversary date of 1 August. Age classes are young (Y), juvenile (J), and adults (A) and are expressed as the total number of individuals (i.e., both male and female). Only adults aged 3+ years can breed.

$$\begin{bmatrix} Y_{t+1} \\ J_{t+1} \\ A_{t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & \phi\alpha \\ \phi & 0 & 0 \\ 0 & \phi & \phi \end{bmatrix} \cdot \begin{bmatrix} Y_t \\ J_t \\ A_t \end{bmatrix}$$

We can decompose the projection matrix into summer and winter components, respectively:

$$\begin{bmatrix} Y_{t+1} \\ J_{t+1} \\ A_{t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & \phi^{4/12}\alpha \\ \phi^{4/12} & 0 & 0 \\ 0 & \phi^{4/12} & \phi^{4/12} \end{bmatrix} \cdot \begin{bmatrix} \phi^{8/12} & 0 & 0 \\ 0 & \phi^{8/12} & 0 \\ 0 & 0 & \phi^{8/12} \end{bmatrix} \begin{bmatrix} Y_t \\ J_t \\ A_t \end{bmatrix},$$

permitting an examination of April abundance, which is the basis for population targets.

Allowing for two breeding units, offtake during the breeding season, no exchange between breeding units during the summer, constant natural survival, and additive mortality from offtake, the complete summer projection matrix is:

$$\boldsymbol{S} = \begin{bmatrix} \boldsymbol{A} & \boldsymbol{B} \\ \boldsymbol{C} & \boldsymbol{D} \end{bmatrix},$$

where:

$$\boldsymbol{A} = \begin{bmatrix} 0 & 0 & \phi^{4/12}\alpha_1(1 - h_{0,2,1}) \\ \phi^{4/12}(1 - h_{1,2,1}) & 0 & 0 \\ 0 & \phi^{4/12}(1 - h_{2,2,1}) & \phi^{4/12}(1 - h_{3,2,1}) \end{bmatrix},$$

and:

$$\boldsymbol{D} = \begin{bmatrix} 0 & 0 & \phi^{4/12}\alpha_2\left(1 - h_{0,2,2}\right) \\ \phi^{4/12}\left(1 - h_{1,2,2}\right) & 0 & 0 \\ 0 & \phi^{4/12}\left(1 - h_{2,2,2}\right) & \phi^{4/12}\left(1 - h_{3,2,2}\right) \end{bmatrix},$$

and:

$$\boldsymbol{B} = \boldsymbol{C} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}.$$

where $h_{a,2,u}$ is the rate of offtake of individuals of age $a \in \{1:3\}$, during the summer season $s = 2$, in spatial units MU1 and MU2, $u \in \{1,2\}$, respectively. Offtake rate of young prior to 1 August is denoted as $h_{0,2,u}$.

The winter projection matrix is more complicated in that it must allow different wintering distributions and breeding-area fidelity of the two management units:

$$\boldsymbol{W} = \begin{bmatrix} \boldsymbol{E} & \boldsymbol{F} \\ \boldsymbol{G} & \boldsymbol{H} \end{bmatrix}$$

where:

$$\boldsymbol{E} = \begin{bmatrix} \pi_1\left[\psi_1\phi^{8/12}\left(1 - h_{1,1,1}\right) + (1-\psi_1)\phi^{8/12}\left(1 - h_{1,1,2}\right)\right] & 0 & 0 \\ 0 & \pi_1\left[\psi_1\phi^{8/12}\left(1 - h_{2,1,1}\right) + (1-\psi_1)\phi^{8/12}\left(1 - h_{2,1,2}\right)\right] & 0 \\ 0 & 0 & \pi_1\left[\psi_1\phi^{8/12}\left(1 - h_{3,1,1}\right) + (1-\psi_1)\phi^{8/12}\left(1 - h_{3,1,2}\right)\right] \end{bmatrix}$$

and:

$$\boldsymbol{H} = \begin{bmatrix} \pi_2\left[\psi_2\phi^{8/12}\left(1-h_{1,1,1}\right)+(1-\psi_2)\phi^{8/12}\left(1-h_{1,1,2}\right)\right] & 0 & 0 \\ 0 & \pi_2\left[\psi_2\phi^{8/12}\left(1-h_{2,1,1}\right)+(1-\psi_2)\phi^{8/12}\left(1-h_{2,1,2}\right)\right] & 0 \\ 0 & 0 & \pi_2\left[\psi_2\phi^{8/12}\left(1-h_{3,1,1}\right)+(1-\psi_2)\phi^{8/12}\left(1-h_{3,1,2}\right)\right] \end{bmatrix}$$

and:

$$\boldsymbol{F} = \begin{bmatrix} (1-\pi_2)\left[\psi_2\phi^{8/12}\left(1-h_{1,1,1}\right)+(1-\psi_2)\phi^{8/12}\left(1-h_{1,1,2}\right)\right] & 0 & 0 \\ 0 & (1-\pi_2)\left[\psi_2\phi^{8/12}\left(1-h_{2,1,1}\right)+(1-\psi_2)\phi^{8/12}\left(1-h_{2,1,2}\right)\right] & 0 \\ 0 & 0 & (1-\pi_2)\left[\psi_2\phi^{8/12}\left(1-h_{3,1,1}\right)+(1-\psi_2)\phi^{8/12}\left(1-h_{3,1,2}\right)\right] \end{bmatrix}$$

and:

$$\boldsymbol{G} = \begin{bmatrix} (1-\pi_1)\left[\psi_1\phi^{8/12}\left(1-h_{1,1,1}\right)+(1-\psi_1)\phi^{8/12}\left(1-h_{1,1,2}\right)\right] & 0 & 0 \\ 0 & (1-\pi_1)\left[\psi_1\phi^{8/12}\left(1-h_{2,1,1}\right)+(1-\psi_1)\phi^{8/12}\left(1-h_{2,1,2}\right)\right] & 0 \\ 0 & 0 & (1-\pi_1)\left[\psi_1\phi^{8/12}\left(1-h_{3,1,1}\right)+(1-\psi_1)\phi^{8/12}\left(1-h_{3,1,2}\right)\right] \end{bmatrix}$$

The complete annual cycle is thus:

$$\begin{bmatrix} n_{1,1} \\ n_{2,1} \\ n_{3,1} \\ n_{1,2} \\ n_{2,2} \\ n_{3,2} \end{bmatrix}_{(t+1)} = [\boldsymbol{S}] \cdot [\boldsymbol{W}] \cdot \begin{bmatrix} n_{1,1} \\ n_{2,1} \\ n_{3,1} \\ n_{1,2} \\ n_{2,2} \\ n_{3,2} \end{bmatrix}_{(t)},$$

where $n_{a,u}$ are abundances per age and management unit on 1 August.

Model Parameterization

Annual survival rate in the absence of anthropogenic mortality was derived using the allometric methods of Johnson et al. (2012) and initially set at $\phi = 0.88$ for all ages entering winter (Johnson and Koffijberg 2021). Natural mortality is initially assumed to be constant throughout the year. Given $\phi = 0.88$ and an age of first breeding of $\omega = 3$, the population growth rate in the absence of anthropogenic mortality is estimated as:

$$\lambda \approx \frac{(\phi\omega - \phi + \omega + 1) + \sqrt{(\phi - \phi\omega - \omega - 1)^2 - 4\phi\omega^2}}{2\omega} \approx 1.16$$

(Niel and Lebreton 2005). We then solved for the reproductive rate, α, that would produce a dominant eigen value of $\lambda = 1.16$ for the following post-breeding population projection matrix:

$$\begin{bmatrix} 0 & 0 & 0.88\alpha \\ 0.88 & 0 & 0 \\ 0 & 0.88 & 0.88 \end{bmatrix},$$

resulting in $\alpha = 0.55$, which is the number of young fledged per adult on 1 August (i.e., 35% young). The same value of ϕ was used for all areas, with the exception of young-of-the-year in MU1, which was set to $\phi = 0.88 * 0.9 = 0.83$ because of evidence that migratory young from MU1 experience greater mortality than young sedentary birds from MU2 (Schneider 2022).

Based on observations of marked birds (Leo Bacon, *personal communication*), the proportions of MU1 birds wintering in the North and South are assumed to be $\psi_1 = 0.845$ and $(1 - \psi_1) = 0.155$, respectively. The proportions of MU2 birds wintering in the North and South are assumed to be $\psi_2 = 0.960$ and $(1 - \psi_2) = 0.040$, respectively. For now, we assume all birds in a wintering unit are exposed to the same harvest pressure, regardless of their breeding-ground origin. Breeding-area fidelity was specified as $\pi_1 = \pi_2 = 1$ for both management units. Birds originating from a particular breeding management unit will often switch units in the next calendar year, but this is usually followed by a return to the original breeding management unit (Schneider 2022).

To initialize population sizes, we first took the mean number of breeding pairs (*bp*, in thousands) estimated for each management unit for the most recently available year (2018): MU1 = 86.8 and MU2 = 122.2. We then calculated the total number of young (both sexes) at the end of summer as a function of the number of breeding pairs: $Y = bp * 2 * \phi^{4/12} * \alpha$. Assuming the same productivity in each management unit ($\alpha = 0.55$) and natural survival is $\phi = 0.88$, the total number of young is $Y = 88.2$ and $Y = 146.9$ for MU1 and MU2, respectively. We then assume the populations are at their stable age distribution (*SAD*), given by the right eigenvector of the annual projection matrix:

$$\begin{bmatrix} 0 & 0 & 0.88(0.55) \\ 0.88 & 0 & 0 \\ 0 & 0.88 & 0.88 \end{bmatrix}, \text{which results in } SAD = \begin{bmatrix} 0.2407 \\ 0.1828 \\ 0.5765 \end{bmatrix}.$$

Thus, the total population size is $N = \frac{Y}{0.2407} = 366.5$ and 610.4 thousand for MU1 and MU2, respectively. Based on preliminary information, these values are similar to those recorded during summer surveys in 2022. Initial abundances of each age class for MU1 and MU2, respectively, on 1 August are therefore (in thousands):

$$\begin{bmatrix} 88.2 \\ 67.0 \\ 211.2 \end{bmatrix} \text{ and } \begin{bmatrix} 146.9 \\ 111.6 \\ 351.9 \end{bmatrix}.$$

Evaluating Offtake Strategies

To evaluate offtake strategies, we specified all possible combinations of offtake rates of $0.00 \leq h \leq 0.20$ in increments of 0.02 for each of the breeding and wintering areas. We assumed that young were twice as vulnerable as older birds to offtake during the wintering season, but we assumed no differential vulnerability during the breeding season. The combinations of unit and season-specific offtake rates resulted in 14,641 offtake strategies. Each of these strategies was simulated over 8 years using the matrix population model. An 8-year timeframe (2022 – 2030) was chosen because the ISSMP is likely to be due for revision in 2030.

Of the thousands of possible offtake strategies, only 31 had high utility ($U > 0.90$), suggesting that only a few of all possible offtake strategies could achieve populations sizes close to the targets after 8 years (on average). The total levels of mean annual offtake for these 31 strategies had a minimum value of 158 thousand and a maximum value of 245 thousand, with an average of 203 thousand. Strategies tended to either have high levels of offtake during the breeding season or high levels of offtake during the wintering season (*Figure 7*). Offtake strategies having lower levels of derogation during the breeding season are likely to be preferred from both a legal perspective and from the perspective of the goose hunter. Mean offtake levels for the South wintering unit were uniformly small (mean: 8 thousand; range: 0 – 17 thousand), in large part due to the relatively small number of geese wintering there (about 8% of the flyway fall flight). By unit and season, the average annual levels of offtake for the 31 strategies were: 41 thousand for MU1, 93 thousand for MU2, 61 thousand for North, and 8 thousand for South. The 31 best strategies were successful in achieving the number of breeding pairs close to their targets at the end of the 8-year timeframe (*Figure 8*). There was a greater spread in projected breeding-pair numbers from MU1, as this was permitted based on the MU1 utility function. The complete set of offtake strategies with high utility, including detailed results of the simulations for both 8 and 10 years, is available at: Optimal Offtake Strategies for Greylag Geese.

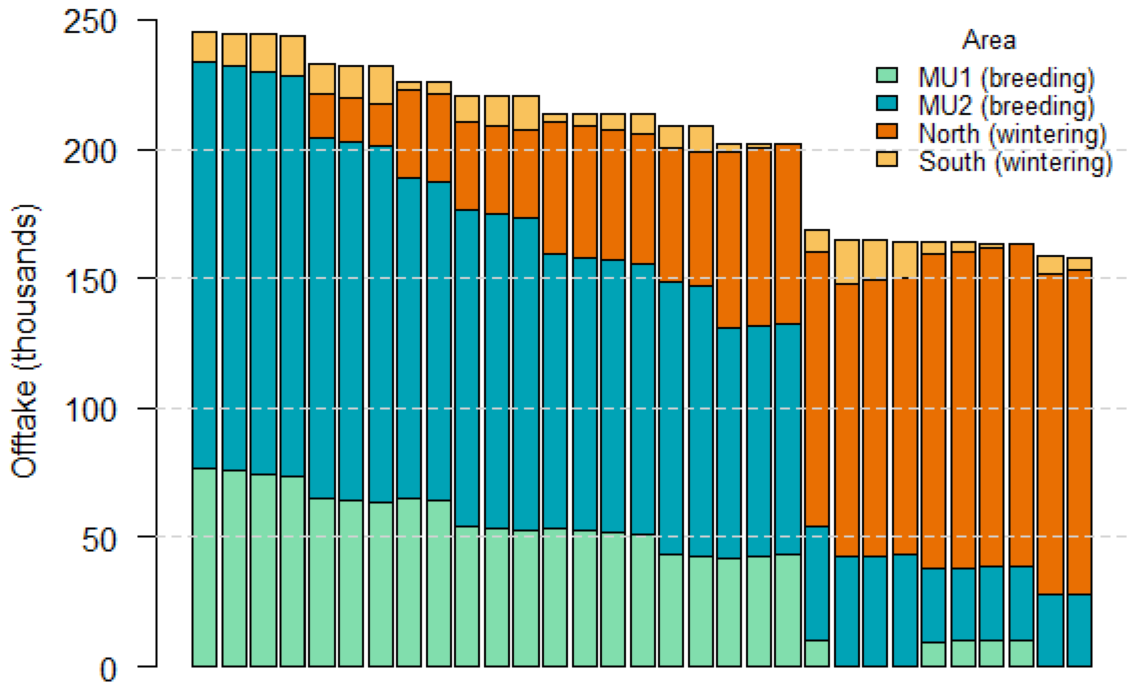

Figure 7. Mean annual levels of offtake over eight years for 31 strategies with high utility for the NW/SW European population of Greylag Geese.

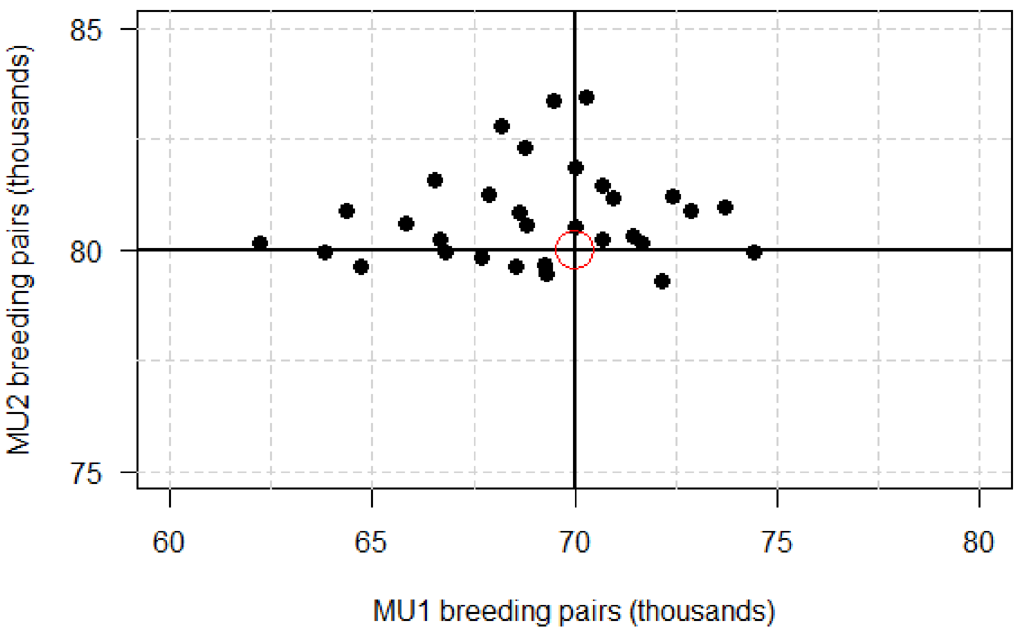

Figure 8. Numbers of breeding pairs at the end of 8 years for 31 offtake strategies with high utility for the NW/SW European population of Greylag Geese. The vertical and horizontal lines represent the targets for the two management units.

Next steps

Prior to June 2023, there are several items requiring attention:

1. The Greylag Goose Task Force should review this progress report, paying particular attention to how the model was parameterized, and recommend any substantive revisions no later than 1 April 2023.

2. The inital populations of breeding pairs used in simulating offtake strategies should be updated as estimates of summer populations become available from new monitoring efforts in the range states (this should be possible by February 2023).

3. The estimates of offtake for the best offtake strategies should be compared with current estimates of offtake by area and season. The EGMP Data Centre is compiling these estimates.

4. The EGMP Data Centre will support the Greylag Goose Task Force in providing guidance to the EGMP regarding evaluation and selection of offtake strategies (no later than 30 April 2023). In addition to the ability of an offtake strategy to achieve population targets, the EGMP must also consider feasibility, costs, and other factors in choosing a preferred strategy.

Literature Cited

Johnson, F. A., H. Heldbjerg, S. Nagy, and J. Madsen. 2021. Setting population-size targets for geese causing socio-economic conflicts. Ambio 51:209–225.

Johnson, F. A., and K. Koffijberg. 2021. Biased monitoring data and an info-gap model for regulating the offtake of greylag geese in Europe. Wildlife Biology 2021:wlb.00803.

Johnson, F. A., M. A. H. Walters, and G. S. Boomer. 2012. Allowable levels of take for the trade in Nearctic songbirds. Ecological Applications 22:1114–1130.

Keeney, R. L., and H. Raiffa. 1993. Decision Analysis With Multiple Objectives. Page Cambridge University Press.

Nagy, S., H. Heldbjerg, G. H. Jensen, F. Johnson, J. Madsen, O. Therkildsen, E. Meyers, and S. Dereliev. 2021. Adaptive Flyway Management Programme for the NW/SW European Population of the Greylag Goose (Anser anser). AEWA EGMP Programme No. 1, Bonn, Germany.

Niel, C., and J. Lebreton. 2005. Using demographic invariants to detect overharvested bird populations from incomplete data. Conservation Biology 19:826–835.

Powolny, T., G. H. Jensen, S. Nagy, A. Czajkowski, A. D. Fox, M. Lewis, and J. Madsen. 2018. AEWA International Single Species Management Plan for the Greylag Goose (Anser anser) - Northwest/Southwest European population. AEWA Technical Series No. 71, Bonn, Germany.

Regan, H. M., M. Colyvan, and L. Markovchick-Nicholls. 2006. A formal model for consensus and negotiation in environmental management. Journal of Environmental Management 80:167–176.

Schneider, E. 2022. Etude démographique des oies cendrées sur la voie de migration européenne NO/SO. Université Jean Monnet.

Acknowledgements

Funding for this study is graciously provided by the Hunters' Nature Fund (Jægernes Naturfond; https://www.jaegernes-naturfond.dk). We also thank Morten Frederiksen, Aarhus University, for reviewing the R code used in the production of results contained herein.

Aarhus University

Coordinating Offtake of the NW/SW European Population of Greylag Geese

Progress Report (21 January 2023) ADDENDUM (27 January 2023)

Fred A. Johnson, EGMP Data Centre, Aarhus University

This ADDENDUM provides an evaluation of potential offtake strategies that are in addition to those examined in the 21 January 2023 Progress Report. In particular, we examined strategies that attempt to minimize derogation during the summer by allowing for higher harvest rates during the winter. This approach would be in accordance with the Birds' Directive that mandates the use of other methods of mitigating socio-economic conflicts before derogation is justified.

As in the 21 January 2023 Progress Report, we simulated populations from 2022 to 2030, when the International Single Species Management Plan evaluation is due. We restricted offtake rates during summer in the two management units (MU1 and MU2) to the range 0.0 – 0.1, while increasing the range of offtake rates during the winter from 0.0 – 0.2 to 0.0 – 0.3. This resulted in 9,216 simulated offtake strategies. Only 12 strategies had utility $U > 0.9$, suggesting they could largely meet population targets for the two management units in the 8-year timeframe. Mean annual harvests in the two breeding management units and the two wintering areas are provided in *Figure 1*. The six strategies with the highest utility ($\overline{U} = 0.96$; the six leftmost strategies in *Figure 1*) eliminated the need for summer derogations in MU1, while minimizing those needed in MU2. For the six strategies, the average annual harvest in the North wintering areas was 106 thousand (min = 88; max = 125 thousand). In the South wintering area, the average annual harvest was 16 thousand (min = 5; max = 25 thousand). Detailed results of the 12 strategies with high utility can be found at: Updated Optimal Offtake Strategies for Greylag Geese.

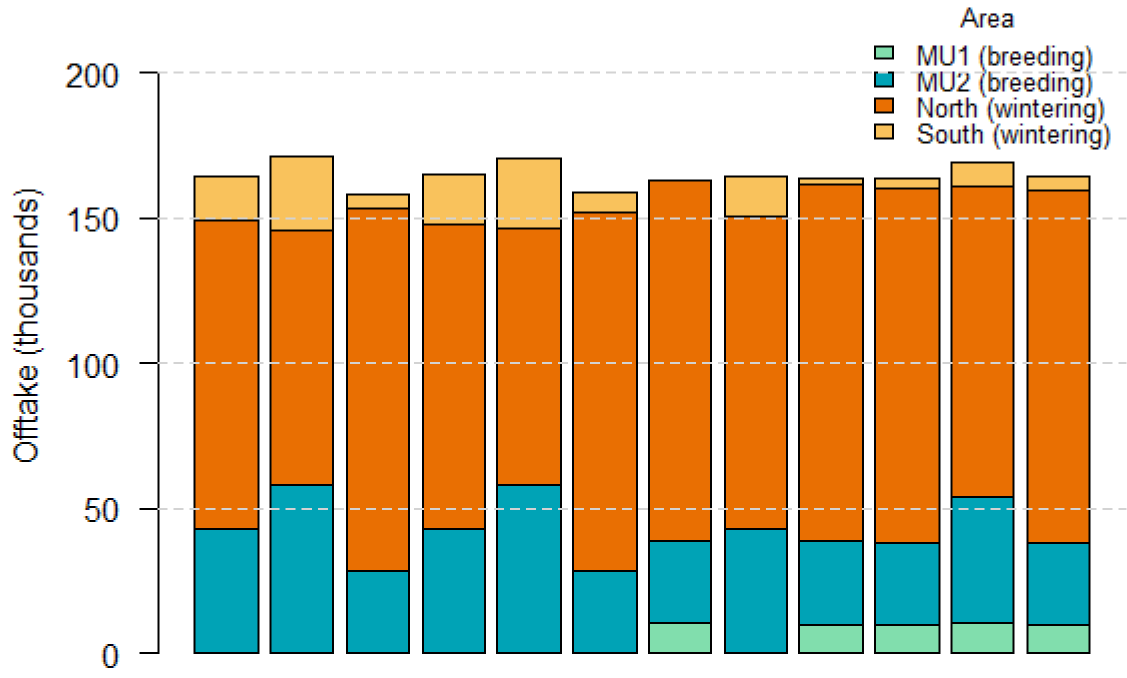

Figure 1. Mean annual levels of offtake over eight years for 12 strategies with high utility for the NW/SW European population of Greylag Geese. These strategies were specifically designed to minimize summer derogations in the two management units.

Acknowledgements

Funding for this study is graciously provided by the Hunters' Nature Fund (Jægernes Naturfond; https://www.jaegernes-naturfond.dk).

NW/SW European Population of Greylag Geese: Model Revisions, Offtake Strategies, Data Needs, and Legal Considerations

Prepared by the EGMP Data Center and Secretariat
4 April 2023

This report provides an update to the last progress report available here: [Greylag Goose Modeling 21Jan2023](). It describes some minor revisions to the population model and simulated offtake strategies based on input from the Task Force. Also included are ongoing data requirements and legal considerations when managing offtake.

Model Revisions based on Task Force Comments

- Modified the biannual seasons to be spring-summer (March-August) and fall-winter (September-February)
- Reduced the post-breeding age ratio to 0.46 (32% young) for both MUs to better reflect the recent flyway population growth rate
- Revised breeding to wintering transition rates to better reflect the wintering (December-February) terminus
- Examined all permutations of offtake rates 0.00 – 0.40 in increments of 0.02 for all seasons and areas (194,481 offtake scenarios)
- Retained all offtake strategies that had Utility ≥ 0.85 (n = 50), indicating a high probability of meeting both MU targets in eight years
- Note that initial, post-breeding population sizes for the two MUs have not yet been updated (some 2022 survey data are still outstanding)

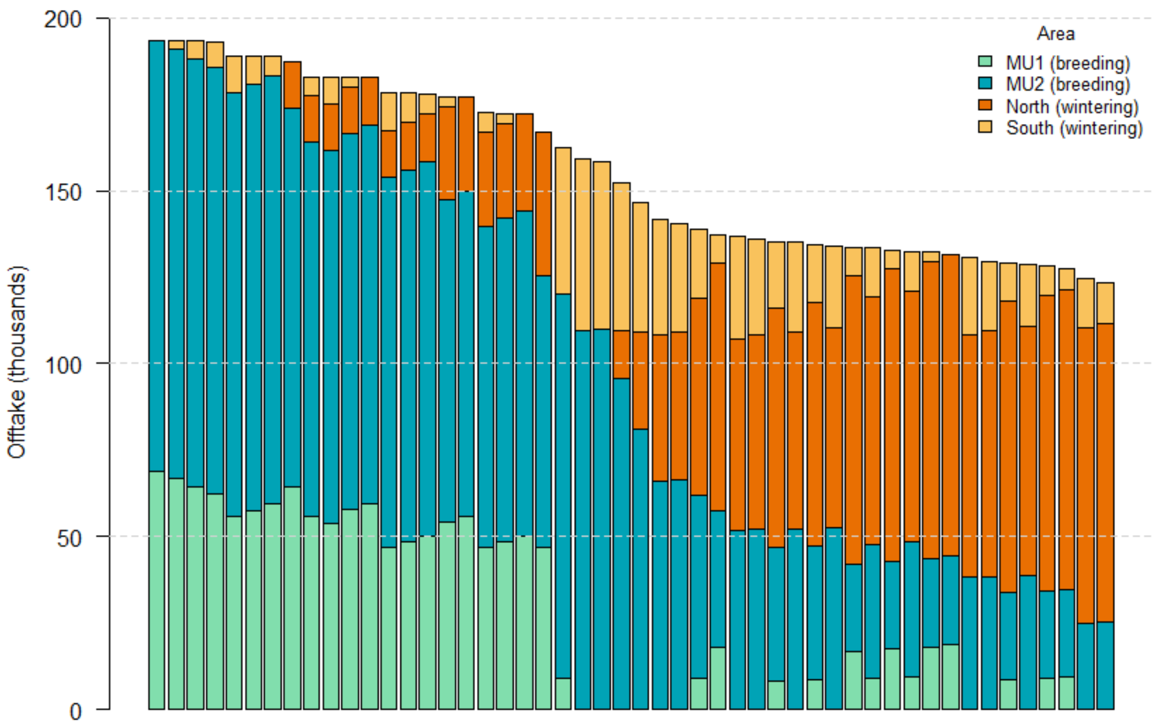

Figure. Alternative offtake strategies for Greylag Geese with high probability of meeting the MU targets after eight years, ordered by decreasing level of total offtake. Values of offtake are the means over the 8-year timeframe.

The complete set of results for these 50 strategies is available here: Revised Offtake Strategies 13Mar2023

The 50 offtake strategies with high utility are of two basic types: (a) those with relatively high spring/summer derogation and low winter offtake, and (b) those with low spring/summer derogation and relatively high winter offtake. The mean levels of offtake (in thousands) for the two sets are:

Area & season	(a) Mean offtake	(b) Mean offtake
MU1 – spring/summer	49	6
MU2 – spring/summer	109	43
subtotal	***158***	***49***
North – fall/winter	12	67
South – fall/winter	10	18
subtotal	***22***	***85***
Total offtake	***180***	***134***

Offtake strategies ultimately must be evaluated not only in terms of their ability to meet population targets for the two Management Units, but also in terms of cost, feasibility, and legal mandates. In reference to the latter, see the last section in this document entitled **Legal Considerations and Implications for Population Management**.

Empirical Estimates of Offtake

The most recently available estimates of offtake during the spring-summer and fall-winter are from spring-summer of 2020 to spring-summer of 2021. Estimates are approximate and rounded to the nearest 0.5 thousand:

MU1	MU2	North	South	Total
4.5	110.0	328.0	12.5	455.0

As described by Johnson and Koffijberg (2021. Biased monitoring data and an info-gap model for regulating the offtake of greylag geese in Europe. Wildlife Biology 2021:wlb.00803), a total level of offtake this high would either imply that the flyway population is underestimated by a factor of three or the flyway population is declining by 20% per year, neither of which seem likely. Thus, these offtake data are likely biased high, perhaps extremely so.

Data Requirements

To reconcile discrepancies between reported levels of offtake and those needed to meet population targets, the following data are needed. Critically, *all data must be accompanied by a short description of the methods for collecting such data* (except for winter counts). At a minimum, the description should specify how the data are collected and should be sufficient to judge their reliability. The methods should also specify the frequency with which the data are collected and when the most recent estimates will be available. The following requirements are in descending order of priority:

1. Offtake estimates: by country and biannual period (spring-summer: March-August and fall-winter: September-February) for the most recent five calendar years
2. Summer or early autumn abundance: by country for those conducting such surveys; all years in which they are available
3. Post-breeding age ratios: all years and countries where available; should include counts of young and total sample size
4. Winter counts: all years and countries where available

Legal Considerations and Implications for Population Management

It should be noted that the International Single Species Management Plan (ISSMP) for the Greylag Goose (Northwest/Southwest European Population) clearly outlines the legal status of Greylag Goose and the implications for population management (see Annex 4 of the ISSMP which has been extracted and provided in full below in this document). We urge concerned countries to carefully review this Annex and take into account the considerations and legal implications for Greylag Goose population management, such as when considering between offtake strategy types (a) and (b) (see page 2 above) take into account the conditions under which derogations are permissible according to the EU Birds Directive and the extent of such derogations that would be generally permissible.

Annex 4 Legal Status of Greylag Goose and Implications for Population Management[31]

***Table 10**. Status of the NW Europe/SW European population of Greylag Goose on AEWA, the Bern Convention and the EU Birds Directive*

	AEWA		**Bern Convention**	**EU Birds Directive**
Greylag Goose *Anser anser*	NW Europe/SW Europe	Col. C	Ap. III	An. II (Part A)

1 AEWA

In principle, AEWA (AEWA 2018) allows the deliberate killing of birds belonging to the NW Europe/SW Europe population of Greylag Geese (including for management purposes), provided that the cumulative impact thereof does not prevent the population from being maintained at a Favourable Conservation Status (Article II(1)). To this end, any use of the population must be based on an assessment of the best available knowledge of its ecology (Article III(2)(b)) and Parties to the Agreement "*shall cooperate to ensure that their hunting legislation implements the principle of sustainable use […], taking into account the full geographic range of [the population] and [its] life history characteristics*" (Action Plan, para. 4.1.1). This International Single Species Management Plan (ISSMP), and the Adaptive Flyway Management Programmes (AFMPs) developed thereunder, can assist Parties to comply with these legal obligations by ensuring that the cumulative impact of harvest is not detrimental to the population's conservation status.

Although AEWA affords Parties considerable flexibility in managing the NW/Europe/SW Europe population of Greylag Geese, caution must be taken to ensure that management measures do not breach the Parties' commitments in respect of populations with a higher Table 1 categorization (e.g. by causing the significant disturbance, or accidental taking, of birds belonging to a Column A population). Any impacts on non-target species must similarly be considered under the other legal instruments discussed in this document.

AEWA's *Conservation Guidelines on National Legislation for the Protection of Species of Migratory Waterbirds and their Habitat* (Slobodian et al. 2015) provide guidance on implementing the Agreement's provisions on taking through national legislation; and the AEWA *Conservation Guidelines on Sustainable Harvest of Migratory Waterbirds* (Madsen et al. 2015) provide guidance concerning sustainable use and adaptive management under the Agreement.

2 EU Birds Directive

The Greylag Goose is listed in Annex II of the Birds Directive 2009) and therefore may be hunted under national legislation in accordance with the provisions of Article 7 of the Directive. Hunting of Greylag Geese is therefore permissible, provided that this does not jeopardise conservation efforts in their distribution area. This may include population control measures where these are ecologically sound and are in proportion to the problem to be resolved and the species' conservation status.[32] It is especially important that populations are not reduced below the level required to satisfy Article 2 - i.e. "*a level which corresponds in particular to*

[31] The original version of this document was compiled by the UNEP/AEWA Secretariat in consultation with the Bern Convention's Secretariat and the European Commission and was presented at the first AEWA international management planning workshop for the Greylag Goose (October 2017). Portions of the document have since been elaborated following discussions at the first and second management planning workshops, comments received from Range States and other stakeholders on subsequent drafts of the international species management plan, and responses from the European Commission to questions raised by the AEWA Secretariat concerning goose management in the context of the EU Birds Directive. A section has also been added on states' legal obligations concerning the collection and communication of data. Although this version of the document does not include annexes with excerpts of each instrument's legal text, hyperlinks to these texts are provided for ease of reference.

[32] See European Commission (2008) at § 2.4.3.3.

ecological, scientific and cultural requirements, while taking account of economic and recreational requirements".[33] The processes provided for in this plan will assist Member States in complying with the requirements of Articles 7 and 2 of the Birds Directive by allowing the better coordination of hunting at flyway level. As discussed below, these processes will further facilitate compliance with Article 2 by facilitating better coordination of killing under derogation.

Article 7 of the Directive requires that Annex II species are not hunted during the period of reproduction or during the pre-nuptial return migration. Information on these sensitive periods is provided in the European Commission's *Key Concepts Document on Article 7 (4)* (European Commission 2014). In addition, birds belonging to these species may not be hunted using the non-selective and large-scale means prohibited by Article 8 of the Directive.

It is possible to derogate from the requirements of Articles 7 and 8 of the Directive if the conditions set out in Article 9 are satisfied (the most relevant grounds for derogation in the context of this ISSMP being those identified in Article 9 (1)(a)). In principle, it may therefore be permissible to apply justified control measures outside the normal hunting period or to introduce culling through means that are otherwise prohibited, as a damage prevention measure. However, all of the following conditions must be fulfilled:

(1) A precondition for the use of derogations is that the population concerned must be maintained at a satisfactory level. In particular, derogations must not result in populations being reduced below the level required by Article 2.

(2) One of the permissible grounds for derogation must be present and there must be a clear basis for concluding that the approach taken is appropriate for preventing the conflict for which the derogation is sought. Thus, where Article 9(1)(a) is relied upon to justify population regulation it must be factually demonstrable that the population being targeted presents a threat to public health, air safety, or the protection of flora and fauna, and/or a risk of serious damage to crops, and that this threat/risk of serious damage is linked to the size of the population. As regards the use of derogations to prevent serious damage to crops, it is clear that this ground relates to an economic interest.[34] However, the Directive does not specify whether damage should be assessed in financial or production terms. Nor does it define what constitutes 'serious damage', and this concept needs to be understood in relative terms.[35] Notably, this ground of justification "*is not a response to already proven damage but of the strong likelihood that this will take place in the absence of action*".[36] As elaborated below, whether management measures are appropriate at the local or transboundary level will depend on the nature and scale of the conflict.

(3) There is no other satisfactory solution for addressing the conflict, and this is demonstrated through strong and robust arguments, based on the scientific and technical evaluation of objectively verifiable factors.[37] There are instances in which it is possible to fulfil this condition in relation to hunting (the use of which can, for example, be "*a legitimate means of safeguarding the interests mentioned in Article 9(1)(a)*" of the Directive[38]). However, it is clear from the existing case law and the guidance produced by the European Commission that if the hunting period under a derogation coincides with

[33] Notably, this formulation gives ecological requirements priority over economic and recreational requirements. Further, Article 2 does not constitute an independent derogation from the requirements of the Birds Directive (European Commission (2008) at § 1.4.1).

[34] European Commission (2008) at § 3.5.7.

[35] European Commission (2013) at p. 10.

[36] European Commission (2008) at § 3.5.7.

[37] European Commission (2008) at § 3.4.12. See also § 3.5.15 ("*there will be cases where hunting of birds to control damage is justified. In order to maximise damage prevention, control measures for a species that causes damage are most likely to be effective when the population is at its seasonal minimum and when there is the least availability of replacement birds – typically this is the breeding or pre-breeding period*").

[38] European Commission (2008) at § 3.4.19.

the periods in which the Directive aims to provide particular protection, there must be compelling reasons to justify this, and that such a derogation is not permissible "*where the sole purpose is to extend a hunting season for wild birds that are available to be hunted during a normal open season*".[39]

(4) It follows from the 'no other satisfactory solution' requirement that derogations must only allow deviation from the Birds Directive's species protection provisions to the extent that this is necessary for resolving the problem concerned.[40] Where derogations are relied upon to achieve population reduction, such reduction must therefore be proportionate to the damage prevention needed.[41]

Since different problems have different spatial dimensions, the appropriate scale of management measures may differ from one case to the next. What is important is that the scale of derogations is justified by the nature and scale of the problems that they aim to address. Thus far, Article 9 derogations have not been relied upon to address conflicts occurring in a Member State other than the one granting the derogation. The definitive interpretation of the Birds Directive is the sole prerogative of the Court of Justice of the European Union, which has yet to consider whether such an approach is legally permissible. The text of Article 9 does not explicitly exclude such an approach and is arguably sufficiently flexible to accommodate it. However, it is clear from condition (2) above that such responses could only be permitted if they would demonstrably address the conflict in question; and satisfying condition (3) would require a robust justification of the need for applying control measures in areas other than those where the conflict occurs. As regards the latter, the European Commission's guidance on hunting under the Birds Directive advises that "*the first approach should be to make the control local in time and place to where the damage is occurring*", but recognizes that broader approaches may be justified in some instances.[42] During the management planning process, the Commission further indicated that it only envisages this approach as being acceptable if:

(1) the link between the serious damage/risk and the birds subject to the derogation is demonstrated;

(2) all other applicable conditions under Article 9 are fulfilled;

(3) it is demonstrated that a derogation in the Member State where the serious damage/risk takes place is not sufficient to prevent that serious damage/risk; and

(4) derogations are only granted at the request of and in consultation with the Member State where the serious damage/risk takes place.

The processes envisaged by this International Single Species Management Plan – in particular, the development of AFMPs and the adaption of these on the basis of information collected and assessed annually – will assist Member States to ensure that the cumulative impact of national derogation schemes is not detrimental to populations' conservation status. The information compiled in AFMPs (see Box 1) may further assist Member States in assessing the need for derogations. However, Member States will remain individually responsible for ensuring that they meet the requirements of Article 9 of the Directive – including their responsibilities to comply with the technical requirements prescribed by Article 9(2) and the annual reporting requirements on the application of derogations prescribed by Article 9(3).

Regardless of whether management measures occur in the context of Article 7 or Article 9, such measures must not result in the deterioration of Special Protection Areas or the disturbance of species for which these have been designated in so far as this would be significant having regard to the objectives of the Directive (Article 4[43]). Hunting activities within SPAs do not necessarily contravene this provision but must be

[39] European Commission (2008) at § 3.4.13-3.4.16.
[40] European Commission (2008) at § 3.4.12.
[41] European Commission (2013) at p. 15.
[42] European Commission (2008) at § 3.4.15 (referring specifically to justifying derogations that are more generalised in their territorial scope in instances where species are widespread and cause damage over large areas).
[43] As amended by Article 7 of the Habitats Directive (Habitats Directive 1992).

compatible with a site's conservation objectives and be managed and monitored in a manner that avoids significant disturbance.[44]

The *Guide to Sustainable Hunting under the Birds Directive* (European Commission 2008) provides further guidance on the hunting provisions of the Directive and the derogation provisions under Article 9.

3 Bern Convention

The exploitation of Greylag Geese is permissible under the Bern Convention (Bern Convention1979), provided that this is regulated in a manner that ensures that populations are not reduced below the level required by Article 2 of the Convention.[45]

Birds belonging to this species may not be killed through the means prohibited by Article 8 of the Convention unless the conditions for exception set out in Article 9 are satisfied.[46] Managing conflict by culling through means that are otherwise prohibited will therefore only be permissible if it is demonstrated that the birds being targeted present a threat to public health and safety, air safety or other overriding public interests, or the protection of flora and fauna, or a risk of serious damage to crops or other property, and that this threat/risk can be addressed by granting the exception; there are objective and verifiable grounds for concluding that there is no other satisfactory alternative; and the exception is not detrimental to the population's survival.

Parties will remain individually responsible for satisfying their commitments under the Convention, regardless of whether an international species management plan is in place. This includes their commitment in Article 9(2) to report every two years to the Convention's Standing Committee on the exceptions they have allowed in terms of Article 9(1).

Revised Resolution No.2 (1993) (Bern Convention 2011) of the Bern Convention's Standing Committee provides further guidance on the exceptions allowed by Article 9.

4 States' Obligations Concerning the Collection and Communication of Data

Regardless of the types of management measures that are proposed by AFMPs, continued research and monitoring are essential for determining whether progress is being made towards meeting management objectives, and for adjusting management measures to better meet these objectives. The importance of continued data collection is further reflected in Box 1 of this plan.

AEWA requires that Parties endeavour to collect various types of data and that they make this available. Relevant provisions of the AEWA Action Plan include the following:

- Paragraph 4.1.3 – requiring Parties to "*cooperate with a view to developing a reliable and harmonized system for the collection of harvest data in order to assess the annual harvest of populations listed in Table 1*" and to "*provide the Agreement secretariat with estimates of the total annual take for each population, when available*".
- Paragraph 4.3.2 – requiring Parties to "*endeavour to gather information on the damage, in particular to crops and to fisheries, caused by populations listed in Table 1, and report the results to the AEWA Secretariat*".
- Paragraph 5 – which contains various obligations concerning research and monitoring, including, *inter alia*, the requirement that Parties "*endeavour to monitor the populations listed in Table 1*" and that the

[44] European Commission (2008) at §1.5.

[45] I.e. "*a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements and the needs of sub-species, varieties or forms at risk locally*". Notably, this formulation gives ecological requirements priority over economic and recreational requirements.

[46] Given the overlap between this provision and Article 9 of the Birds Directive, it can be assumed that an approach that complies with the Birds Directive will also satisfy the requirements of the Bern Convention, although the Convention offers greater flexibility in several of its grounds for exception.

results of such monitoring "*be published or sent to appropriate international organizations, to enable reviews of population status and trends*".

The Bern Convention also obliges Parties to "*encourage and co-ordinate research related to the purposes of [the] Convention*" (Article 11(1)(b)); while the Birds Directive requires EU Member States to encourage research, paying particular attention to, *inter alia*, research which assesses the influence of methods of taking wild birds on population levels and research which develops or refines ecological methods for preventing the type of damage caused by birds (Article 10, read with Annex V).