Feasibility study for a re-introduction/ supplementation programme for the Lesser White-fronted Goose *Anser erythropus* in Norway

WWT Report to the Directorate for Nature Management, Norway

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Consultations

- The scope of the study was discussed with DN, NOS and the AEWA Secretariat at a workshop on 5–6 May 2009 in Hell near Trondheim, Norway, and then discussed on 7–8 September 2009 at the second meeting of the Committee for Captive Breeding, Re-introduction and Supplementation of the Lesser White-fronted Goose in Fennoscandia (RECAP) at Nordens Ark in Åby säteri, Sweden.

- The first draft was submitted to DN in December 2009. The comments and suggestions from DN and the Swedish EPA were used to prepare this final version.

Terms and definitions

The terminology related to re-introduction and supplementation has been used inconsistently in the past resulting in some confusion. This report uses the following terms and definitions.

Re-introduction:	release of an animal into an area of its native range where it no longer occurs.
Supplementation:	release of an animal into an area of its native range where it still occurs in order to supplement the existing population.
Translocation:	movement of individuals from one wild area to another.

A term to describe any programme that involves the release of an animal into its historic range either for re-introduction or supplementation is not in common usage. In this feasibility study, the term 're-introduction/supplementation' is used for this purpose.

To describe the populations of LWfG breeding in Fennoscandia, the following terms are used.

Norwegian population:	population breeding in northern Norway and wintering in Greece and possibly Turkey; thought to use traditional LWfG migratory routes.
Swedish population:	population breeding in Swedish Lapland and wintering in the Netherlands; uses non-traditional migratory routes.

These terms are in line with the outcomes of the first meeting of the RECAP committee. The term 'Fennoscandian population' is used more broadly to refer to birds breeding in Fennoscandia (Norwegian population, Swedish population, and the unknown number of birds breeding on the Kola Peninsula) or the historic population breeding widely across Fennoscandia in the early 20th century.

Note on the population model used for this report

To address a number of key issues relating to the feasibility of supplementing or re-introducing the Lesser White-fronted Goose in Norway, a population model was prepared. While the model is described in full in Annex 5, various model outputs are also discussed in the main body of the report. To avoid repetition in the report's text, the following describes some of the key assumptions and limitations of the model. For full details, see Annex 5.

While the model is largely based on observed demographic data from the existing population of Lesser White-fronted Geese breeding in Norway, where these data were lacking, data from other *Anser* species were used. The parameters that were estimated – and hence the model structure – were based on data availability and the features of the life cycle that are relevant to conservation management possibilities. Despite a lack of good empirical data, survival of birds using the western and eastern routes was estimated separately, because the difference between the two routes has important implications for extinction risk and management options. Where there were inconsistencies between data gathered at different staging sites, data gathered at the Valdak Marshes staging site were given priority.

The model makes many assumptions, and the parameter estimates themselves are based on small data-sets or data-sets that are not derived directly from the population in question. It also assumes no effect of inbreeding. The model assumes no density-dependence and no Allee effects, other than demographic stochastic processes. The model assumes no senescence (age-related decline in demographic parameters), in common with most wildfowl population models. Given the many assumptions made in the model, the absolute values of the model outcomes (*e.g.* probabilities of extinction within a particular number of years) should not be treated as hard predictions. Rather, attention should focus on the relative differences between the outcomes of modelling different scenarios as a guide to the likely efficacy of different management options.

SUMMARY

The Lesser White-fronted Goose *Anser erythropus* (hereafter LWfG) is a candidate for a re-introduction/supplementation programme in Norway. The population has declined dramatically from an estimated 10,000 individuals in the early 20th century, breeding widely across northern Norway, Sweden and Finland and parts of north-western Russia, to an estimated 20 pairs (or 60–70 individuals), breeding in a relatively small (600 km^2) area of northern Norway. The population is considered to be facing an immediate risk of extinction.

Re-introduction and supplementation programmes carry significant risks and costs, and accordingly the Directorate for Nature Management, Norway (DN), commissioned the Wildfowl & Wetlands Trust (WWT) to conduct a comprehensive feasibility study. This report presents the results of that study.

Clear and comprehensive guidelines for completing a feasibility study for a re-introduction/ supplementation programme do not exist. It is possible, however, to draw upon a number of sources which have examined re-introduction programmes and their outcomes, including a wealth of scientific reviews, feasibility and planning work for past re-introductions, the AEWA Review of Waterbird Re-establishments, and, in particular, the IUCN *Guidelines for Re-introductions* as well as other IUCN policy documents. These sources indicate that a feasibility study should include assessments of both justification (*i.e.* is the programme necessary?) and feasibility (*i.e.* is the programme technically possible?), and should also consider timescale and urgency.

Justification assessment

The justification for supplementing/re-introducing LWfG within the range of the existing population breeding in Norway and using traditional migratory routes was assessed against five key criteria relating to conservation needs, to benefits, costs and impacts, and to policy requirements:

- Is the species/population extinct or facing a high risk of extinction/extirpation in the wild? Or has the species/population undergone a significant decline and is currently in a depleted state in a particular area, either in terms of distribution or number?
- Are existing conservation measures insufficient for recovery within a reasonable timescale?
- Would the programme's benefits outweigh potential negative impacts?
- Could the desired outcomes be achieved by an alternative, less expensive method, *i.e.* would the programme be cost-effective?
- Would the programme's aims and objectives be in line with existing, relevant conservation plans and policies, particularly the IUCN *Guidelines for Re-introductions* and any existing Action Plans?

The poor conservation status of the LWfG population breeding in Norway, and the lack of significant recovery despite conservation measures, demonstrates a need for supplementation. This view is further supported by the results of population modelling, which suggests there is a 50% probability of extinction by approximately 2018–2027 and 90% probability of extinction by approximately 2030–2040. Should the population be extirpated from Norway there would be a need for re-introduction.

Available information suggests that the potential negative impacts of a re-introduction/supplementation programme would be minimal and would be outweighed by the potential benefits. The proposed aim, namely to improve the conservation status of the LWfG population breeding in Norway by enhancing the long-term survival of LWfG in Fennoscandia using traditional migratory routes, would be in line with the IUCN *Guidelines for Re-introductions* as well as the goals of the International Single Species Action Plan and Norway's National Action Plan. Cost-effectiveness depends on the available resources and priorities of DN, and, therefore, could not be fully-assessed as part of this report. A preliminary

estimation of costs based on UK prices suggests that a 20 year programme could cost approximately 48,580,000 NOK (7,504,592 USD).

The report concludes that a supplementation/re-introduction programme for LWfG in Norway using traditional migratory routes fulfils the key justification criteria and therefore can be considered justified, subject to DN's decision regarding cost-effectiveness and assuming such a programme is conducted as part of a wider conservation programme for the LWfG population breeding in Norway.

Feasibility assessment

The feasibility of both supplementing and re-introducing LWfG within the range of the existing Fennoscandian population using traditional migratory routes was assessed against 10 key criteria, taking into account biological, environmental and technical factors, socioeconomic, political and legal factors, and resource requirements.

- Is a suitable source of animals available?
- If using captive animals, are captive-breeding techniques for the species known?
- Are release techniques for the species known?
- Is a suitable environment available in which to release the animals?
- Have the original causes of decline been sufficiently reduced or eliminated?
- Is there sufficient knowledge of the species' natural history?
- Does stakeholder support exist?
- Will the programme conform to relevant laws and regulations?
- Are sufficient financial resources available?
- Are sufficient technical resources available?

Time constraints were also considered and factored into assessments of the above criteria.

Obtaining a suitable source of birds to release will depend on the cooperation of authorities in Russia and/or parties responsible for the recently established captive population at Nordens Ark, Sweden. Available information suggests that a captive source population is preferable to translocation given the logistical difficulties of moving birds from the wild in Russia to suitable release sites within a reasonable timescale. Captive-breeding techniques for LWfG are well-established and it may be possible to provide 20 birds for release each year as soon as the summer of 2012 if the Nordens Ark population, with the addition of birds from the wild, is used as a source population. Direct release and human-led release are both potential release techniques for LWfG in Fennoscandia, and both have shown at least some success for LWfG or similar species. It is unclear how successful these techniques would be for establishing migratory habit in released birds, such that the birds use the traditional migratory routes.

The critical needs of the species are known, and suitable habitat for released birds is available at known breeding, staging and wintering sites. These sites, however, have varying degrees of protection and are vulnerable to various threats. Available evidence suggests the original causes of decline at these sites have not been eliminated and have probably not been reduced to a level sufficient to allow for significant population increase.

It will likely be possible to gain stakeholder support for both a supplementation and a re-introduction if the programme is conducted in line with the IUCN *Guidelines for Re-introductions* and effective public awareness campaigns are conducted. Possible exceptions could include stakeholders negatively impacted by restrictions at or near the existing breeding grounds. Available information suggests a programme would conform to laws and regulations in Norway, but if birds are to be released outside of Norway, the laws and regulations of the country in question would need to be considered.

Significant financial resources would be required for a supplementation or re-introduction programme. Whilst DN would likely be the primary funding body, consideration should be given to forming project partnerships with other organisations to increase funding opportunities and reduce the risk of administrative discontinuity. The technical resources required could be provided by various organisations with expertise and experience in the relevant project areas.

A supplementation programme for LWfG in Norway sufficiently fulfilled seven of the ten feasibility criteria. The criterion concerning the original causes of decline was judged not applicable as the purpose of a supplementation in this case would be to maintain the extant population while the original causes of decline are addressed. Criteria regarding the availability of source animals and knowledge of suitable release techniques were only partially fulfilled and, accordingly, these factors may present significant difficulties. It may be difficult to obtain a suitable number of birds for release given the limited amount of time available, and while direct release is likely a suitable release technique, it is unclear if this technique could establish migratory habit in LWfG and an experimental approach would be required. The report concludes that a supplementation of the LWfG population breeding in Norway can only be considered feasible assuming the identified problems with regard to obtaining a source of birds and release technique can be overcome.

A re-introduction programme for LWfG in Norway (following extirpation) sufficiently fulfilled seven of the ten feasibility criteria. The criterion regarding causes of decline was not fulfilled, and criteria regarding knowledge of a suitable release technique and stakeholder support were only partially fulfilled. Accordingly, these factors may present significant difficulties. Evidence suggests that the original causes of decline have not been eliminated or sufficiently reduced, which would critically limit the success of a re-introduction programme. It may be difficult to gain support for a re-introduction that would require human-led release to establish migratory habit, and while human-led release is likely a suitable release technique, the technique has had limited success establishing migratory habit in geese and is unproven for LWfG. The report concludes that a re-introduction of LWfG in Norway cannot be considered feasible until further evidence is provided concerning the elimination of or sufficient reduction in the original causes of decline, and then only assuming the identified problem with regard to stakeholder support and release technique can be overcome.

Decision-making and next steps

The conclusions regarding justification and feasibility are based on available information and current circumstances. The assessments should be reviewed if additional information becomes available or circumstances change. The final decision with regard to implementing a supplementation or re-introduction programme will depend on the conclusions of DN, with input as appropriate from other members of the Committee for Captive Breeding, Re-introduction and Supplementation of the Lesser White-fronted Goose in Fennoscandia (RECAP).

As well as the results of the justification and feasibility assessments, the following key issues and risks should be factored into decision-making:

- A re-introduction/supplementation alone will not change the trend of the LWfG population breeding in Norway. For re-introduction or supplementation to result in a long-term increase in the population, the original causes of decline must have been eliminated or reduced to a sufficient level. Thus, it is vital that re-introduction/supplementation is undertaken as part of a wider conservation programme if it is to result in a long-term change in the status of the population.

- Re-introductions and supplementations of migratory species are particularly complex, and establishing migratory habit in released birds will pose a significant challenge. There can be no guarantee that released birds will use traditional sites, and whilst measures can be taken to increase the chances of this, the possibility that released birds could use a migratory route different to the route traditionally used by Fennoscandian LWfG should be considered.
- Timescale is an important factor to consider, particularly for a supplementation. A supplementation would require the LWfG population breeding in Norway not only to be extant but present in high enough numbers for the direct release technique to be viable.
- Establishing a captive-breeding population with birds from the population breeding in Norway would pose some risk to the wild population. Establishing a captive-breeding population with birds from the Western Main population and/or birds from Nordens Ark will depend on cooperation with the relevant parties.
- As a re-introduction or supplementation of LWfG using traditional migratory routes will involve birds moving through a number of range states, measures such as habitat protection and monitoring and public awareness activities may be needed in these range states requiring international cooperation.
- Socio-economic, political and legal aspects would be critical to the implementation and outcomes of a re-introduction/supplementation programme and the importance of such aspects is often underestimated. Measures may be required to gain the support of local communities, organisations, government agencies and other stakeholders. Long-term financial and political support has been shown to be one of the most important factors in the success of supplementation and re-introduction programmes.
- A re-introduction or supplementation would not be complete upon the release of birds. A range of post-release activities would be required, including monitoring, assessment of outcomes, reporting and possibly interventions. These activities should be factored into estimations of costs.

If a decision were made to implement a supplementation programme, the programme should aim to release birds with utmost urgency while the existing LWfG population breeding in Norway is large enough to support a supplementation, and in conjunction with wider conservation measures. The following next steps are recommended in the short-term:

- Produce a project plan in consultation with relevant scientific and technical experts.
- Identify all stakeholders.
- Inform relevant stakeholders of the plan to implement a supplementation programme, including local and national authorities, AEWA and other international and national bodies concerned with the conservation of LWfG.
- Identify a project team and seek collaborations with relevant organisations.
- As far as possible, secure long-term financial and political support.
- Determine and secure a suitable source of birds, and establish a new captive-breeding population if needed.
- Undertake research to determine how best to proceed with the direct release technique:
    i. Explore methods of attracting wild Fennoscandian LWfG to specific areas within potential release sites.
    ii. Conduct monitoring of site usage at potential release sites.
    iii. Subject to considerations of possible disturbance, conduct monitoring of breeding LWfG in Norway to assess the feasibility of catching families on the breeding grounds, and to inform the planning of capture attempts and release site locations.

- Build capacity for a supplementation programme by training key personnel in the relevant skills.

If a decision were made not to implement a supplementation programme but to plan for a re-introduction programme following extirpation, the following next steps are recommended in the short-term:

- Conduct intensive research to fill the key knowledge gaps with regard to the natural history of LWfG. In-depth understanding of migratory routes and habitat usage is particularly important.
- Study causes of decline. Eliminating causes of decline following extirpation will benefit from a clear understanding of the issues and their impacts before extirpation.
- Determine and secure a suitable source of birds, and establish a new captive-breeding population if needed.

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1 INTRODUCTION

The Wildfowl & Wetlands Trust (WWT) has undertaken to produce a feasibility study for establishing a re-introduction/supplementation programme for the Lesser White-fronted Goose *Anser erythropus* (hereafter LWfG), for the Directorate for Nature Management, Norway (DN).

The LWfG is a globally threatened species recognised as Vulnerable by IUCN (43) and ranked by BirdLife International as 'SPEC 1' within Europe (16), denoting a European species of global conservation concern. It is listed in Column A (1a 1b 2) of the African-Eurasian Waterbird Agreement (AEWA, 4), in Annex II ('Strictly protected species') of the Bern Convention (9), and in Annex I of the European Council Directive 79/409/EEC on the Conservation of Wild Birds (32).

The global population of LWfG has declined rapidly since the middle of the 20th century (46). The population decline has been accompanied by fragmentation of the breeding range, which is continuing to affect all populations, giving rise to fears that the species may go extinct (46). Three subpopulations are generally recognised: the Fennoscandian population (breeding in Fennoscandian Lapland and the Kola Peninsula of north-western Russia); the Western Main population (breeding in northern Russia to the west of the Taimyr Peninsula); and the Eastern Main population (breeding from the Taimyr Peninsula eastwards).

While the Fennoscandian, Western Main and Eastern Main populations have all declined since the middle of the 20th century, none has declined as dramatically as the Fennoscandian. In the early 20th century there were an estimated 10,000 individuals breeding widely across northern Norway, Sweden and Finland and parts of north-western Russia (69). The population breeding in Norway is now estimated at only 20 pairs (or 60–70 individuals) breeding in a relatively small (600 km^2) area of northern Norway (hereafter Norwegian population, 1). There are approximately 10–15 LWfG pairs (or 100 individuals) breeding in Sweden but these birds do not use the traditional migratory route of the Fennoscandian population as a result of a release programme in the 1980s and 1990s (hereafter Swedish population, 124). Evidence of breeding has not been confirmed in Finland since 1995 (101). An unknown number of birds may still breed on the Kola Peninsula, Russia (94). The drivers of historic declines are not fully understood but are thought to be primarily habitat loss, land-use changes and human persecution (over-harvesting). The most important factors driving the recent declines are thought to be those factors that cause high mortality among fully grown birds, operating primarily on staging and wintering sites. Over-hunting is considered to be the primary threat and the single most important factor threatening the long-term survival of the population (46).

Captive-bred LWfG have been released in Fennoscandian as part of a number of programmes since the early 1980s. The only programme thought have resulted in a self-sustaining population is the programme initiated by Lambart Von Essen in Sweden. During the period 1981 to 1999, this programme released 348 captive-bred LWfG in the Tjålmejaure area of Swedish Lapland. There has been considerable debate as to whether this programme should be considered a re-introduction or a supplementation. LWfG had not been declared extinct in Sweden at the time of the releases and observations were made of LWfG adults with young and of other small flocks in the Tjålmejaure area during 1979–1984 (Swedish Environmental Protection Agency (EPA) *pers. comm.* 2 Feb 2010, 46). It is unclear, however, whether the released birds joined breeding birds in Sweden or established a new breeding population coincident with the extirpation of the wild population. Regardless, the Swedish population contains at least a proportion of birds descendent from captive-bred birds, and winters in the Netherlands as a result of the release programme using Barnacle Goose *Branta leucopsis* foster parents with wintering grounds in the Netherlands.

As a result of its poor status, the Fennoscandian LWfG population has been the subject of a range of conservation measures in Europe in recent years, many of these occurring as part of the EU Life-Nature project 'Conservation of Lesser White-fronted Goose on the European migration route' (April 2005 –

March 2009) (95). This project included satellite-tracking and ringing to map key sites; preparation of National Action Plans for the species in Norway, Finland and Estonia; habitat restoration and management at staging sites in Estonia and Hungary; and public awareness campaigns. In Norway, actions proposed in the National Action Plan have begun to be implemented including banning all goose hunting at an important autumn staging site (Valdak Marshes) and control of the Red Fox *Vulpes vulpes* population in the breeding area (95). An International Single Species Action Plan for the conservation of LWfG in the Western Palearctic (hereafter ISSAP, 46) was adopted by AEWA in 2008.

Despite these conservation measures, the Norwegian population has not shown signs of significant recovery. Data from Norway suggest the population continues to decline at a rate of approximately 4% per year (2), while data from other range countries suggest the population may have remained stable or slightly increased between 2004 and 2008 (95). The very small size of the population, even if slightly increasing, and concentration in one core breeding area makes the population highly vulnerable to stochastic events. As a result, the population is generally considered to be facing an immediate risk of extinction (95).

The reality of the current situation is that it may not be possible to ensure the survival of the Norwegian population without using a range of complementary conservation approaches and techniques including, if appropriate, supplementation (supplementing the existing breeding population in Norway) and re-introduction (re-introducing to a part of its former breeding range in Norway from which it has been extirpated). The LWfG is a candidate for a re-introduction/supplementation programme in Norway for the following primary reasons:

- It was formerly a widespread breeding bird in Norway, which has been reduced to approximately 20 pairs (1) because of human persecution (over-harvesting) and habitat loss throughout its range (46).
- The LWfG is recognised as threatened by a number of international conservation conventions and ranked by BirdLife International as ‘SPEC 1’ within Europe, based on its large historical decline and current ‘depleted’ status (16).
- The species is now fully protected by law in Norway and measures have been taken to protect the species in its core breeding area, including predator control and banning of all goose hunting (46).
- Habitat protection and restoration measures in recent years have resulted in the improved condition of a number of staging sites – most notably the Hortobágy in Hungary (30), which is one of the most important autumn and spring staging sites for Fennoscandian LWfG (93).
- The small breeding population of LWfG in Norway is vulnerable to stochastic events and considered to be facing an immediate risk of extinction (98).
- Despite conservation measures, the Norwegian LWfG population has not shown signs of significant recovery (98), and an increase in numbers and re-colonisation of the historic breeding range is unlikely to occur naturally within a reasonable timescale (such as the next 20–30 years).

Re-introduction, supplementation and captive-breeding techniques are improving continuously. For some species, such as the California Condor *Gymnogyps californianus* (84), the Mauritius Kestrel *Falco punctatus* (45) and the Black-footed Ferret *Mustela nigripes* (65), these techniques have clearly represented the difference between survival and extinction in the short-term.

As well as the potential benefits, re-introduction and supplementation programmes carry significant risks and costs. Problems that have been significant include (1) difficulty establishing self-sustaining captive populations, (2) poor success in release attempts, (3) high costs, (4) introgression of alien DNA, (5) pre-emption of other conservation measures, (6) disease outbreaks and (7) maintaining administrative continuity.

For these reasons, re-introduction and supplementation programmes should not be undertaken lightly, and should only be conducted as part of wider conservation programmes. Effective integration between any re-introduction/supplementation efforts and wider conservation efforts for existing wild populations should be sought wherever possible. It is vital that a comprehensive feasibility study is conducted prior to any planning or implementation as recommended in the IUCN *Guidelines for Re-introductions* (44) and the AEWA Review of Waterbird Re-establishments (54).

Clear and comprehensive guidelines for completing a feasibility study for a re-introduction/ supplementation programme do not exist. It is possible, however, to draw on a number of sources which have examined re-introduction programmes and their outcomes, including a wealth of scientific reviews (*e.g.* 83, 82, 78), feasibility and planning work for past re-introductions and supplementations, the AEWA Review of Waterbird Re-establishments (54), and, of course, the IUCN *Guidelines for Re-introductions* (44, see Box 1-1) as well as other IUCN policy documents.

Box 1-1. Recommendations from the IUCN *Guidelines for Re-introductions* (44) on what should be included in feasibility studies.

- An assessment should be made of the **taxonomic status of individuals to be re-introduced**. They should preferably be of the same subspecies or race as those which were extirpated, unless adequate numbers are not available.
- Detailed studies should be made of the status and biology of wild populations (if they exist) to **determine the species' critical needs**. For animals, this would include descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, home range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases. For migratory species, studies should include the potential migratory areas. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire re-introduction scheme.
- The species, if any, that has filled the void created by the loss of the species concerned, should be determined; an understanding of the **effect the re-introduced species will have on the ecosystem** is important for ascertaining the success of the re-introduced population.
- The build-up of the **released population should be modelled** under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.
- A **Population and Habitat Viability Analysis** will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

These sources reveal common themes concerning what should be considered when assessing feasibility, namely, that three major areas should be addressed: biological, environmental and technical factors (*e.g.* are there suitable animals to release and a suitable environment in which to release them?); socio-economic, political and legal factors (*e.g.* is there stakeholder support for the programme?); and resource factors (*e.g.* do we have enough knowledge and funds to complete the programme with a reasonable chance of success?). Also, despite its name, a feasibility study should include more than simply an assessment of feasibility (*i.e.* is the programme technically possible?), but should also include an assessment of the justification for the proposed programme (*i.e.* is the programme necessary?) and a discussion of timescale and urgency (*i.e.* when should the programme be implemented?). In summary, a feasibility study should include the following sections: a justification assessment, a feasibility assessment (covering biological, environmental and technical factors; socio-economic, political and legal factors; and resource factors), and a timescale and urgency assessment.

This document presents a feasibility study, as described above, for a re-introduction/supplementation programme for LWfG in Norway and has been prepared in line with the IUCN *Guidelines for Re-introductions* (44).

2 KEY ISSUES

The decision to proceed with a re-introduction/supplementation programme is a complex one, based on many considerations. The key questions can perhaps be resolved as: is it justified, is it feasible, what methods should be used, when should it be done, and how much does it cost? The issues to be addressed in order to answer these questions are necessarily interrelated, while political, practical and biological considerations may provide conflicting viewpoints.

The main sections of this report address in detail the range of possible options and considerations for re-introduction/supplementation, and how they apply to LWfG in Norway. An overview of the key considerations is provided below, including any significant implications of the current situation for an LWfG re-introduction/supplementation in Norway.

Original causes of decline. For re-introduction or supplementation to result in a long-term increase in the population, the original causes of decline must have been eliminated or reduced to a sufficient level. Otherwise, in most cases, re-introduction/supplementation alone will not change the population trend; it will simply boost the number of individuals on a temporary basis. Data suggest that the Norwegian population is probably still declining (2); while conservation measures have been implemented at some sites along the flyway, key threats have yet to be adequately addressed. A supplementation could, however, be used to maintain a population in Norway while the causes of declines are addressed. This has particular implications for 'migratory route' and 'timescale' (see below). Supplementation would need to be undertaken as part of a wider conservation programme if it were to achieve long-term benefits.

Migratory route. Re-introductions/supplementations involving migratory species have an additional level of complexity. In most cases, the intention is for birds in supplementation programmes to use existing migratory routes, or for re-introduced birds to re-establish traditional migratory routes (since these will generally contain the sites where specific conservation measures have been undertaken). In some cases, new or artificial migratory routes have been deliberately established. A migratory route can be 'taught' in three main ways: 'direct release' into an existing wild population so that released birds are led on migration by wild birds; human-led migration, where released birds are trained to follow a vehicle (*e.g.* ultra-light aircraft); or release with foster parents of another species. The traditional migratory route of Fennoscandian LWfG is complex: two routes are used during autumn migration from the Arctic breeding grounds, and it is likely that greater mortality occurs on the more easterly of these routes. Further, it is likely that several staging sites are unknown. Whilst each method for release has inherent problems, direct release is the method most able to ensure that the existing route and suite of staging sites is maintained. This option would, obviously, no longer be possible were the Norwegian population to be extirpated. DN has determined that a re-introduction or supplementation in Norway should aim to use the traditional migratory route of Fennoscandian LWfG, and that an artificial or new route should not be established. This, too, has implications for the suitability of certain release methods. There can be no guarantee that released birds will use traditional sites, and whilst measures can be taken to increase the chances of this, the possibility that released birds could establish a new migratory route should be factored into decision making.

Timescale. Timescale is an important factor to consider in assessing feasibility as it may have implications for many aspects of a re-introduction or supplementation programme. For a supplementation of the Norwegian LWfG population, releases would have to occur not only while the current Norwegian population is extant but also while there are enough wild geese for released birds to join on migration. Exactly how many wild birds would need to be present is unknown. Past work with Aleutian Canada Geese *Branta canadensis leucopareia* has demonstrated that captive-bred geese will follow a relatively small number of wild geese (21, 86), and it may be possible that 20–40 captive-bred birds might follow as few as 10 adults or 2–3 family groups. Thus, only a few breeding pairs may provide a large enough population to supplement, but it is likely that many more would be required. The Fennoscandian population may already be too small to support a supplementation. If the Fennoscandian population becomes extinct, consideration should be given to the timing of further releases, particularly with regard to whether the original causes of decline have been eliminated or reduced to a sufficient level.

Establishing a captive population. While it may be possible to translocate birds directly from the Western Main population to the Norwegian population, establishing a captive population would likely be the only way to supply a predictable and regular supply of birds for release. Genetic studies have shown that there is only moderate genetic difference between the Western Main population and Fennoscandian population (represented by birds breeding in Norway) and that each population probably still contains the range of genetic variability necessary to adapt to local conditions (52). Thus, the Western Main population could be considered as a possible source of birds to found a captive population. Indeed, the greater genetic variability in the Western Main population suggests that a captive population estabilished with birds from this population could provide a valuable genetic boost to the Norwegian population. Taking birds from the Norwegian population could increase this population's risk of extinction and therefore increase the risk of losing the traditional Fennoscandian migratory route.

Maintaining a captive population. Demographic and genetic management plans are required to ensure the long-term viability of a captive population. Ideally, a captive population would be housed at more than one facility to reduce the chances of losing the entire population as the result of catastrophic loss at any one facility. Each facility should have strict biosecurity to prevent disease, and predator-proof enclosures to prevent loss through predation. Breeding should be maximised where possible, and the use of hand-rearing and double-clutching should be considered. It is important that birds for release are reared in conditions where they can gain necessary survival skills and imprint on appropriate objects. Guidance should be sort from organisations and/or individuals with expertise in breeding geese and rearing birds for release.

International cooperation. Releasing migratory birds that will be expected to use a number of countries on migration will require international cooperation between the countries involved. For an LWfG re-introduction/supplementation programme in Norway, key countries will likely be Finland, Russia, Estonia, Hungary and Greece, and perhaps also Lithuania, Sweden and Kazakhstan. These countries should be kept informed of release plans as appropriate and the stakeholders in these countries must be considered when assessing potential impacts and should be included in public awareness campaigns as appropriate.

Socio-economic, political and legal aspects. The socio-economic, political and legal aspects of a re-introduction/supplementation programme are critical to its implementation and outcomes, because current species declines and extinction problems are often the result of socio-economic and political drivers. Many re-introduction/supplementation programmes overlook these factors and concentrate on the biological and technical considerations, which has been suggested as the reason many programmes fail (78). Thus, it is vital that these elements are given careful consideration.

Programme phases. Following the completion of pre-project activities (feasibility study, background research and decision making), there are three basic phases in a re-introduction/supplementation programme: the planning and preparation phase, the release phase, and the post-release phase. It is important to remember that a programme is not complete upon the release of birds. A range of post-release activities would be required, including monitoring, assessment of outcomes, reporting and possibly interventions. These activities should be factored into project planning and budgeting.

3 JUSTIFICATION ASSESSMENT

3.1 BACKGROUND

A justification assessment for a re-introduction/supplementation programme is a generic and high-level process to determine if there is a need for re-introduction or supplementation. It should address the conservation need, and also whether the benefits would outweigh potential costs and negative impacts, including the allocation of resources away from other conservation measures.

Re-introduction and supplementation programmes can be considered justified if (1) there is a clear need for re-introduction or supplementation; (2) negative impacts would not be significant and would not outweigh potential benefits; (3) the programme would be cost-effective; and (4) the programme would be in line with relevant conservation plans and policies. Negative impacts could include impacts on wild and source populations, the ecosystem, local communities and other stakeholders, and attitudes towards the species or conservation as a whole. If such impacts are likely and would be significant, serious thought must be given to whether these negative impacts would outweigh potential benefits. Secondary benefits should be considered, particularly how the programme could contribute to addressing conservation needs not directly linked to re-introduction/supplementation. For example, well-run supplementation and re-introduction programmes often include monitoring, habitat restoration and public awareness activities, which could benefit existing populations of the species in question or other species.

Based on these requirements, a justification assessment should address the following key criteria:

Conservation needs

- Is the species/population extinct or facing a high risk of extinction/extirpation in the wild? Or has the species/population undergone a significant decline and is currently in a depleted state in a particular area, either in terms of distribution or numbers?
- Are existing conservation measures insufficient for recovery within a reasonable timescale?

Benefits, costs and impacts

- Would the programme's benefits outweigh potential negative impacts?
    - What would be the primary and secondary benefits of the programme and would they contribute to addressing the established conservation needs of the species or other species?
    - Would there be any negative impacts on existing wild populations, if present; the environment; local communities and other stakeholders; or public, political and/or organisational attitudes?
- Could the desired outcomes be achieved by an alternative, less expensive method, *i.e.* would the programme be cost-effective?

Policy requirements

- Would the programme's aims and objectives be in line with existing, relevant conservation plans and policies, particularly the IUCN *Guidelines for Re-introductions* (44) and any existing Action Plans?

The answers to these questions should be considered sequentially as illustrated in Figure 3-1, which presents a flowchart to aid decision-making.

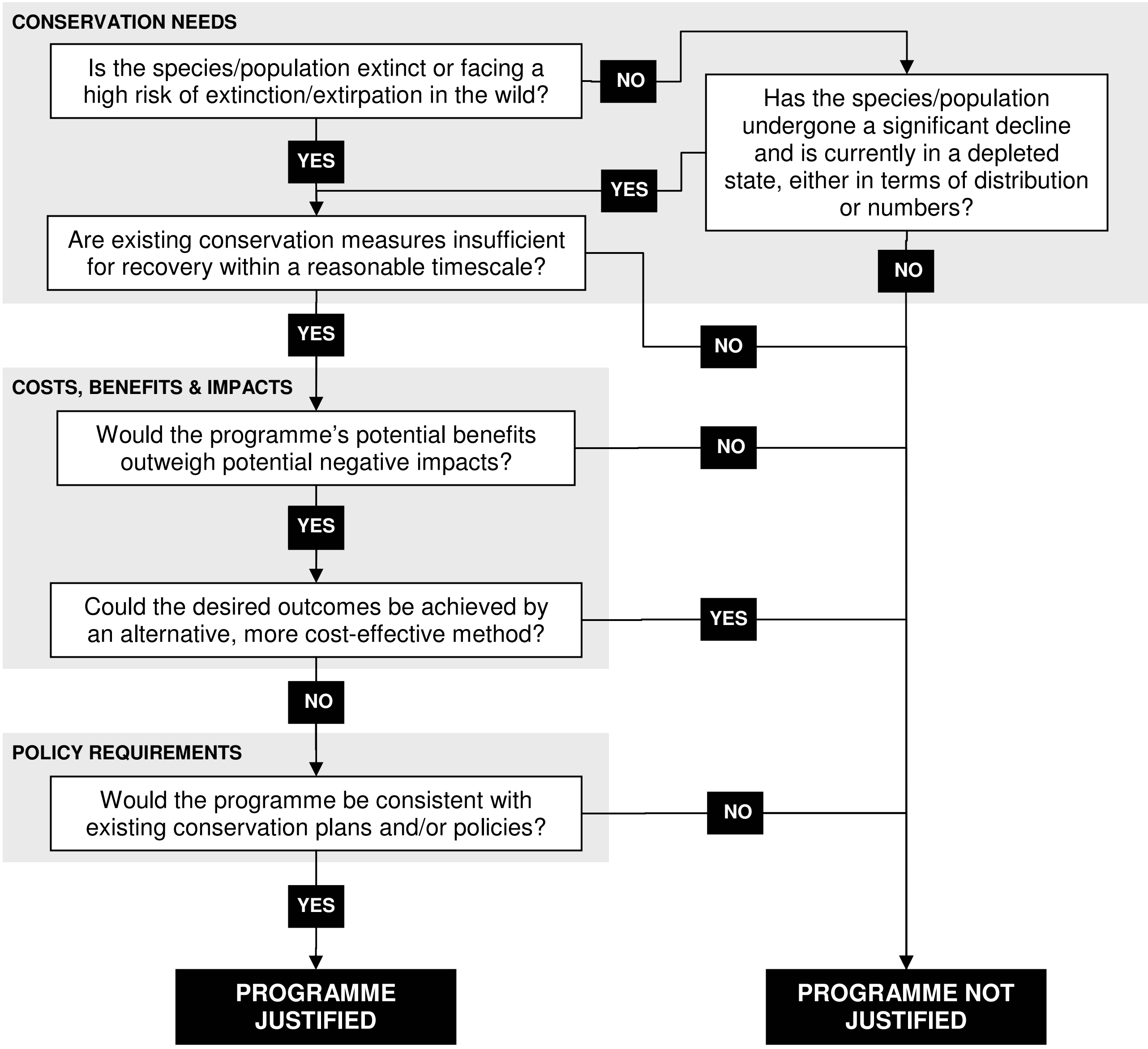

Figure 3-1. Flowchart assessing the justification for re-introduction/supplementation programmes.

The following sections address the key justification questions for a re-introduction/supplementation programme for LWfG in Norway considering the needs of the Norwegian LWfG population; the potential benefits, costs and impacts throughout the population's range; and accordance with the IUCN *Guidelines for Re-introductions* (44), the ISSAP and Norway's National Action Plan.

3.2 CONSERVATION NEEDS

3.2.1 Status in the wild

Criteria with which to determine when a bird population is in need of re-introduction/supplementation currently do not exist. Criteria developed for other species, however, suggest that a population is in need of either re-introduction or supplementation when it (1) is extinct, (2) faces a high risk of extinction, (3) has declined to a size from which it is unlikely to recover naturally within a reasonable timescale, (4) has been extirpated from an area that was a part of its range, or (5) faces a high risk of extirpation from an area.

As already outlined, the Fennoscandian LWfG population has undergone a rapid long-term decline, from an estimated 10,000 individuals in the early 20th century (69) to an estimated 60–70 individuals in Norway (3) and approximately 100 individuals in the Swedish population (124) in 2008. According to data gathered at the Valdak Marshes staging site in Norway between 1993 and 2008, the Norwegian population has decreased at an annual rate of more than 4%, with an overall decrease of 50% during this 15-year period (3). Monitoring data from other staging sites (*e.g.* the Hortobágy, Hungary), however, show the number of LWfG using these sites remained stable or slightly increased during 2004 to 2008 (98).

Small populations are inherently more vulnerable to stochastic and catastrophic events. In the last 15 years, declines in the Norwegian LWfG population have occurred in relatively abrupt steps. This is thought to have been caused by a complex interaction between breeding disturbance, migratory route choice, and over-hunting (73). Based on satellite telemetry, successful breeders appear to stay longer on the breeding ground, moult there and then fly south down a relatively 'safe' migration route through staging sites with good protection from over-hunting – the 'western route'. The non-breeders appear to leave the breeding ground early, fly east to moult on the Taimyr Peninsula and then south through Russia and Kazakhstan using staging sites where hunting pressure is known to be high (73) – the 'eastern route'. Thus, disturbance early in the breeding season, *e.g.* by White-tailed Eagles *Haliaeetus albicilla* as thought to have occurred in the early 2000s, is thought to push the majority of the small population down the 'unsafe' eastern route, leading to high adult mortality in addition to low recruitment (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009).

Applying the IUCN Red List criteria to the Fennoscandian LWfG population (excluding the Swedish population) reveals that the population is facing a 'very high risk of extinction' (see 46).

Modelling of the Norwegian population (see Annex 5 for a complete description) indicates that there is a 50% probability of extinction by approximately 2018–2027, and that extinction is highly likely (90%) by approximately 2030–2040 (Figure 3-2). Given the many assumptions made in the population model, these findings cannot be treated as exact predictions but do provide support for the conclusion that the population of LWfG breeding in Norway faces a high risk of extinction within the next 20–30 years.

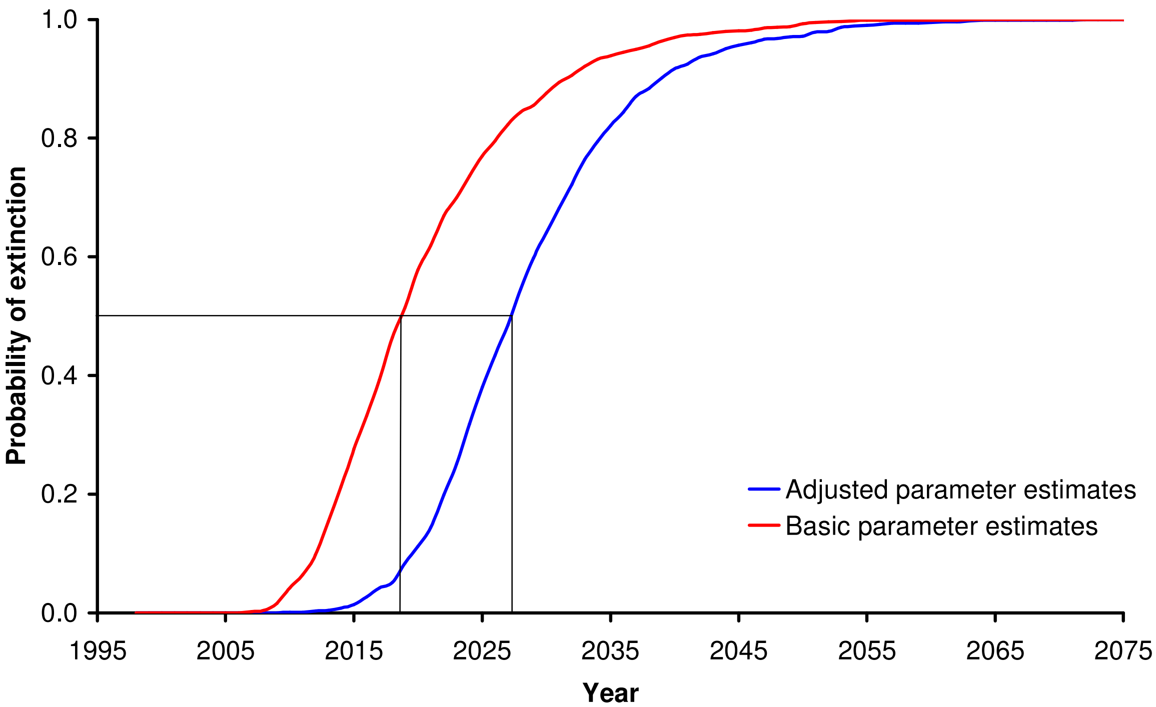

Figure 3-2. Probability of extinction of the Lesser White-fronted Goose population breeding in Norway, at current demographic rates.
Probabilities are the proportion of 1,000 model runs that reached quasi-extinction (zero remaining females) by a given time. The 'basic parameter estimates' are based on observed data and slightly over-estimate the 1998–2008 population decline rate (see Annex 5). The 'adjusted parameter estimates' are also based on observed data but with survival values multiplied by 1.05 to achieve a population trend similar to the observed 1998–2008 trend.

Genetic studies have revealed that there is moderate genetic divergence between the Fennoscandian population (represented by birds breeding in Norway) and the Western Main and Eastern Main populations, but that there has been enough interchange between the populations to have prevented extreme loss of genetic diversity (52). Thus, the extinction of the Norwegian population would not result in a significant loss of genetic diversity from the species as a whole, but could result in the loss of some local adaptations.

The traditional migration route of the Norwegian population is, however, unique. Extirpation of LWfG from Norway would likely result in the loss of this migration route. While a re-introduction programme could aim to replicate the route, technical limitations (*e.g.* maximum flight distance of ultra-light aircraft) and knowledge gaps would make it difficult if not impossible to replicate the route accurately.

In summary:

- The Fennoscandian population has undergone a rapid long-term decline and is currently in a depleted state both in terms of population size and extent of breeding range (3).
- The small Norwegian population is vulnerable to stochastic and catastrophic events.
- According to IUCN Red List criteria, the Norwegian population is facing a very high risk of extinction (46), and modelling suggests there is a 50% probability of extinction by approximately 2018–2027 and 90% probability by approximately 2030–2040 (see Figure 3-2).
- The loss of the Norwegian population would likely result in the loss of a unique migratory route.

3.2.2 Existing conservation measures

The LWfG has been the subject of a range of conservation measures in Europe in recent years, many of these occurring as part of the EU Life-Nature project 'Conservation of Lesser White-fronted Goose on the European migration route' (April 2005 – March 2009) (95). This project included extensive monitoring at known key sites; satellite-tracking and ringing to map migration routes and sites; preparation of National Action Plans for the species in Norway, Finland and Estonia; habitat restoration and management at staging sites in Estonia and Hungary; and public awareness campaigns.

In Norway, actions proposed in the National Action Plan have begun to be implemented including banning all goose hunting at an important autumn staging site (Valdak Marshes) and control of the Red Fox population in the breeding area (95).

The ISSAP for the conservation of LWfG in the Western Palearctic (46) was adopted by AEWA in 2008.

Despite these conservation measures, the Norwegian population has not shown signs of significant recovery. As already discussed, data from Norway suggest the population continues to decline at a rate of approximately 4% per year (2), while data from other range countries suggest the population may have remained stable or slightly increased between 2004 and 2008 (95).

3.3 BENEFITS, COSTS AND IMPACTS

3.3.1 Potential benefits

The primary benefit of any re-introduction programme should be the re-establishment of a species in a part of its historical range. Accordingly, if the Norwegian LWfG population were to be extirpated, the primary benefit of a re-introduction in Norway would simply be the re-establishment of an LWfG population in the historical range.

Supplementation, however, may have one or more of a number of primary benefits:

- Reduction of the short-term extinction risk: supplementation can be used to reduce the risk that a population will be lost in the short-term by expeditiously boosting the number of individuals in a given year.
- Preservation of a population while factors causing decline are being addressed: if the causes of decline have not been eliminated or reduced sufficiently to prevent long-term extinction or extirpation, supplementation can be used to maintain a population while the causes of decline are addressed.
- Increase the rate of recovery: if the causes of decline have been eliminated or reduced sufficiently, supplementation can be used to accelerate the recovery of a population by increasing abundance in a shorter time-frame than may be achievable through natural recovery.
- Reduction in the risk of deleterious genetic and ecological effects: supplementation can be used to reduce the risk of inbreeding depression and the risk that the depleted size of a population will affect the ecological characteristics of the population.

If such a programme also aimed to establish a new breeding area, the following benefits could also apply:

- Reduction of the chances of catastrophic loss by establishment of a breeding site separate from existing sites: re-introduction could be used to create an additional breeding site for the population to prevent loss of the entire population due to natural or anthropogenic catastrophes.
- Re-colonisation of vacant habitat capable of supporting birds: re-introduction could be used to re-colonise areas where the population has been extirpated and the causes of extirpation have been addressed.

Modelling supplementation of the Norwegian LWfG population, where 10–50 birds are released per year for a period of up to eight years, indicates that supplementation would essentially provide a temporary, unsustained boost to the adult population. This would give the population approximately 10–20 years before it decreased to the level observed at the start of the supplementation programme (Figure 3-3, for a complete explanation see Annex 5). Similarly, such a supplementation would effectively postpone extinction by approximately 10–20 years, depending on the number of birds released (Figure 3-4, see Annex 5 for explanation).

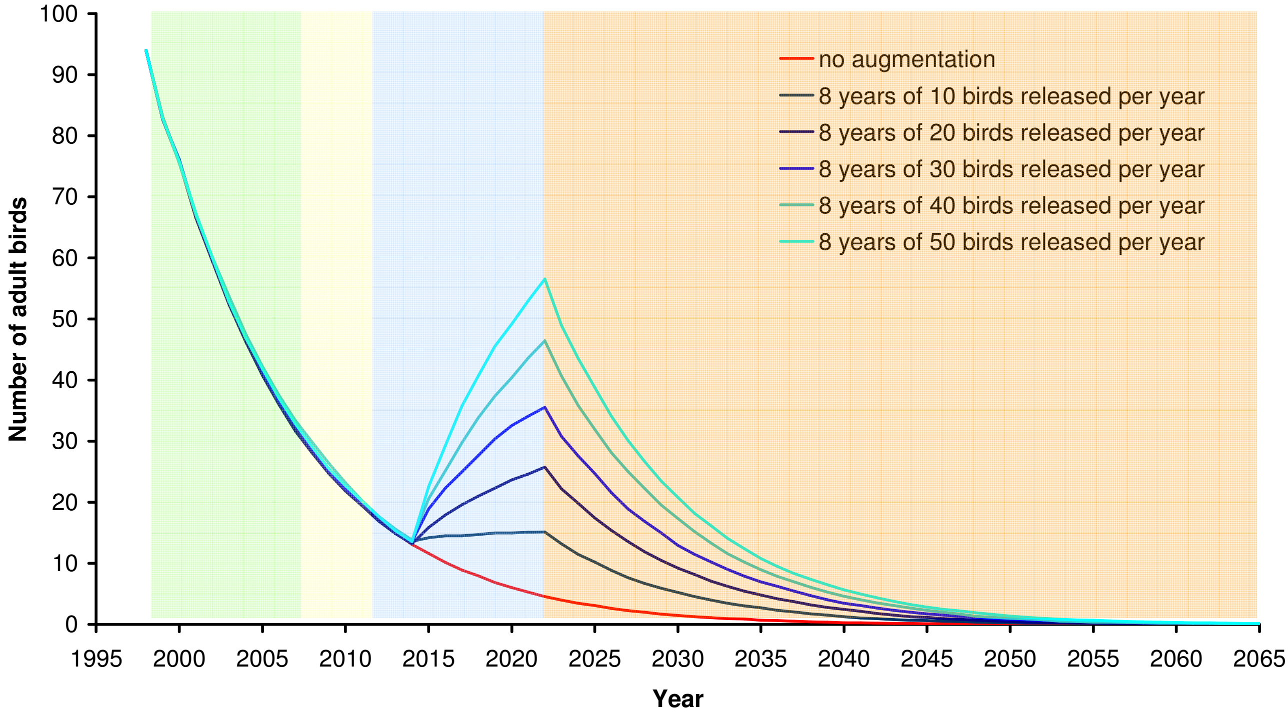

Figure 3-3. Effect of supplementation on size of the Lesser White-fronted Goose population breeding in Norway, for different numbers of released birds.
Green shading indicates the period from model start (1998) to present (2008); yellow shading indicates lead-in time to supplementation programme (2008–2012), blue shading indicates supplementation period; orange shading indicates post-supplementation.

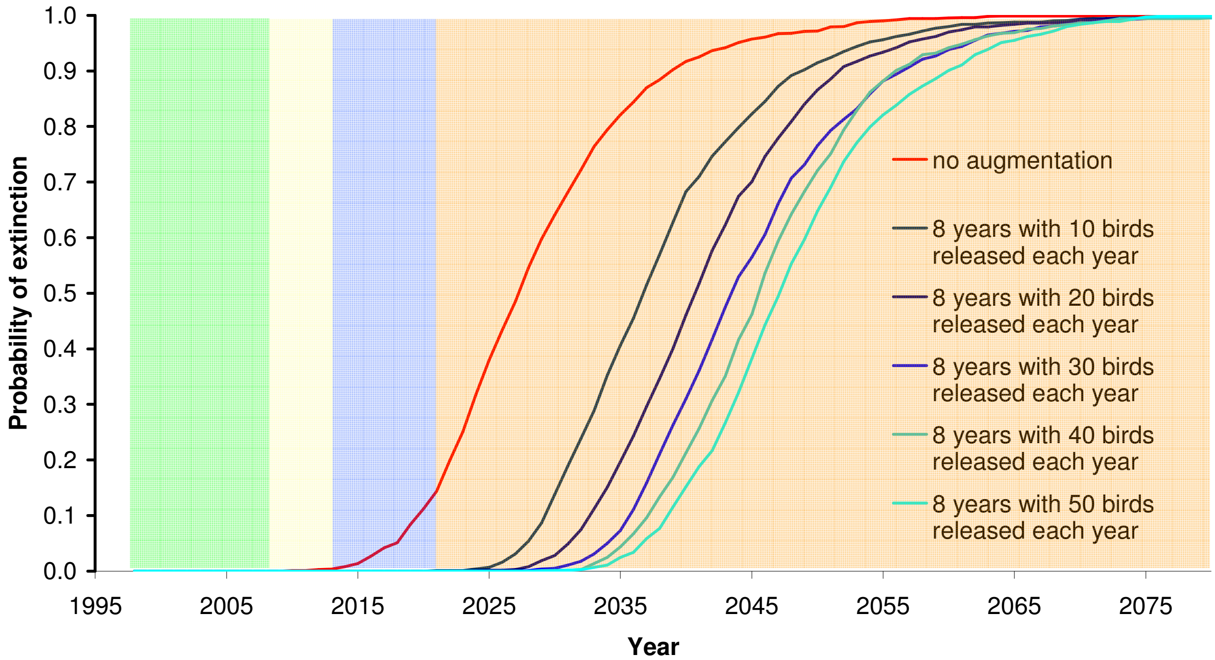

Figure 3-4. Effect of supplementation on extinction risk for the Lesser White-fronted Goose population breeding in Norway, for different numbers of released birds.

Based on these results, the primary benefits of supplementing the Norwegian LWfG population would be to reduce the short-term risk of extinction and to preserve the population while factors causing decline can be addressed.

Modelling was also used to assess the effect of supplementing the population and simultaneously improving the survival rate of the population. This scenario helps to examine whether, if the population size is relatively stable (*i.e.* not rapidly decreasing or increasing), supplementation might significantly improve the conservation status of the population, or conversely, whether, if the population is stabilised, it is largely immaterial. At observed reproductive rates for LWfG, a relatively stable population (*i.e.* not rapidly increasing or decreasing in size) of approximately 90 birds could be achieved in the model with juvenile survival of 0.32 and adult survival of 0.86. However, because reproductive output tends to fall at very low population levels, even a population with these survival rates continues to decline very slowly. Modelling supplementation as well as the increased survival rates produces a slowly increasingly population of approximately 90 birds (Figure 3-5).

This has a major effect on the extinction risk of the population (Figure 3-6). The stabilised population that is not supplemented continues to run a substantial risk of extinction, by virtue of its continued small size, whereas the stabilised and supplemented population has a negligible risk of extinction by the end of the century. Note that the positive effect of supplementation might be underestimated here, because the model does not capture Allee effects which might occur when the population is very small.

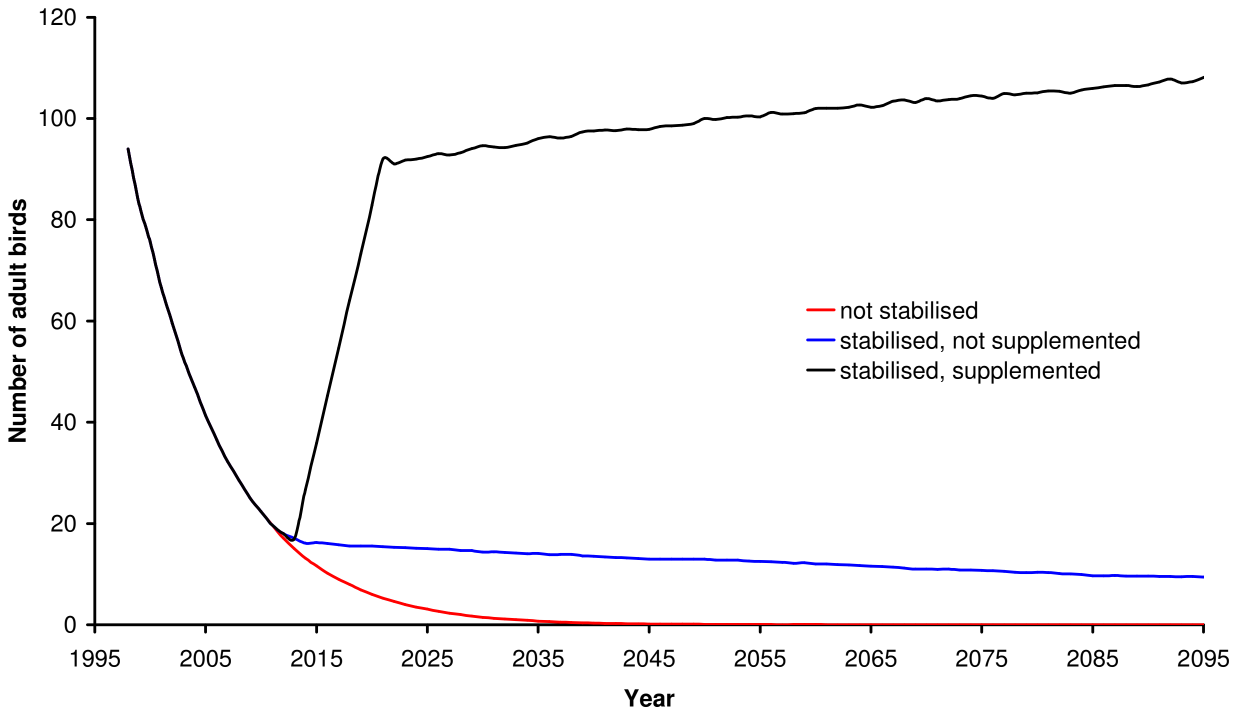

Figure 3-5. The effect of supplementation on size of the Lesser White-fronted Goose population breeding in Norway if the original population size had stabilised.
Population trajectory from 1998 to 2013 based on the default adjusted model values (see Annex 5). After 2013, the red scenario is a continuation using the default adjusted values, the blue scenario depicts an increase in survival to a level that delivers a relatively stable population at approximately 90 birds (juvenile survival = 0.32, adult survival = 0.86), and the black scenario shows the same increase in survival, combined with a supplementation programme of eight years at 40 birds per year.

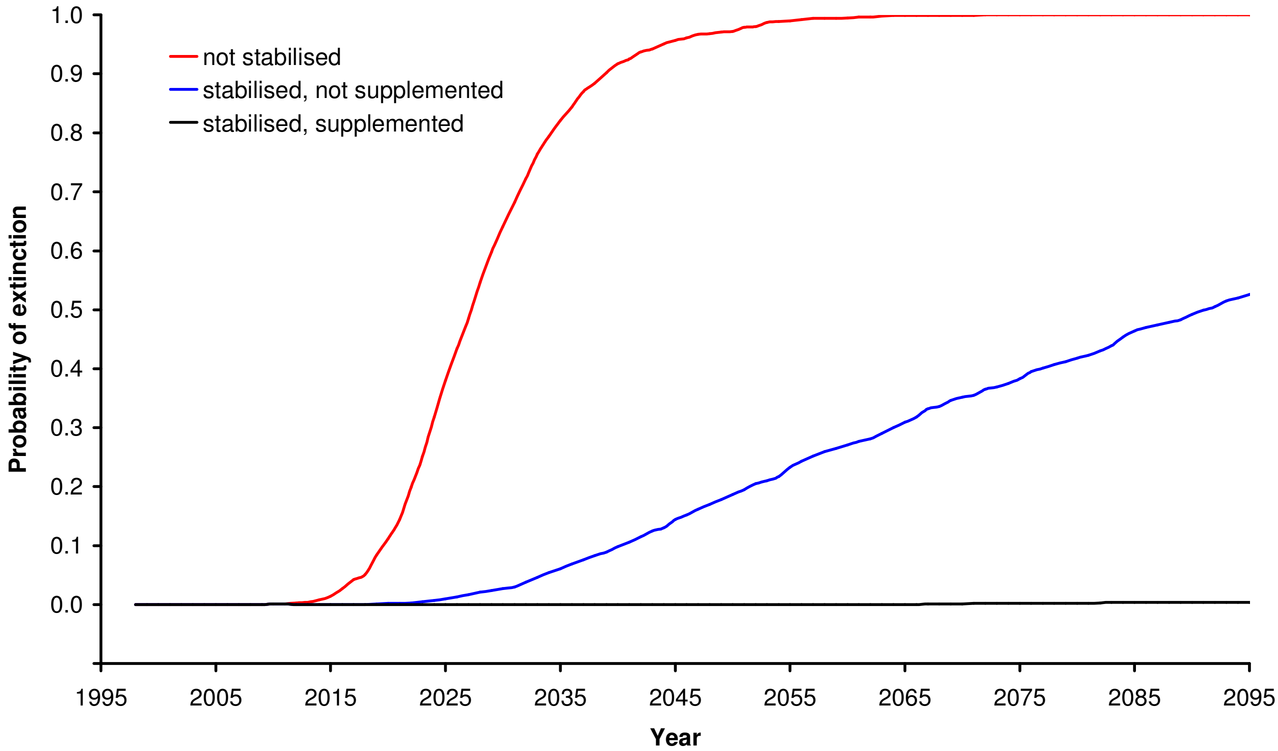

Figure 3-6. The effect of supplementation on extinction risk for the Lesser White-fronted Goose population breeding in Norway if the original population size had stabilised.
Population trajectory from 1998 to 2013 is based on the default adjusted model values (see Annex 5). After 2013, the red scenario is a continuation at the default adjusted values, the blue scenario represents an increase in survival to a level that delivers a relatively stable population at approximately 90 birds (juvenile survival = 0.32, adult survival = 0.86), and the black scenario shows the same increase in survival, combined with a supplementation programme of eight years at 40 birds per year. Probability of extinction is the proportion of 1,000 model runs that have zero remaining females.

3.3.1.1 Secondary benefits

The conservation needs of the existing Fennoscandian population are established in the ISSAP, Norway's National Action Plan, and the National Action Plans of Finland, Estonia and Greece.

To restore the LWfG to a favourable conservation status within the AEWA Area, the ISSAP calls for six results and outlines a range of activities required to achieve these results. While re-introduction/ supplementation is not a recommended activity of the ISSAP, such a programme could directly and indirectly benefit the implementation of a number of activities that are recommended. The results and activities of the ISSAP and potential links with a re-introduction/supplementation programme are summarised in Table 3-1.

Table 3-1. ISSAP results and activities and potential links with a re-introduction/ supplementation programme for LWfG in Norway.

Results and required activities in ISSAP	Potential links with a re-introduction/supplementation programme
Mortality rates are reduced ▪ Identify and protect key sites ▪ Ban all goose hunting at key sites ▪ Enforce hunting legislation ▪ Train hunters in identification ▪ Attract geese to safe areas ▪ Public awareness of hunting ▪ Redirect hunting from adults to juveniles in areas where Greater White-fronted Geese and LWfG occur together away from key sites ▪ Establish captive-breeding population.	Maximising the survival of the released birds would be an essential part of a re-introduction/supplementation programme. These activities would likely benefit the existing population. Public awareness as part of the programme could be used to highlight the over-hunting threat. A re-introduction/supplementation programme would very likely include the establishment of a captive population.
Further habitat loss and degradation is prevented ▪ Protect key sites include breeding sites ▪ Produce site management plans ▪ Monitor breeding grounds ▪ Restore staging and wintering sites	Habitat protection and restoration measures may be a required as part of a re-introduction/supplementation programme as the availability of suitable habitat (both in terms of condition and protection) would be essential. Such measures would benefit the existing population. In addition, a re-introduction/supplementation programme may bring with it increased public awareness and political will for further protecting and restoring habitat.
Maximised reproductive success ▪ Avoid disturbance in the breeding area ▪ Minimise predation if possible ▪ Eliminate all waterbird hunting on the breeding grounds and in all staging areas close to the breeding grounds	A re-introduction/supplementation programme may artificially increase reproductive success by boosting the number of juveniles in a given brood year. It is possible that the best release or rearing site option could be at or near the existing breeding area, which would present a risk of disturbance. Steps would need to be taken to minimise this risk.
No introgression of DNA from other goose species into the wild population occurs as a result of further releases and introgression from already released birds from captive-breeding programmes is minimised. ▪ Establish an international LWfG working group ▪ Establish a captive-breeding, re-introduction and supplementation committee, which will review captive-breeding programmes ▪ Establish a captive stock of wild Fennoscandian birds ▪ Swedish population should remain subject to a feasibility study ▪ Postpone Aktion Zwerggans project ▪ Commission independent review of genetics	If the status of the Norwegian population could be significantly improved by a well-run re-introduction/ supplementation programme in combination with other conservation measures, the need for other release programmes may be reduced. It cannot be guaranteed that wild-caught birds used to establish a captive population will be free of alien DNA as hybridisation may have occurred in the wild. While a re-introduction/supplementation programme would very likely include the establishment of a captive population, it may be appropriate to source birds from the Western Main population rather than the Fennoscandian.
Key knowledge gaps filled	A re-introduction programme would require post-release

Results and required activities in ISSAP	Potential links with a re-introduction/supplementation programme
▪ Provide financial support for research ▪ Locate key breeding grounds of Western Main population ▪ Locate key staging and wintering sites ▪ Locate key sites of Eastern Main population ▪ Study hunting pressure, predation, small mammal cycles, diet and habitat use ▪ Produce PVA ▪ Survey the Kola Peninsula ▪ Establish strategic monitoring programme at wintering sites ▪ Refine genetic techniques and knowledge	monitoring of birds and habitats. As birds will most likely be released into the existing population, monitoring of the released birds would include monitoring of the existing population. While the primary objective of establishing a captive-breeding population of LWfG would be to provide a source of animals for release, the population could also provide a source of animals for research, which could contribute to filling knowledge gaps. For example, the captive birds could be used to test satellite-tracking attachment techniques, develop genetic management strategies, and study predator avoidance and feeding behaviour. Such studies may, however, be possible on other already existing captive populations.
International cooperation maximised ▪ Develop international cooperation	While the re-introduction programme would most likely involve releasing birds in Norway, it would be beneficial to have collaboration with other countries along the migratory routes. This collaboration could help develop international cooperation.

A re-introduction/supplementation programme for LWfG could also have a range of other benefits including:

- Acting as a 'flagship' project for the conservation of waterbirds in Europe;
- Acting as a 'flagship' project for the conservation and restoration of wetland landscapes and encourage wide adoption of accompanying conservation-friendly land-use and other practices;
- Engaging land managers in wetland conservation action;
- Serving as an example of positive conservation measures, and helping to counteract the negative 'static' and protective image in which conservation is sometimes portrayed;
- Encouraging partnerships between organisations and individuals; and
- Generating popular support and publicity for conservation.

3.3.2 Potential negative impacts

3.3.2.1 Negative impacts on existing wild populations

When a species or population is heading towards extinction in the wild, it is sometimes appropriate to bring the whole of the remaining wild population into captivity in order to establish a captive breeding population where the genetic diversity of the species or population can be maintained until return to the wild becomes an option. Thus, it is sometimes necessary and justifiable to dramatically impact a wild population in order to prevent extinction.

In the case of the Norwegian LWfG, however, the loss of both genetic diversity and migratory route must be considered. The migratory route will only exist for as long as birds in the wild are using it. Thus, removing this population from the wild or increasing the risk of extinction in the wild to preserve genetic diversity is likely not appropriate. In addition, as already discussed, the total genetic diversity of LWfG is likely represented for the most part in the Western and Eastern Main populations (52).

To examine the impact of removing birds from the Norwegian population to found a captive breeding population, the population model was used to model the effect of removing eight fledglings (four males, four females) from the Norwegian population every year for three years (2010–2012). Figure 3-7 shows that the impact is remarkably small, causing only a minor decrease in the adult population size and a shift in extinction risk of just approximately two years. As previously stated, care must be taken in interpreting these results given the many assumptions made in the population model (see Annex 5). DN, in consultation with the other members of the RECAP committee as appropriate, would need to decide what level of risk to the Norwegian population would be acceptable.

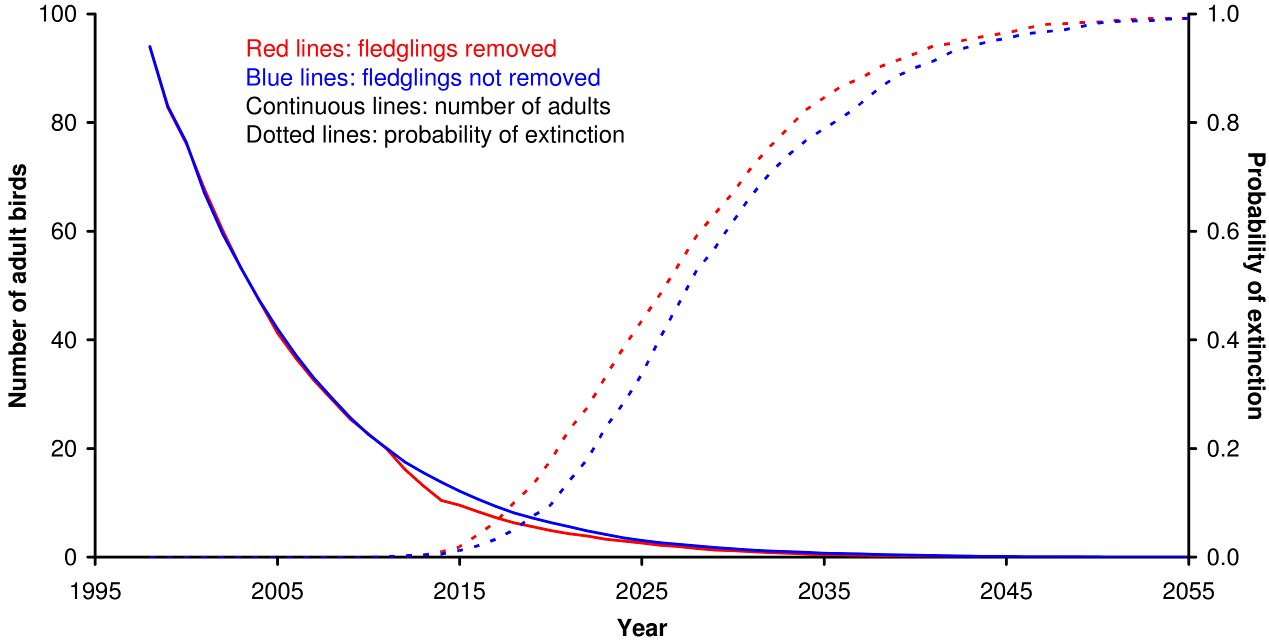

Figure 3-7. Impact of removing fledglings from the Lesser White-fronted Goose population breeding in Norway to create a captive population.

Although thought to be in decline, the Western Main population is much larger than the Fennoscandian population and the overall population would likely not be affected by removing a relatively small number of birds to establish a captive population. Impacts on particular breeding areas should be considered, however, and measures taken to minimise impacts, such as only taking juveniles and not taking entire broods. These measures were taken in establishing the captive population at Nordens Ark, Sweden.

3.3.2.2 Negative impacts on the environment

A re-introduction/supplementation programme for LWfG would likely have insignificant or no negative impacts on the environment.

The historic breeding grounds in Norway are unsaturated (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009), so an increased LWfG population in that area would not displace other species. Similarly, the key staging and wintering sites are capable of supporting a large number of geese and would likely not be negatively impacted by an increase in the LWfG population (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009). If numbers increased dramatically, there may be impacts, but a re-introduction/supplementation programme would likely only serve to maintain the current population while causes of decline are addressed or to increase the rate of natural recovery.

3.3.2.3 Negative impacts on local communities and other stakeholders

On the breeding grounds and at some staging sites, local stakeholders include reindeer herders, hunters, ecotourists and an ecotourism business. Measures taken as part of a re-introduction/supplementation programme, such as movement restrictions and construction of infrastructure, could negatively impact these stakeholders. Measures should be taken to minimise these impacts and mitigate where possible.

The major stakeholder groups to consider at other staging sites as well as wintering sites are farmers and hunters. Farmers could be negatively impacted if a re-introduction/supplementation programme resulted in increased pressure on agricultural fields for feeding. LWfG, however, generally prefer natural habitat to agricultural fields (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009) and, as discussed above, a re-introduction/supplementation programme would likely only serve to maintain the current population or to increase the rate of natural recovery. Hunters could be negatively impacted by increased bans on hunting, including banning all goose hunting at key sites and all waterbird hunting on the breeding grounds. These measures, however, are already required in the ISSAP.

3.3.2.4 Negative impacts on public, political and organisational attitudes

Impacts on attitudes are hard to predict and often may be influenced through effective public awareness campaigns. A successful re-introduction or supplementation would likely have many positive impacts, including generating public support for LWfG conservation, conservation as a whole and re-introduction/supplementation as a conservation tool.

Re-introductions and supplementations are, however, notoriously difficult and the failure rate of re-introductions has been high in the past (8). An unsuccessful re-introduction or supplementation could negatively impact public, political and organisational attitudes towards such programmes.

Negative attitudes could also result if a re-introduction/supplementation programme is seen to negatively impact stakeholders. For example, increased hunting legislation and movement restrictions in the breeding area, if linked to a re-introduction/supplementation programme, could create negative attitudes in Finnmark towards LWfG and/or conservation in general.

3.3.3 Cost-effectiveness

Determining the exact costs of a re-introduction/supplementation programme is not possible until a detailed work plan has been produced. As has been demonstrated by other programmes, however, costs should be anticipated to be very high and run for a number of years, perhaps decades.

Section 4.4.1 provides an example of some of the costs that could be associated with a programme that would require the construction of breeding and rearing facilities and involve releasing birds over a period of 10 years with a captive population maintained for 20 years. These preliminary figures suggest such a programme could cost approximately 48,580,000 NOK (7,504,592 USD). This figure, however, is based on a number of significant assumptions (see Section 4.4.1) and should not be used as a guide for future planning, but simply as an indication of the costs to consider in assessing justification for such a programme.

Determining cost-effectiveness depends on the available resources and priorities of DN and therefore could not be fully-assessed as part of this report. If allocating funds to a re-introduction/ supplementation programme for LWfG would jeopardize other conservation programmes either for LWfG or other species, the potential impacts of this must be factored into decision-making.

It is vital that such a re-introduction/supplementation be conducted as part of a wider LWfG conservation programme, and effective integration between re-introduction/supplementation efforts and conservation efforts for the existing Norwegian population should be sought wherever possible.

3.4 POLICY REQUIREMENTS

3.4.1 Accordance with existing conservation plans and policies

According to the IUCN *Guidelines for Re-introductions* (44), the principal aim of a re-introduction programme for any species should be to improve the conservation status of the species in the wild, and objectives may include: 1) enhancing the long-term survival of the species in the wild; 2) maintaining or re-establishing a keystone species (in the ecological or cultural sense); 3) maintaining or restoring natural biodiversity; 4) providing long-term economic benefits to the local and/or national economy; and/or 5) promoting conservation awareness.

DN has confirmed that the principal aim of a re-introduction/supplementation programme for LWfG in Norway would be to improve the conservation status of the Fennoscandian population of LWfG using the traditional migratory routes. This aim, therefore, is in line with the IUCN *Guidelines for Re-introductions* (44).

The above aim will be achieved by enhancing the long-term survival of the Norwegian LWfG population again in line with the IUCN *Guidelines for Re-introductions* (44) as well as the goals of the ISSAP and Norway's National Action Plan.

As well as enhancing long-term survival, a re-introduction/supplementation programme for LWfG in Norway could also address the other objectives outlined in the IUCN *Guidelines for Re-introduction*s (44) with the possible exception of providing economic benefits. While the LWfG is not considered to be a keystone species in the ecological sense (extinction of LWfG in Norway is unlikely to lead to the extinction of other species), it is an iconic species for Norway and other European countries and can be considered a keystone species in the cultural sense. In addition, a re-introduction programme would help maintain natural biodiversity in Norway and other range countries, and provide a number of opportunities for promoting conservation awareness.

3.5 SUMMARY

Is the species/population extinct or facing a high risk of extinction in the wild? Or has the species/population undergone a significant decline and is currently in a depleted state, either in terms of distribution or number? The conservation status of the Norwegian LWfG population, and the lack of significant recovery despite conservation measures, demonstrates the need for supplementation. This view is further supported by the results of population modelling. Indeed, supplementation should be considered a key conservation need to ensure that the conservation efforts in recent years at sites along the migratory routes are not wasted. Should the population be extirpated from Norway there would be a need for re-introduction.

Are existing conservation measures sufficient for recovery within a reasonable timescale? Conservation measures undertaken in the last five years have not resulted in a significant increase in the population. The required activities of the ISSAP and various National Action Plans, including fox control in the breeding area, will hopefully produce an increase in the population. ISSAP implementation in all Range States, however, cannot be guaranteed, particularly in Range States that are not Parties to AEWA. The ISSAP calls for activities to commence within the next five to 10 years. Population modeling suggests this could be too late to prevent extirpation of the Norwegian population. Thus, existing and proposed conservation measures are likely not sufficient for recovery within a reasonable timescale.

What would the primary and secondary benefits of the programme be and would they contribute to addressing the established conservation needs of the species or other species? The primary benefits of supplemented the Norwegian LWfG population would be to reduce the short-term risk of extinction and to preserve the population while factors causing decline can be addressed. Re-introduction into historical breeding areas would have the benefit of establishing a breeding site separate from existing sites to reduce the chances of catastrophic loss and re-colonising vacant habitat. Re-introduction following extinction would have the primary benefits of re-establishing a keystone species and maintaining natural biodiversity. While re-introduction/supplementation is not a recommended activity of the ISSAP, such a programme could directly and indirectly benefit the implementation of a number of activities that are recommended in the ISSAP as well as have a range of other benefits, including acting as a 'flagship' project for conservation in Europe, engaging land managers and encouraging partnerships.

Would there be any negative impacts on existing wild populations, if present? Negative impacts on the wild LWfG populations could occur through disturbance on the breeding grounds and taking birds from the wild. Modelling indicates that removing approximately 24 juveniles (eight per year) during 2010–2012 would cause a minor decrease in the population size and a leftward shift in extinction risk of approximately two years. Negative impacts on the Western Main population would not be expected.

Would there be any negative impacts on the environment? A re-introduction/supplementation programme for LWfG in Norway is unlikely to have negative impacts on the environment. Negative impacts are only likely to arise if the Fennoscandian population increases dramatically and beyond the carrying capacity of its habitats. A re-introduction/supplementation programme, however, would likely only serve to maintain the current population while causes of decline are addressed or to speed up a recovery that would have occurred naturally or as a result of other conservation measures.

Would there be any negative impacts on local communities and other stakeholders? Negative impacts on local stakeholders could include disruption to reindeer herders, increased pressure on agricultural fields, increased hunting restrictions, and movement restrictions for ecotourists and an ecotourism business. With the exception of disruption to reindeer herders, these impacts are likely to occur regardless of a re-introduction/supplementation programme, either as a result of ISSAP implementation, or a recovery that would have occurred naturally or as a result of other conservation measures.

Would there be any negative impacts on public, political and/or organisational attitudes? Negative impacts on stakeholders could in turn have negative impacts on attitudes, both towards LWfG and conservation in general. These impacts on attitudes could be minimised by effective public awareness campaigns, sympathetic programme design and mitigation where possible and appropriate.

Would the programme's benefits outweigh potential negative impacts? While negative impacts may occur they will likely not outweigh the benefits of maintaining or restoring LWfG in the range of the Fennoscandian population. Measures should be taken to minimise negative impacts wherever possible.

Could the desired outcomes be achieved by an alternative, more inexpensive method, *i.e.* would the programme be cost-effective? Whilst a re-introduction/supplementation programme would have high costs, it may be the only conservation tool available either to reduce the risk of extinction in the short-term in order to maintain the Norwegian population while the causes of decline are addressed, or to re-establish LWfG in Norway following extirpation. A re-introduction/supplementation is, however, only justified (and is only likely to be ultimately effective) if undertaken as part of a wider conservation programme for the population. Determining cost-effectiveness depends on the available resources and priorities of DN, and therefore could not be fully assessed as part of this report.

Would the programme's aims and objectives be in line with existing, relevant conservation plans and policies, particularly the IUCN *Guidelines for Re-introductions* (44) and any existing Action Plans? The proposed aims and objectives, namely to improve the conservation status of the Norwegian population of LWfG by enhancing the long-term survival of LWfG in Norway using traditional migratory routes, would be in line with the IUCN *Guidelines for Re-introductions* (44) as well as the goals of the ISSAP and Norway's National Action Plan.

4 FEASIBILITY ASSESSMENT

4.1 BACKGROUND

A feasibility assessment aims to determine, to the best available knowledge, if a proposed re-introduction/supplementation programme is practically possible, considering biological, environmental and technical factors; socioeconomic, political and legal factors; resource requirements; and time constraints.

The IUCN *Guidelines for Re-introductions* (44) clearly outlines the factors that should be considered when undertaking a re-introduction programme, and a number of comprehensive scientific reviews (*e.g.* 83, 82, 78) as well as the AEWA Review of Waterbird Re-establishments (54) have determined the factors most associated with success. From these sources, it is possible to identify 10 key criteria to address when assessing feasibility:

- Is a suitable source of animals available?
- If using captive animals, are captive-breeding techniques for the species known?
- Are release techniques for the species known?
- Is a suitable environment available in which to release the animals?
- Have the original causes of decline been sufficiently reduced or eliminated?
- Is there sufficient knowledge of the species' natural history?
- Does stakeholder support exist?
- Will the programme conform to relevant laws and regulations?
- Are sufficient financial resources available?
- Are sufficient technical resources available?

As the objectives of re-introduction/supplementation programmes can vary greatly (from establishing viable self-sustaining populations in the long-term to reducing the risk of extinction in the short-term), the objectives must be taken into account when assessing feasibility. For example, it may be feasible to maintain a species in an area for a given period while the causes of decline are addressed, but not feasible to establish a self-sustaining population in vacant habitat.

It is also vital to consider the timescale within which a re-introduction/supplementation programme might need to occur and the potential problems associated with limited time. Where a species or population is facing a high risk of extinction in the wild, there is often the need to act quickly to establish a captive population to preserve genetic diversity, and/or supplement the existing wild population to preserve ecological characteristics, such as a migratory route. Where a species or population has already become extinct in the wild or has been extirpated from a particular area, there are often fewer time constraints, but according to the IUCN *Guidelines for Re-introductions* (44), 'special care is needed when the population has long been extinct.'

The following sections address the key feasibility criteria for a re-introduction/supplementation programme for LWfG in Norway taking into consideration time constraints and the objective, as outlined by DN, to enhance the long-term survival of LWfG in Fennoscandia using traditional migratory routes.

4.2 BIOLOGICAL, ENVIRONMENTAL AND TECHNICAL CONSIDERATIONS

4.2.1 How could a re-introduction/supplementation proceed and what options should be considered for LWfG in Norway?

To assess feasibility it is useful to know in general how the re-introduction/supplementation programme could proceed. This section briefly describes the options available for a re-introduction/ supplementation programme for LWfG in Norway and the various advantages and disadvantages associated with each.

There are numerous examples of successful establishments and re-establishments of bird populations through either the release of captive-bred birds or translocation. Re-introductions and supplementations of non-threatened birds (*e.g.* invasive species, island migrants and game birds) tend to be more successful than those of threatened birds, however, and there are few examples of successful establishments of migratory birds, particularly of species that require taught migration.

Past re-introductions/supplementations of migratory species that require taught migration have met with varying success (*e.g.* LWfG, Aleutian Canada Goose and crane species) and illustrate the challenges faced by such programmes.

In the 1970s and 1980s, attempts were made to restore the Aleutian Canada Goose to a number of Aleutian Islands. The first re-introduction attempt occurred in 1971, when 75 free-flying birds were released on Amchitka Island (21, 86). Most of these birds left the island shortly after release and were never seen again (21, 86). In 1974, 41 wing-clipped captive-bred birds were released on Aggatu Island in early May, where the birds remained close to the release site all summer and two pairs nested, with one pair successfully rearing young (21, 86). To establish migration, nine wild, moulting geese were brought from Buldir Island and released with the captive-bred birds (21). Observations from the wintering areas in California confirm that at least some of the captive-bred birds migrated, but the birds were not seen again on Aggatu or Buldir Islands in subsequent summers (21). In May 1976, 30 captive-bred birds and three wild birds were released on Amchitka Island. Again, these birds were not seen in following years on Amchitka Island (86). Releases continued into the 1980s on both Amchitka and Aggatu Islands with over 450 birds released (40). Releases on Amchitka Island were unsuccessful with no confirmed nesting, but releases on Aggatu Island are thought to have established a breeding population (40). These releases in combination with intensive fox control and other recovery efforts are credited with saving this species from extinction (100). The population, numbering only hundreds in the mid-1970s, increased to 6,300 birds by 1990 and numbered over 32,000 in 1999 (100).

LWfG re-introduction/supplementation attempts have also met with varying success (see Section A1.5). Past efforts have included direct release into the wild, human-led migration and the use of foster parents, and provide a number of useful lessons. The foster parent method was used successfully in Sweden between 1981 and 1999. Birds released as part of this programme use traditional Barnacle Goose wintering grounds rather than traditional LWfG wintering grounds (see 46). The 1999 pilot project demonstrated that LWfG can be trained to follow an ultra-light aircraft on migration (see 46). These projects have also demonstrated LWfG can be bred in captivity in sufficient numbers to supply relatively large numbers of birds for release.

Releasing LWfG into the historical range of the Fennoscandian population such that released birds and their descendants not only survive and breed but also use the traditional migratory route of Fennoscandian LWfG presents a number of significant challenges. The following briefly describes possible methods for releasing birds, and how outcomes could be influenced by using different source populations (captive or wild), release timings and locations, and ages of released birds.

4.2.1.1 Captive or wild source population?

The source of animals for a re-introduction or supplementation programme can be either captive or wild. Captive and wild source populations require different re-introduction/supplementation techniques and both are associated with various advantages and disadvantages.

Translocation, defined as the direct movement of wild birds from one area to another, has been used successfully to re-introduce or supplement threatened birds, e.g. Black Robin *Petroica traversi*, Northern Brown Kiwi *Apteryx mantelli* and species of honeyeaters (85). The translocation process (catching, handling, confining, transferring and releasing into an unfamiliar environment) has, however, been associated with a number of problems, including reduced breeding success, rapid dispersal from the release area and low survival (85). These effects vary depending on the species involved and age of the birds translocated – as adults, juveniles or eggs.

Translocation is most suitable for birds that do not rely on phase-sensitive learning to develop survival skills and food, habitat and site preferences; that are resident in an area, *i.e.* birds which do not normally move or migrate long-distances; and that can be found, caught, transported and released relatively easily with a minimum amount of stress.

LWfG generally do not fit the profile of a species that could be easily translocated for the following reasons:

- *LWfG are long-distance migrants.* Merely the fact that LWfG regularly move long-distances makes them more likely to disperse from the release area if they are capable of flight when released. Birds which have been translocated are likely to be stressed when released and want to move away from the source of their stress. It may be possible to overcome this problem by releasing flightless adult (moulting or wing-clipped) or juvenile birds, or holding the birds in a netted enclosure at the release site where they can settle and acclimatise to their new environment.
- *Learning plays a role in site selection.* Site selection in LWfG is thought to be influenced by where birds learn to fly and the sites that are encountered on migration. For this reason, adult LWfG which have been translocated to a new breeding area may not return to this area the following summer, but rather return to their original breeding grounds, where they learned to fly. Translocating flightless juvenile geese may overcome this site selection problem.
- *Locating, catching and transporting suitable numbers of individuals from the donor population within a reasonable timescale may be difficult.* While not practically or logistically simple, catching a group of adult LWfG could be achieved by rounding-up a group or groups of moulting birds, or cannon-netting birds at a staging site. Catching a group of flightless juveniles could be achieved by rounding-up a number of family groups. It would be necessary to catch 10– 20 juveniles in order to supply enough birds for one release. The amount of time required not only to catch and transport the geese, but also to process them through quarantine and customs may be significant (in the case of the Nordens Ark captive population up to four months were required). This amount of time in captivity would present significant problems to a successful translocation: geese may adapt to captivity, imprint on humans and human infrastructure, and gain the ability to fly. For these reasons, translocating juvenile birds is only feasible if the time required to transfer the geese from the capture area to the release area could be reduced to less than approximately three weeks and occur before flight is achieved. In order to translocate eggs, the primary requirements would be the ability to locate a sufficiently high number of donor nests with incubating females to ensure finding some nests in the appropriate stage of incubation, and the ability to locate foster nests at an appropriate incubation stage to receive the eggs. Finding nests of LWfG has proven to be very difficult both in Norway and Russia. LWfG nest amongst shrubs and their nests are well hidden. Birds are often quite active during the early stages of incubation, but during the later stages (when eggs should be collected) birds are often inactive making the later stage nests particularly hard to find. These problems alone make translocating eggs almost certainly unfeasible.

Table 4-1 presents a summary of the key constraints associated with translocating LWfG.

Table 4-1. The key constraints associated with translocating Lesser White-fronted Geese and the implications for using translocation as part of a re-introduction/supplementation programme in Norway.

Age of birds for translocation	Key constraints	Implications
Adults	Adult LWfG will have learned the location of their native breeding site (and other sites including staging and wintering sites) and may be unlikely to return to their release site following a migration. Adult geese may have become conditioned to use the habitat and food types in their native range. The time between capture and release could negatively affect the birds' ability to survive when released, and the stress of capture, transportation and release into an unfamiliar habitat will be significant.	It may be possible to translocate adults, if adult birds can be persuaded to use the Fennoscandian migratory route (experimental approach required).
Juveniles	Juvenile geese may have become conditioned to use the habitat and food types in their native range. The time between capture and release could negatively affect the birds' ability to survive when released, and the stress of capture, transportation and release into an unfamiliar habitat will be significant.	Translocating juvenile geese would likely have a better outcome than translocating adult geese.
Family groups	Translocating family groups would have the same constraints as translocating adults and juveniles separately. The presence of parent birds will improve the survival chances of the juvenile birds, but also increase the chances of juvenile birds not returning to the appropriate breeding area.	It may be possible to translocate family groups, if adult birds can be persuaded to use the Fennoscandian migratory route (experimental approach required).
Incubating female with eggs	Locating an incubating female with male and transporting the pair with eggs within a reasonable amount of time would be practically very difficult if not impossible. The stress of capture and transport may cause the female to abandon incubation	Considering the difficulty locating nests, this is likely not feasible.
Eggs	A sufficient number of nests at the correct incubation stage both in Russia and Norway could likely not be found.	Considering the difficulty locating nests, this is likely not feasible.

The alternative to releasing translocated wild birds – releasing captive-bred birds – may provide a more predictable and regular supply of birds without many of the above constraints. Captive-breeding techniques are well-established (see Section 4.2.4) and captive-bred birds have been used successfully to re-introduce and supplement many bird populations.

The main disadvantage of using captive-bred birds compared to wild-translocated birds is the need to ensure captive-bred birds are given the opportunity to learn the necessary survival skills. Rearing for release should be considered as a separate process from rearing birds which will remain in a captive-breeding situation and accordingly separate rearing facilities may be required. Special steps would need to be taken to ensure birds for release imprint on or become conditioned to appropriate items (*e.g.* adult birds of the same species, the release site and natural food types), do not imprint on or become conditioned to humans or human infrastructure (*e.g.* buildings and vehicles), and learn survival skills such as predator avoidance. Such steps are not required for birds which will remain in captivity, and it is in fact often beneficial for these birds to become conditioned to human infrastructure and develop preferences for an artificial diet. Rearing-for-release techniques have been successfully demonstrated for geese and cranes.

Table 4-2 provides a summary of the main advantages and disadvantages associated with releasing captive-bred and wild-translocated LWfG.

Table 4-2. A summary of the main advantages and disadvantages associated with releasing captive-bred and wild-translocated LWfG.

Source type	Advantages	Disadvantages
Wild	No opportunity for hybridisation or domestication in captivity. Birds will have naturally acquired survival skills. Birds will likely be in a physical condition suitable for surviving in the wild (assuming physical condition is not significantly affected by the stress of capture, transportation and release). Relatively inexpensive, *e.g.* infrastructure such as a breeding facility would not be required.	Birds will experience stress as a result of capture, transportation and release into an unfamiliar area, which may negatively affect survival. Birds may have developed preferences for inappropriate sites, food types and habitat types as a result of their time in the wild in a different area.
Captive	Numbers available for release at a given time will likely be more predictable and controllable than taking birds directly from a wild population. Manipulations can be made during rearing to improve the birds' chances of survival.	Domestication may occur if birds are held in captivity for a large number of generations. Relatively expensive, *e.g.* breeding and rearing facilities would be required. Birds released from captivity may have reduced survival skills.

4.2.1.2 Release timing and location

Birds which require taught migration must be given an opportunity to learn the desired migratory route. If this route is to be that of existing wild birds, birds must be released in such a way that they come into contact with wild birds and follow them on migration. If the route is to be human taught, the birds must be trained to follow a vehicle (usually ultra-light aircraft).

Releasing migratory birds directly into the wild without human intervention to establish migration is known as 'direct release'. The timing and location of direct release is critical to ensure released birds have the best chance of joining wild birds. LWfG would need to be released at the sites most regularly used by the largest numbers of Norwegian LWfG at appropriate times during the annual life-cycle.

According to monitoring data from the EU Life-Nature project 'Conservation of Lesser White-fronted Goose on the European migration route' (April 2005 – March 2009) (95), the four sites with the largest numbers of LWfG staying on average for over two weeks are:

1. Core breeding area, Norway
   10–16 pairs, early May to mid September
2. Valdak Marshes, Norway
   27–66 individuals, mid August to mid September
   30–43 individuals, May
3. Hortobágy, Hungary
   31–54 individuals, mid September to late November
   26–59 individuals, early February to late April
4. Lake Kerkini and Evros Delta, Greece
   44–56 individuals, late October to mid March

A release at any site would require an acclimatisation period of at least two weeks (ideally longer) during which the birds should be held at the release site in a large predator-proof enclosure. Contact with wild birds could be achieved either by attracting wild birds to the enclosure area (*e.g.* by provision of food, playing of contact call recordings, or simply the presence of captive birds), or by capturing wild adults or family groups and holding the wild-caught birds with the captive-bred birds before releasing both groups together. Capturing and holding wild birds would be difficult during periods outside of moult. Fully-flighted birds would require cannon-netting for capture. If attempted at the release area, this would disturb other geese in the release area, and fully-flighted birds could injure themselves inside an enclosure. Moulting birds, although possibly more difficult to locate, could potentially be caught without disturbing a large area and these flightless birds would be less likely to injure themselves inside an enclosure. Fully-flighted birds could, however, be caught some distance from the final release area and could be wing-clipped depending on the time of year.

Figure 4-1 illustrates a selection of possible release timings and locations and the associated acclimatisation periods. Each release location and timing is associated with various advantages and disadvantages, as described in Table 4-3. Outcomes will also be influenced by the age and group structure of released birds, which is a consideration in Table 4-3 and discussed in more detail in Section 4.2.1.3.

Table 4-3. Selection of possible timings and locations for releases of Lesser White-fronted Geese into the Norwegian population and the associated advantages and disadvantages.

Release timing and location	Advantages	Disadvantages
A. Birds released at or near core breeding area between beginning and end of moult period for breeding wild birds. Contact with wild birds could be gained by catching and holding moulting wild birds with captive-bred birds. Second-calendar-year birds could be held at release site from early May to the end of the moult period. First-calendar-year birds could be held from hatching to the end of the moult period.	▪ Opportunity for extended acclimatisation period of 1–4 months. ▪ Wild-caught family groups may be more likely to 'adopt' captive juveniles during the breeding season than at other times of year. ▪ Captive-bred birds would gain flight ability at a suitable breeding site, which they may return to the following summer. ▪ If releasing first-calendar-year birds, these birds would have experienced a minimal amount of time in captivity.	▪ Possible disturbance to core breeding area. ▪ Capture of wild birds would likely be the only option for providing captive-bred birds contact with wild birds, *i.e.* it is unlikely wild birds could be attracted to the release enclosure because they are usually widely dispersed during this period and leave for Valdak soon after moulting. ▪ Locating and catching moulting birds may be difficult and unpredictable from one season to the next.
B. Birds released at Valdak Marshes during autumn staging. Contact with wild birds could be gained by attracting wild birds to the release enclosure. Birds could be held at or near the core breeding area before being transported to Valdak. Ideally, second or first-calendar-year birds would be released to limit the time spent in captivity.	▪ During autumn migration a relatively large number of wild LWfG use Valdak Marshes and remain for on average approximately 26 days, providing a relatively good chance of wild and captive birds making contact during the acclimatisation period.	▪ The location of wild LWfG in Valdak Marshes is often unpredictable and groups can be widely dispersed. ▪ Only 1–2 weeks would be available for acclimatisation, unless birds were held at Valdak during the normal breeding season. ▪ Captive-bred birds would likely gain flight ability at Valdak and could possibly return to this area to breed in subsequent years (not a disadvantage if Valdak is deeming a suitable breeding area).
C. Birds released at the Hortobágy during autumn staging. Contact with wild birds could be gained by attracting wild birds to the release enclosure. Ideally, second or first-calendar-year birds would be released to limit the time spent in captivity.	▪ The Hortobágy would provide a well-managed and protected release site with opportunities for habitat manipulation to encourage wild birds to use particular areas. ▪ During autumn migration a relatively large number of wild LWfG use the Hortobágy and remain for on average approximately 5–6 weeks, providing a relatively good chance of wild and captive birds making contact during the acclimatisation period. ▪ Up to 4 weeks would be available for acclimatisation.	▪ Released birds would likely first experience flight at Hortobágy and could possibly return to this area to breed in subsequent years. ▪ Released birds would not be led on the full autumn migratory route missing important staging sites, including Valdak Marshes, the Kanin Peninsula, the Bothnian Bay coast in Finland and sites in Estonia. This may increase chances of the released birds following non-breeding wild birds on the 'eastern' route the following year.

Release timing and location	Advantages	Disadvantages
D. Birds released at Lake Kerkini or Evros Delta during winter. Contact with wild birds could be gained by attracting wild birds to the release enclosure. Ideally, second or first-calendar-year birds would be released to limit the time spent in captivity.	▪ Up to 6 weeks would be available for acclimatisation. ▪ First-calendar-year birds will be approximately 6 months old and presumably stronger than birds released at 1 month old.	▪ Large numbers of geese other than LWfG would be present at these sites. Released birds may join flocks of other species. ▪ Second-calendar year birds will have spent approximately 18 months in captivity and may have diminished abilities to learn survival skills. ▪ The location of wild LWfG at these sites is often unpredictable. ▪ Hunting pressure may exist. ▪ If released birds migrate to Norway with wild LWfG, having not experienced autumn migration down the 'western' route they may be more likely to accompany non-breeding birds on the 'eastern' route in the following autumn.
E. Birds released at the Hortobágy during spring migration. Ideally, second-calendar-year birds would be released to limit the time spent in captivity.	▪ The Hortobágy would provide a well-managed and protected release site with opportunities for habitat manipulation to encourage wild birds to use particular areas. ▪ During spring migration a relatively large number of wild LWfG use the Hortobágy and remain for on average approximately 4 weeks, providing a relatively good chance of wild and captive birds making contact during the acclimatisation period. ▪ Up to 3 weeks would be available for acclimatisation.	▪ If released birds migrate to Norway with wild LWfG, having not experienced autumn migration down the 'western' route they may be more likely to accompany non-breeding birds on the 'eastern' route in the following autumn. ▪ Released birds would likely first experience flight at Hortobágy and could possibly return to this area to breed in subsequent years. ▪ Birds released in the middle of spring migration may not experience the same physiological drive to migrate as birds released at other times of the year.

Release timing and location	Advantages	Disadvantages
F. Birds released at Valdak Marshes during spring staging. Ideally, second-calendar-year birds would be released to limit the time spent in captivity.	▪ Second-calendar-year birds will be approximately 9–11 months old in the spring, and presumably stronger than birds released earlier in the year. ▪ Because Valdak Marshes are relatively close to the core breeding area in Norway, released birds would not be required to fly long distances soon after release. ▪ If the released birds did not follow wild LWfG to breeding areas, this may not present a significant problem. Released birds could stay in Valdak until the following autumn.	▪ The location of wild LWfG in Valdak Marshes is often unpredictable and groups can be widely dispersed. ▪ Having not experienced autumn migration down the 'western' route birds released in spring may be more likely to accompany non-breeding birds on the 'eastern' route in the following autumn. ▪ Released birds would likely first experience flight at Valdak Marshes and could possibly return to this area to breed in subsequent years (not a disadvantage if Valdak is deeming a suitable breeding area). ▪ Birds will have spent a relatively long period in captivity. Their ability to learn new survival skills may be compromised compared with birds released at a younger age.

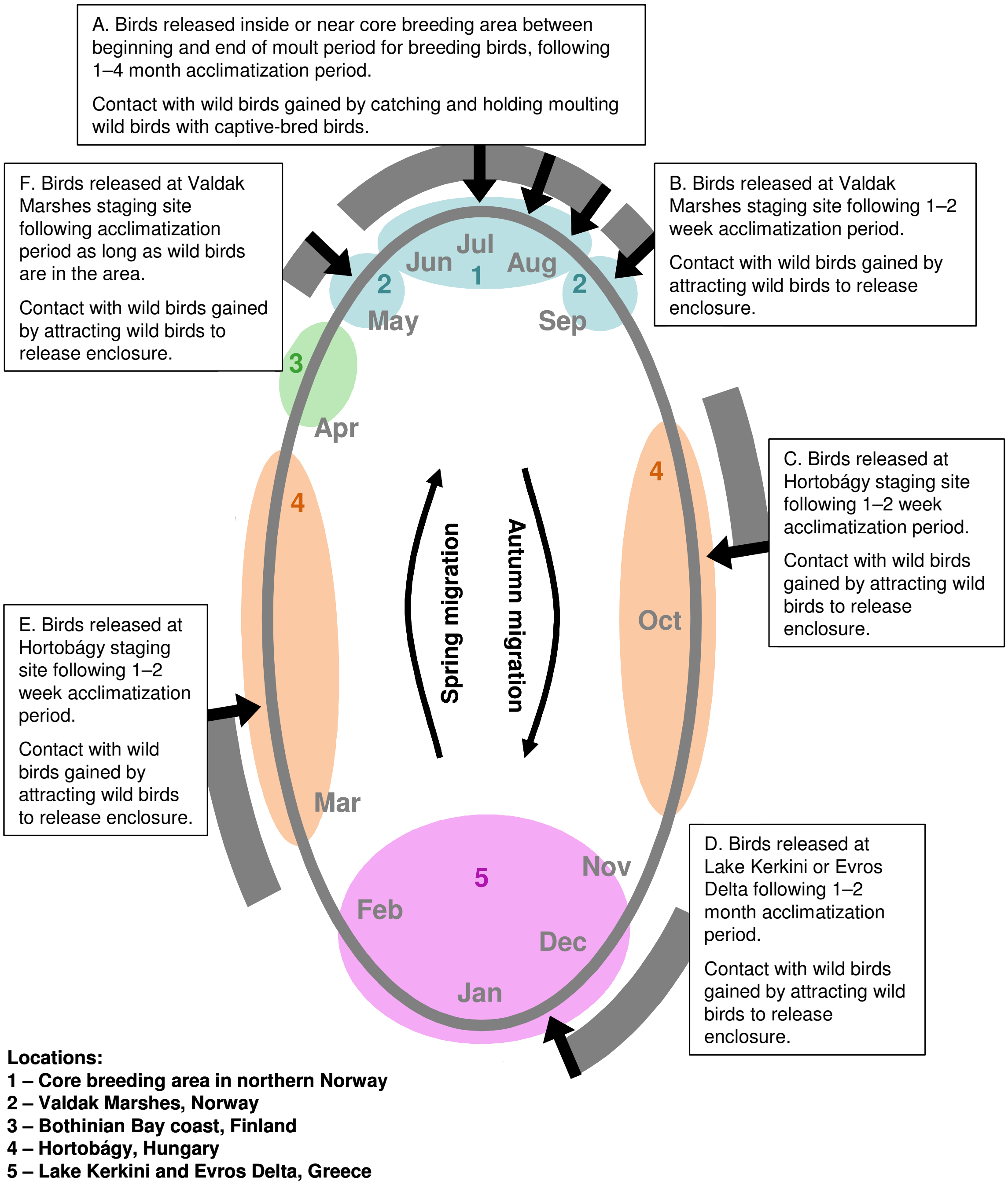

Figure 4-1. Simplified illustration of the locations (coloured ovals) of Norwegian Lesser White-fronted Geese during their annual life-cycle (considering only the 'western' migration route through Europe) showing possible opportunities for releases (arrows) and the associated available acclimatisation periods (grey bands adjoining arrows).

The options discussed above assume that the Norwegian LWfG population is extant at the time of release. If the population has become extirpated by the time of release, the only remaining options for establishing migratory habit would be human-led migration (*e.g.* using ultra-light aircraft) or foster parent-led migration. As discussed in Section 3.4.1, DN has determined that a re-introduction or supplementation in Norway should aim to establish the traditional Fennoscandian LWfG migratory route. Foster parent-led migration would result in the released birds learning the traditional migratory route of the foster parent population. Thus, this method will not be discussed further in this feasibility study. Human-led migration, while not able to exactly replicate the migratory route of Fennoscandian

LWfG due to current knowledge gaps, could lead birds from traditional breeding grounds to traditional wintering grounds via traditional staging sites, maintaining a large portion of the traditional route.

As contact with wild birds would not be required for human-led migration, this method would have fewer time constraints. To ensure birds learned the full 'western' migratory route, it would be necessary to hold birds at suitable breeding grounds during the summer before leading them by ultra-light aircraft to key sites along the migratory route, matching the timing of wild LWfG as closely as possible but also ensuring the welfare of the birds. Based on work with cranes, it is possible that the birds would migrate back to the breeding grounds (the location where they first learned to fly) the following spring without human intervention (31).

For any release of birds, it would not be possible to fully control post-release movements and there would be a risk of the birds using sites not used by the wild Norwegian population. This risk would exist both for a re-introduction/supplementation programme using human-led migration and the direct release technique.

4.2.1.3 Age considerations

The age at which birds are released may influence release outcomes.

If releasing captive birds, in order to develop appropriate survival skills and natural behaviours, birds for release would ideally spend as little time as possible in captivity. It is presumed that young birds are more able to adapt to new situations and learn new behaviours than older birds. While juveniles released in the same year as hatch will have had a minimal amount of time in captivity, this advantage must be weighed against the disadvantage of birds at this age not having reached the size and strength of older birds. Thus, advantages and disadvantages are associated with different age groups.

It is important to consider that captive birds for release can be held in different conditions to those of captive birds held for breeding. Breeding birds should be held in an environment that best encourages breeding, while birds for release should be held in an environment that best encourages the development of survival skills. It may be possible, therefore, to limit the effects of captivity on birds for release by holding these birds in conditions which allow for the acquisition of survival skills and appropriate imprinting.

If releasing wild birds transported from a wild area (*e.g.* transporting LWfG from the Western Main population), it is probably important that these birds are captured before they have learned a migratory route or significantly developed preferences for habitat and food types, *i.e.* juveniles probably present the best option. It is unknown whether or not a new migratory route (*i.e.* the traditional route of the Fennoscandian population) could be established in transported adult LWfG; it is thought likely that these birds would disperse in search of previously used sites. Birds from the Western Main population, however, have in the past joined the Fennoscandian population and presumably used the Fennoscandian migratory routes.

Timing of release may be able to reduce the chances of adult birds rapidly dispersing from a release site. For example, past re-introduction attempts with Aleutian Canada Geese have demonstrated that when released fully-flighted, geese will often disperse quickly from the release site, whereas geese released in moult or wing-clipped tend more often to remain in the release area even after flight has been regained. Thus, it may be possible to increase the chances of adult birds (either from captivity or the Western main population) developing site fidelity for the release area by releasing them wing-clipped or during moult. For example, if wing-clipped adult birds were released in early May at or near the Fennoscandian breeding grounds, they would likely remain near the release area until after moult, when they might join birds from the Norwegian population on migration. Fully-flighted adults released on the breeding grounds, however, would probably disperse from the area before contact could be made with wild birds.

Serious consideration would have to be given to how flightless birds are released as their chances of survival will likely be greatly affected. Thus, it may be more appropriate to release flightless adults into a large predator-proof enclosure with food provision.

4.2.2 Required numbers of birds for release and timing

The impact of supplementing the population with juvenile birds was modelled, comparing the effect of releasing different numbers of birds over a constant number of years, and releasing the same number of birds over different time periods.

As discussed in Section 3.3.1, the model suggests that supplementing the Norwegian population for eight years with 10–50 birds per year would essentially provide a temporary, unsustained boost to the adult population (Figure 3-3) that would postpone extinction by approximately 10–20 years, depending on the number of birds released (Figure 3-4).

Although the duration of the boost to the population is greater when greater numbers of birds are released, there are quite strongly diminishing returns (Figure 3-3, Figure 3-4). Modelling indicates releasing 10 birds per year for eight years would shift the 50% probability of extinction by approximately 10 years, 20 birds per year by 13 years, 30 birds per year by 16 years, 40 birds per year by 18 years, and 50 birds per year by 19 years.

For a constant number of birds released, the duration over which the releases take place has relatively little effect on the outcome for the population (Figure 4-2, Figure 4-3): releasing 160 birds over eight years marginally prolongs the time to extinction, and increases the population at a given time point, compared with releasing 160 birds over four years.

As previously stated, care must be taken in interpreting these results given the many assumptions made in the population model (see Annex 5).

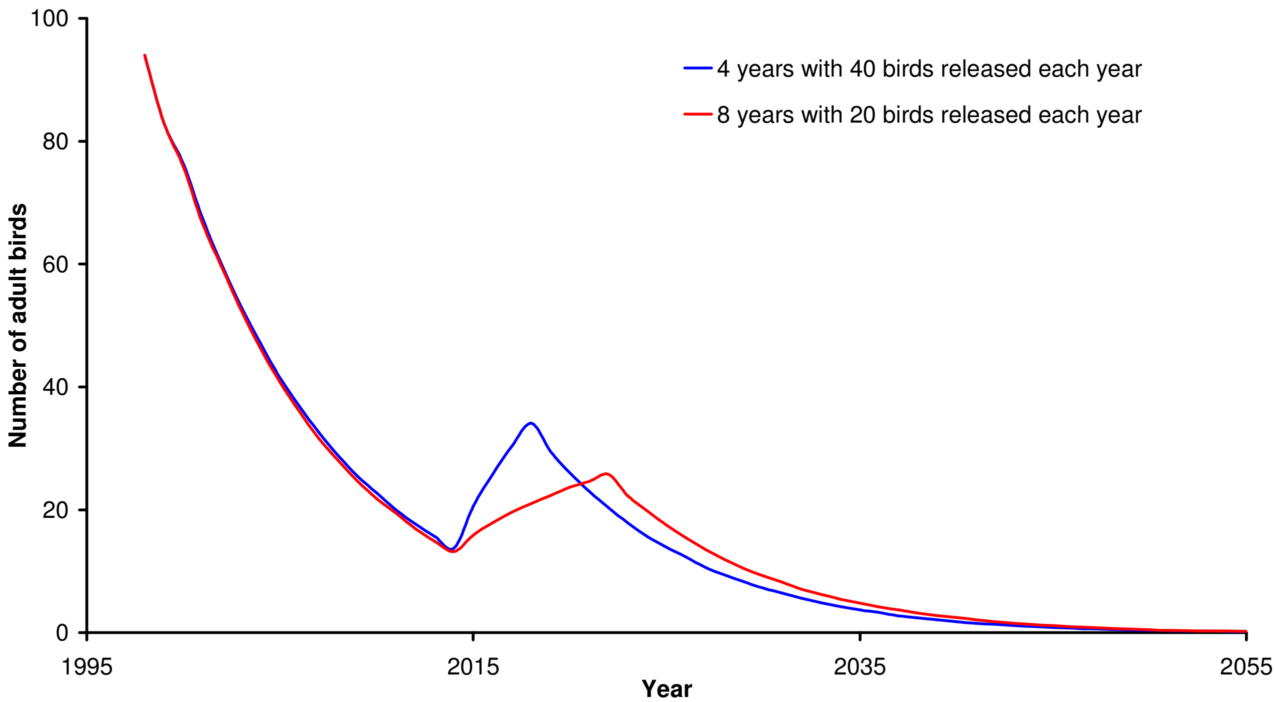

Figure 4-2. Number of adult birds as a function of duration of supplementation programme.

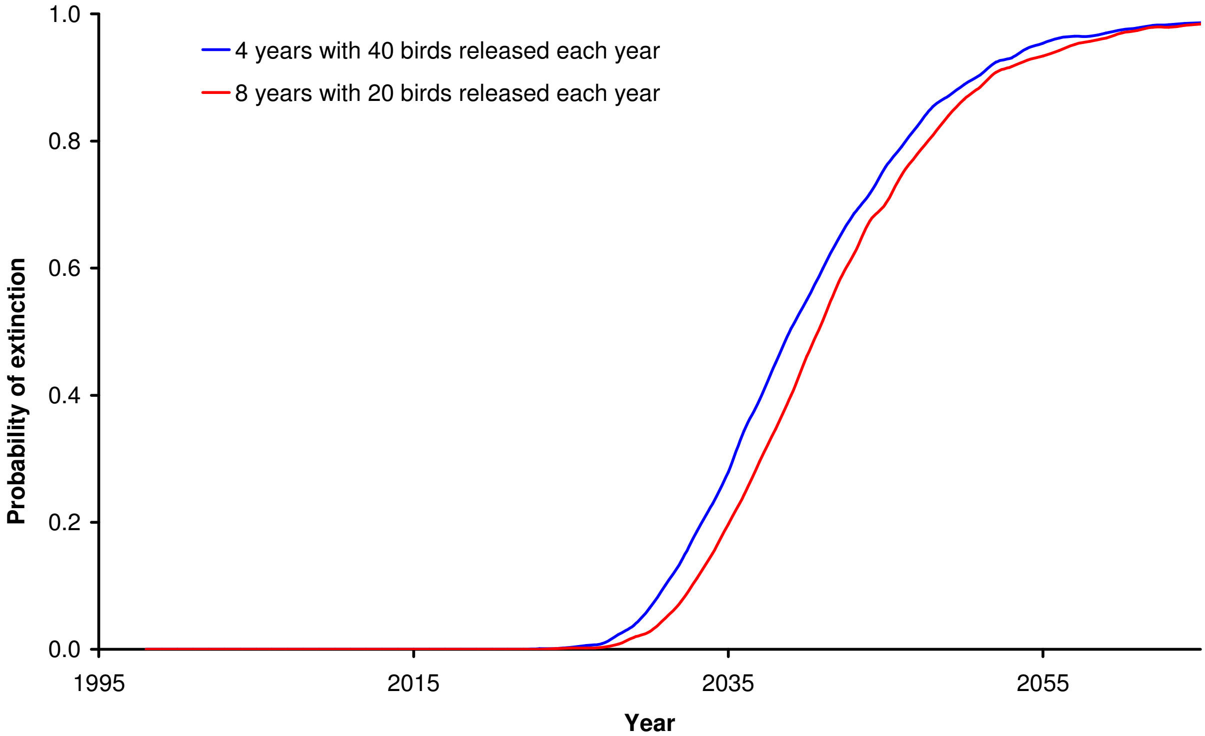

Figure 4-3. Probability of extinction as a function of duration of supplementation programme.

4.2.3 Potential source(s) of animals

Box 4-1. Recommendations from the IUCN *Guidelines for Re-introductions* (44) on source populations.

- The source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics.
- Removal of individuals must not endanger the captive stock population or the wild source population.
- Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.
- If captive stock is to be used, it must be from a population which has been soundly managed both demographically and genetically.

In the case of LWfG, there are a number of options for providing a source of suitable birds for release. The source population could be:

- A wild population other than the Fennoscandian population;
- An existing captive population;
- A new captive population established with birds from an existing captive population;
- A new captive population established with birds from a wild population; or
- A combination of the above.

4.2.3.1 Taxonomic status of potential wild source populations

For re-introduction/supplementation in Norway, it is necessary to determine if the Western Main and Eastern Main populations provide a possible source of individuals or whether these two populations are genetically distinct enough from the Norwegian population that using birds from these populations would either significantly alter the genetic composition of the existing Norwegian population through supplementation, or introduce a genetically distinct population through re-introduction.

Genetic studies have suggested that these populations are distinct (80, 81). The genetic divergence, however, is considered moderate. Robert Lacy, Population Geneticist/Conservation Biologist at the Chicago Zoological Society and Chair of the IUCN/SSC Conservation Breeding Specialist Group, made the following comments with regard to the genetic divergence between wild LWfG populations:

> "The combination of mtDNA and nuclear DNA data are now showing a clear pattern of moderate but not strong genetic divergence among wild populations of LWfG. The lack of sharp discontinuities in the allele frequencies and the estimated numbers of migrants that would result in the observed differences in allele frequencies indicate that there is (or recently has been) enough movement of LWfG between eastern, central, and western parts of the species range to have prevented evolutionary divergence and also to have prevented extreme loss of genetic diversity and accumulated inbreeding within any population segment. Thus, the populations do not appear to be genetically isolated to the extent that they would be considered to be evolutionarily significant units or subspecies. The populations may have diverged partially with respect to traits adapted to local conditions, but the genetic mixing makes it unlikely that important adaptive differences have become "fixed" in (*i.e.*, unique to) segments of the species range. Thus, dispersing or translocated individuals may have lower fitness because they may more often have genotypes best suited for a different habitat, but each population probably still contains the range of genetic variability necessary to adapt to local conditions" (see Section A4.3 for complete comments).

Based on these comments, it can be concluded that the Fennoscandian (represented by birds breeding in Norway), Western Main and Eastern Main populations are not so distinct that using birds from the two more eastern populations to supplement the Norwegian population or re-introduce birds to Norway (following extirpation) should be ruled out. A possible disadvantage of using birds from the more eastern populations may be that individuals are less well adapted to local conditions in Norway. As each population probably still contains the full range of LWfG genetic diversity, however, this should not be a major concern.

Robert Lacy also provided comments on potential problems related to inbreeding in the small Norwegian population:

> "The populations in Fennoscandia appear to have some reduction in genetic variation relative to more eastern populations, but there is not yet evidence of problems arising from inbreeding, and such problems would not be likely to accumulate rapidly, given the evidence for some genetic connections to the larger populations to the east. Thus, it does not seem to me that it is necessary at this time to release individuals in Fennoscandia in order to "rescue" the population from a lack of genetic diversity.
>
> Although I do not think that the evidence suggests a current need to provide genetic rescue of the Fennoscandian population of LWfG, I do not agree with the suggestion that restoration of genetic variation should wait until the Fennoscandian population is extinct. Release of birds from other sources (whether from captive flocks of documented origin or translocations from other wild populations) may shift allele frequencies, but given the genetic closeness of the LWfG populations in different regions it is hard to see how such releases could disrupt local adaptations to the extent that it would damage the prospects for the population. Instead, the effects of such releases would be to restore genetic variants that could have been lost from the small population and to reverse local inbreeding. Moreover, the extent of disruption of any local adaptations would be greatest if the remnant population is allowed to become nearly extinct before genetic management was

> resumed. Waiting until the local population is extinct would actually ensure that any local adaptations that did exist would be lost, instead of remaining within a more variable gene pool that could continue to adapt to local conditions" (see Section A4.3 for complete comments).

These observations suggest that using birds from the more genetically diverse Western Main or Eastern Main population may actually benefit the Norwegian population by restoring genetic variation lost in the small breeding population in Norway. Indeed, these observations suggest that the more eastern populations may actually provide a more desirable genetic source of birds than the Norwegian population itself.

In summary, birds originating from any one of the three LWfG populations – whether in captivity or in the wild – provide a potential, suitable source of animals for re-introduction or supplementation of the Norwegian population based on taxonomic status. While the Norwegian population may provide birds more adapted to local conditions, the Western Main and Eastern Main populations could provide a valuable boost to the genetic diversity of the Norwegian population.

The breeding range of the Eastern Main population is geographically furthest away from Norway, therefore more time would be required to transport birds between sites, which would increase the stress associated with transportation for the birds and would probably be logistically more complicated. For this reason, this feasibility study will not further address the option of using the Eastern Main population as a source population, but will instead consider only the Norwegian and Western Main populations.

4.2.3.2 Taxonomic status of existing captive populations

As described in Section A1.3, there are at least 41 captive populations of LWfG worldwide. With the exception of the birds recently acquired by Nordens Ark, Sweden, the origin and captive-breeding history of birds in these collections cannot be guaranteed. And because a genetic test sensitive enough to determine the exact hybridisation status of an individual LWfG does not currently exist, birds from these collections should not be released into the wild, as recommended by both the Convention on Migratory Species (CMS, see Section A4.1) and AEWA (see Section A4.2).

The captive population recently established at Nordens Ark was founded with birds captured as juveniles in Russia, west of the Urals. Thus, this population is assumed to be representative of the Western Main population. It is not possible to guarantee that these birds do not carry genes from other goose species as a result of hybridisation in the wild. This possibility, however, is considered to be highly unlikely considering the rarity of hybridisation events in the wild, especially among the relatively numerous Western Main population.

4.2.3.3 Feasibility of establishing a new captive source population

A new captive population could be established with birds either from an existing captive population, the Fennoscandian population breeding in Norway or the Western Main population.

The captive population at Nordens Ark offers a convenient source of birds of known taxonomic status. Establishing a new population with birds from Nordens Ark, would provide the benefit of spreading the existing captive resource between two sites which would reduce the chances of losing the entire captive population as a result of a catastrophic event at either site, *e.g.* as result of a disease outbreak. Thus, as well as providing a source of birds for release as part of the proposed programme in Norway, splitting this captive population could also be beneficial for the Nordens Ark breeding programme. The feasibility of using birds from Nordens Ark depends on cooperation with the Swedish EPA, which is responsible for the population. If the Nordens Ark population could not be used to establish a new captive population and a wild population was used, it would still be beneficial to both populations for there to be periodic exchanges of birds/eggs to increase genetic diversity as well as exchanges of information and expertise.

Establishing a captive population with birds from a wild population would require taking eggs, juveniles or adults from the donor population, transporting them to a breeding facility and providing the right conditions for breeding. Only when breeding is occurring regularly and the captive population can be considered sustainable in the long-term should birds be taken from the population for release, *i.e.* removing birds should not endanger the captive source population.

Sourcing eggs from the wild.

In order to establish a captive population with eggs from the wild, the primary requirement would be the ability to locate a sufficiently high number of nests with incubating females to ensure finding some nests in the appropriate stage of incubation. Eggs should be taken during the late stages of incubation, as eggs in the early stages are often negatively affected by being moved and often fail to hatch.

Finding nests of LWfG has proven to be very difficult both in Norway and Russia. LWfG nest amongst shrubs and highly camouflage their nests. Birds are often quite active during the early stages of incubation, but during the later stages (when eggs should be collected) birds are often inactive making the later stage nests particularly difficult, if not impossible, to find.

Sourcing juveniles from the wild

Broods of juveniles with their moulting parents are relatively easy to locate and can be readily caught on small lakes and rivers. Capturing and transporting juveniles from the Western Main population has been achieved by parties in Russia although it was said to be difficult due to the terrain and remote locations. During this operation, just two juveniles were taken from each brood to minimise impacts on the wild population and reduce the number of related juveniles brought into captivity.

Capturing and transporting juveniles from the Norwegian population would also be possible, if difficult, to achieve. There would be two main methods for capturing the birds: rounding-up families on the breeding grounds, and cannon-netting families at or near Valdak Marshes or another suitable staging site. If families could be located during moult, the chances of successfully catching the families would be high, as has been demonstrated for other geese in similar habitats. This method, however, could result in disturbance at the breeding grounds. Cannon-netting families at a staging site could result in the capture of a large number of birds, *e.g.* one capture attempt could potentially catch almost the entire breeding population (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009). It would, however, be very difficult to identify broods in a catch of multiple families.

Sourcing adults from the wild

Adult geese taken from the wild have been known to require up to approximately five years to achieve breeding status in captivity. LWfG caught as adults by Sir Peter Scott, however, were observed to breed in captivity just one year after capture.

Adult LWfG could be caught either by cannon-netting at staging sites or round-ups at moulting sites. The moulting sites of non-breeding LWfG are largely unknown, thus it may only be possible to round-up moulting families not large groups of non-breeding adults.

Summary

Table 4-4 presents a summary of the advantages and disadvantages associated with taking LWfG at different life stages – eggs, juveniles and adults – from the wild to establish a captive population.

Table 4-4. Summary of the advantages and disadvantages of taking Lesser White-fronted Geese at different life stages – eggs, juveniles and adults – from the wild to establish a captive population.

Life stage	Advantages	Disadvantages
Egg	▪ Relatively easy to collect and transport. ▪ Birds would hatch in captivity, so no time would be required to adapt to captivity. ▪ Generally considered to the most successful technique.	▪ Extremely difficult to locate, especially considering the need to locate eggs at the correct incubation stage. ▪ Would require hand-rearing.
Juvenile	▪ Possible to locate as part of families at the breeding grounds and staging sites. ▪ Possible to catch by round-up or cannon-netting. ▪ Birds will have spent relatively little time in the wild, so will likely adapt to captivity quickly.	▪ Would require some hand-rearing.
Adult	▪ Easy to locate, particularly at key staging sites. ▪ Possible to catch by round-up or cannon-netting, although round-up would need to occur during moult and moulting sites of non-breeding birds are largely unknown.	▪ Adult birds will likely experience a significant amount of stress in the process of the move to captivity, and may require as many as five years to adapt to captivity and breed. ▪ Taking adult geese generally has a much greater impact on the population than taking juveniles or eggs.

4.2.4 Captive-breeding techniques

There is no doubt that the captive-breeding techniques for LWfG are known and that LWfG breed readily in captivity under the right conditions. This has been demonstrated by numerous captive collections throughout the world, notably including the collections which supplied LWfG for releases during the 1980s and 1990s in Sweden and Finland: the Öster-Malma Hunting and Wildlife Management School in Nyköping, Sweden; Nordens Ark in Sweden; a farm on the isle of Hailuoto on the west coast of Finland; and Hämeenkoski farm in southern Finland.

While these techniques have largely not been documented, the expertise for breeding and rearing LWfG can easily be provided by organisations and/or individuals experienced in breeding LWfG and other geese, such as Nordens Ark, Sweden, and the Wildfowl & Wetlands Trust, UK. The IUCN/SSC Conservation Breeding Specialist Group may also be able to provide useful advice and/or contacts.

Figure 4-4 presents an indication of the numbers of birds that could potentially be available for release from a captive population, and compares the growth rate of captive populations founded with different numbers of birds:

- Blue population: a population founded with eight wild juveniles per year between 2010 and 2014, *i.e.* a population starting with zero birds.
- Red population: a population the size and age structure of the existing breeding population at Nordens Ark (founded with wild birds from Russia) with the addition of eight wild juveniles per year between 2010 and 2014, *i.e.* a population starting with approximately 60 birds.

The projection is based on productivity data for Hawaiian Geese *Branta sandvicensis* bred for release (50). Although these data are for a tropical *Branta* species, they reflect the productivity levels reported for LWfG bred at Hämeenkoski farm in Finland (48). The projection assumes the captive populations are managed under ideal conditions and are not constrained by the size of breeding facilities. Survival for juvenile birds (less than one year of age) was set at 90% and that for birds one to eight years of age was set at 100%. Although optimistic to expect a survival rate of 100%, this could be expected for a well-managed population. To account for birds dying of old age and reduced productivity in later years, birds older than eight are not included in the projection.

The projection indicates that the population founded entirely with new wild juveniles could potentially provide 20 birds for release annually by 2016, whereas the Nordens Ark population with the addition of juveniles from the wild could potentially provide 20 birds for release by 2012. The projection also indicates that a captive population would require approximately 10 years to reach a stable level of approximately 150 birds, providing approximately 80 juveniles for release each year.

The projection does not control for genetic factors. A captive population would require a demographic and genetic management plan.

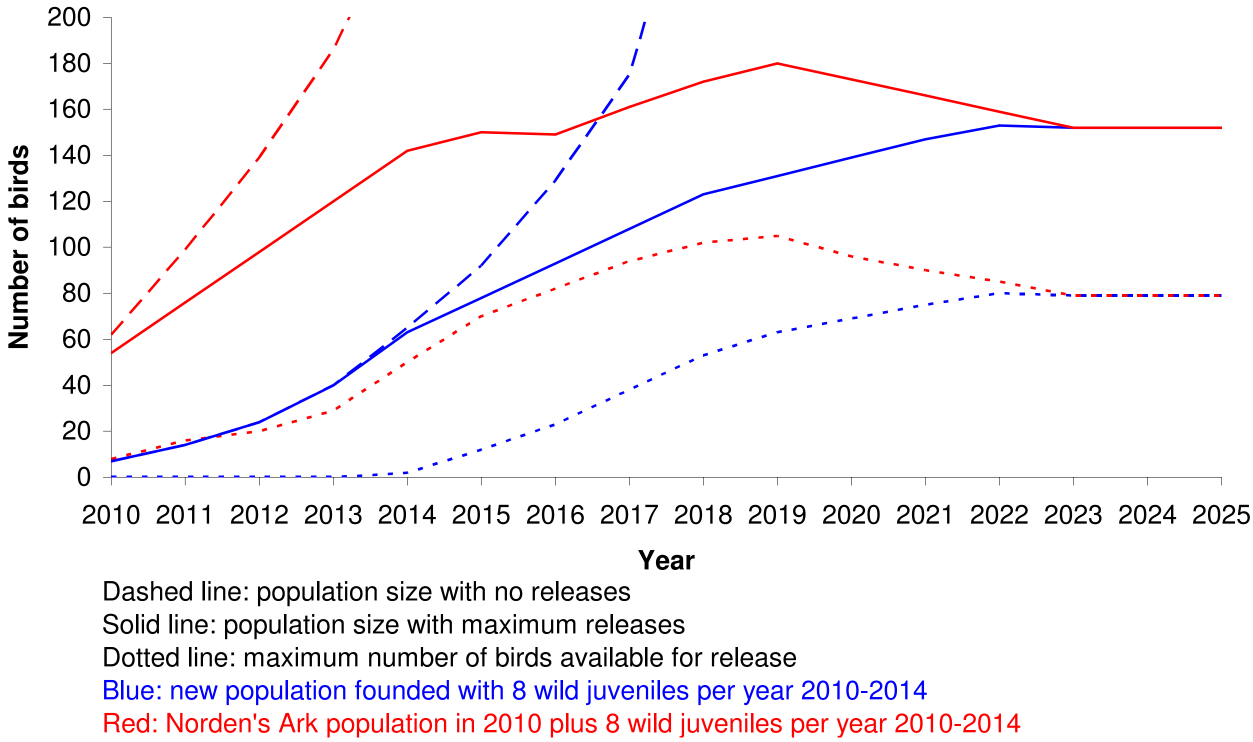

Figure 4-4. Projected numbers of birds in captive-breeding populations of Lesser White-fronted Geese held in optimum conditions founded either with new wild birds or with new wild birds and the existing Nordens Ark breeding population, and the number of juvenile birds that could be available for release per year from each population.

4.2.5 Release techniques

As outlined in Section 4.2.1, there are two main release techniques available for LWfG considering that LWfG is a migratory species and a re-introduction or supplementation programme would aim to use the traditional Fennoscandian LWfG migratory route:

- *Direct release (sometimes called 'direct autumn release')*. Birds are released into an existing population that the released birds would be expected to join and follow on migration.
- *Human-led release*. Birds are released and led on migration by humans, using for example ultra-light aircraft.

4.2.5.1 Direct release

Direct release has been used successfully for establishing migratory habit in released cranes but has met with varying success when used for geese. The technique was used for Aleutian Canada Geese in the 1970s and 1980s with little success (21, 86). Evidence suggests that at least a proportion of released geese successfully reached traditional wintering grounds, but almost all released geese did not return to the release site for breeding the following summer (21, 86). The failure to return to release sites may have occurred because captive or translocated geese were released with wild birds translocated from different breeding grounds. Thus, on spring migration, the released birds may have followed wild birds to alternative breeding grounds. Direct release was attempted as part of the LWfG re-introduction programme in Finland between 1987 and 1997. The birds were thought to have quickly dispersed from the release area, not joined a wild flock and not proceeded on migration (see 46). The reasons for this failure, however, are unknown, but it is suspected that there were only very small numbers of LWfG in Finland at that time and it is likely that the necessary contact between wild and released birds was not made.

4.2.5.2 Human-led release

Human-led release requires training birds to follow a particular object by imprinting birds on this object from hatching. This object can then be transported by humans with the trained birds following. For example, captive-bred Whooping Cranes *Grus americana* have been trained to follow a model of an adult Whooping Crane's head (31). The birds will follow the model even when it is presented to them from a four-wheel drive vehicle or ultra-light aircraft (31).

This technique was successfully used to lead LWfG on migration as part of the 1999 pilot project that led birds by ultra-light aircraft from Sweden to Germany (see 46). The use of ultra-light aircraft has also been used successfully to lead Canada Geese *Branta canadensis* and Trumpeter Swans *Cygnus buccinator* on migration, but with varying success. In 1993–1994, of 103 Canada Geese trained to follow an ultra-light aircraft on autumn migrations (680 or 1,320 km), 83 (81%) returned the following spring to near their release sites. Only two geese, however, were confirmed to complete the same autumn and spring migrations in the following year (31). Trumpeter Swans have proven more difficult to train than Canada Geese, but in 1997–1998, at least three of seven successfully followed an ultra-light on autumn migration and returned to the release sites (31).

One disadvantage of this technique compared with direct release is the inability to exactly replicate a traditional migratory route due to knowledge limitations (*e.g.* not all sites are known) and flight limitations (*e.g.* an ultra-light aircraft cannot fly the maximum distances flown by LWfG before needing to re-fuel). Thus, ultra-light aircraft (or other forms of human-led release) could only partially recreate the traditional migratory route.

A second disadvantage is cost. According to an external review of the Whooping Crane Eastern Partnership which aims to establish a migratory, self-sustaining population of Whooping Cranes in eastern North America, the costs of using the ultra-light migration technique is 100 times that of direct release (approximately 1,000,000 USD *vs.* 10,000 USD per year) (122).

4.2.5.3 Hard *vs.* soft release

Hard release involves releasing birds from captivity directly into the wild without an acclimatisation period. Conversely, soft release involves gradually releasing birds from captivity into the wild with an acclimitisation period to allow birds to adapt to wild conditions, *e.g.* releasing birds into a large enclosure at the release site, providing supplementary feeding after release.

With very few exceptions, soft release has produced better results than hard release in bird re-introductions/supplementations as demonstrated in the AEWA Review of Waterbird Re-establishments (54). Unsurprisingly, soft release is recommended in the IUCN *Guidelines for Re-introductions* (44).

4.2.5.4 Summary

Direct release and human-led release are both potential release techniques for LWfG in Norway, and both have shown at least some success for LWfG or similar species. While human-led release has been used successfully to migrate geese south in the autumn with most birds returning to release areas the following summer, using the technique to establish migratory habit (autumn and spring migration at least twice) is not well-documented. Establishing migratory habit in geese using direct release has also not been well demonstrated. Knowledge of the species and past experiences with both release techniques may allow for suitable techniques to be developed for LWfG. An experimental approach will be required.

All releases should be 'soft,' *i.e.* provide an acclimatisation period during which captive-bred LWfG can adapt to wild conditions and develop survival skills.

As outlined in Section 4.2.1.2, for any release of birds, it would not be possible to fully control post-release movements and there would be a risk of the birds using sites not traditionally used by the wild Norwegian population. This risk would exist both for a re-introduction/supplementation programme using human-led release and direct release.

4.2.6 Habitat availability

Box 4-2. Recommendations from the IUCN *Guidelines for Re-introductions* (44) on habitat.

- The release area should satisfy the habitat and landscape requirements of the species.
- The release area should have sufficient carrying capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.
- Original causes of decline should have been identified and eliminated or reduced to a sufficient level.
- A habitat restoration programme should be initiated before the re-introduction is carried out.
- Site should be within the historic range of the species. In some circumstances, a re-introduction or supplementation may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range.
- The re-introduction area should have assured, long-term protection (whether formal or otherwise).

For birds to have a chance of survival after release, there must be adequate habitat at their release site where the critical needs of the species can be met, and for a migratory species like LWfG there must also be suitable habitat available at staging and wintering sites. This habitat must not be saturated, should have assured long-term protection where possible and should be within the historic range of the species.

The Fennoscandian LWfG population historically bred widely in the sub-Arctic tundra and forest-tundra zones of northern Finland, Sweden and Norway, and north-western Russia (26, 69). The breeding area in Norway is now thought to comprise an approximately 600 km^2 (60,000 ha) core area in Finnmark (90). Large areas of the historic breeding grounds remain in suitable condition and are unsaturated by other species (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009). Likewise, the core breeding area is unsaturated (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009). Thus, the habitat in northern Norway is capable of supporting an increase in the LWfG breeding population. For conservation reasons, the exact location and protection status of the breeding grounds is unavailable. This information is known to DN and the Norwegian Ornithological Society, and should be factored into final decision-making.

Norwegian LWfG utilise a large number of sites in over eight countries on migration and during winter (45). While not all of these sites have been identified, the majority of the key sites along the western migration route are known. These sites have varying degrees of protection (see Table 4-5) and habitat quality. Again, these sites are not thought to be saturated and enough habitat is thought to be available to support an increase in the LWfG population (T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009). Problems may arise if the population increases to such a degree that LWfG spread beyond the boundaries of protected sites where they may be exposed to an increased threat of over-hunting and may use agricultural fields. A re-introduction/supplementation programme, however, would likely only serve to maintain the current population while causes of decline are addressed or speed up a recovery that would have occurred naturally.

Table 4-5 provides descriptions of the key known LWfG sites (breeding, wintering and staging) in terms of area, protection status and conservation issues, as far as can be determined from available information.

Table 4-5. Known key sites of Norwegian LWfG that would likely be used by released birds.

Site	Life cycle stage	Area (ha)	IBA	Protection status	Threats	Ref.
Core breeding area (mountain plateaus in Finnmark, Norway)	Breeding	60,000	No	N/A	Disturbance from off-road vehicles and other human activities may be a serious threat. Plans to build major power lines through the area have been suggested.	90, T Aarvak & IJ Øien *pers. comm.* 5–6 May 2009
Inner part of Porsangerfjord, including Valdak Marshes, Norway	Staging	2,000	Yes	National: partial International: partial 1620 ha covered by Nature Reserve, 1620ha covered by Ramsar Site.	All human traffic is prohibited in Valdak Marshes (part of the Nature Reserve, c.3.5–4.0 km²) between 1 May and 30 June.	11
Varangerfjord, Norway	Staging	60,000	Yes	National: low International: low 160 ha covered by Nature Reserve.	Planned oil production in the Barents Sea may have a negative impact on coastal and marine areas.	15
Tana River valley, Norway	Staging		No	Not protected.		46
Oulu region wetlands, including Bothnian Bay coast, Finland	Staging	81,781	Yes	National: low International: partial 764 ha covered by Private Protection Area, 128 ha covered by Protected Area on Private Land, 20,684 ha covered by six Special Protection Areas. Part of the area is a candidate Special Area of Conservation.	Human impact has detrimentally affected the area, resulting in nutrient pollution of water areas and overgrowth of wetlands and meadows. Active cultivation of farmland has benefited birds, creating large feeding grounds, especially for geese and cranes. Hunting pressure is very heavy in autumn, when hundreds or thousands of hunters gather here for wildfowling; hunting is prohibited in small parts of the area only.	14
Kanin Peninsula, Russia	Staging	500,000	Yes			12
Tahu & Haeska, Estonia	Staging					

Site	Life cycle stage	Area (ha)	IBA	Protection status	Threats	Ref.
Hortobágy, Hungary	Staging	136,300	Yes	National: high International: high Covered by National Park and numerous Landscape Protection Areas and Nature Conservation Areas. Partly covered by Special Protection Area, UNESCO World Heritage Site and Ramsar Site.		46
Lake Kerkini, Greece	Staging/ Wintering	12,000	Yes	National: none International: high 10,996 ha covered by Ramsar Site, 10,995 ha covered by Special Protection Area Part of the area is a candidate Special Area of Conservation.	The major threat is alteration of the dyke system to raise water-levels. Illegal land-reclamation, road construction, rubbish tipping and disturbance from fishing are also threats.	13
Evros Delta, Greece	Wintering	19,000	Yes	National: partial International: partial 4,600 ha covered by Wildlife Refuge, partly covered by Protected Area, 9,267 ha covered by Ramsar Site, 9,218 ha covered by Special Protection Area.	There are many threats to the site including the effects of drainage, groundwater abstraction and over-hunting.	10

4.2.7 Original causes of decline

For re-introduction or supplementation to result in a long-term increase in the population, the original causes of decline must have been eliminated or reduced to a sufficient level. Otherwise, in most cases, re-introduction/supplementation alone will not change the population trend; it will simply boost the number of individuals on a temporary basis.

As already outlined, the Fennoscandian LWfG population has undergone a rapid long-term decline, from an estimated 10,000 individuals in the early 20th century to an estimated 60–70 individuals in Norway (3) and approximately 100 individuals in the Swedish population (124) in 2008. The drivers of historic declines are not fully understood but are thought to be primarily habitat loss, land-use changes and human persecution (over-harvesting). According to data gathered at the Valdak Marshes staging site in Norway between 1993 and 2008, the Norwegian population is still declining and at an annual rate of more than 4%, with a total decrease of 50% during the 15 year monitoring period. The most important factors driving the recent declines are thought to be those factors that cause high mortality among fully grown birds, operating primarily on staging and wintering sites. Over-hunting is considered to be the primary threat and the single most important factor threatening the long-term survival of the population, despite LWfG being protected throughout most of its range.

While over-hunting is the only factor listed as critically important in the ISSAP, a number of other factors are also identified and rated according to their importance with the acknowledgement that there are fundamental knowledge gaps. As well as over-hunting, factors causing increased adult mortality are listed as poisoning (unknown importance) and human disturbance (medium importance). Factors causing reduced reproductive success are listed as human disturbance (possibly of local importance), predation by a variety of species, including Red Fox and American Mink *Mustela vison,* (possibly of local importance) and genetic impoverishment (low importance). Factors causing habitat loss and/or degradation are listed as agricultural intensification (formerly of high importance, now probably of low importance), construction of dams and other river regulation infrastructure and wetland drainage (probably of medium importance), climate change (unknown importance), over-grazing (local importance), land abandonment (locally high importance) and pollution (unknown importance). According to the ISSAP, there is also a potential risk of genetic introgression of DNA from other goose species (unspecified importance).

As discussed, conservation measures have been implemented at a number of sites along the migratory routes, including banning all goose hunting at Valdak Marshes and control of the Red Fox population in the breeding area (95). Some data gathered at sites other than Valdak Marshes (*e.g.* at the Hortobágy, Hungary) show the number of LWfG has remained stable or slightly increased during the years 2004 to 2008 (95). If the population is genuinely increasing, then it may be appropriate to assume that the causes of recent declines have been at least somewhat reduced. The Valdak Marshes data, however, are considered to be the best indicator of the size and trend of the population breeding in Norway and as these data show a continuing decline, it is likely that the key factors causing decline have yet to be adequately addressed.

Based on this information, it is highly unlikely that a supplementation programme for LWfG in Norway could alone result in a long-term increase in the population. The primary objective of the supplementation programme could, however, be to maintain the population and therefore preserve the traditional Fennoscandian migratory route while the causes of decline are being addressed. Thus, it is sometimes appropriate to release birds as part of a supplementation programme before the causes of decline have been eliminated or reduced to a level sufficient for natural recovery. This is only appropriate, however, if the supplementation is conducted as part of a wider conservation programme aimed at addressing the causes of decline.

If birds are to be released as part of a re-introduction programme (following extirpation), there should be clear evidence that the causes of decline have been eliminated or sufficiently reduced before releases occur.

4.2.8 Knowledge of the species' natural history

As outlined in the IUCN *Guidelines for Re-introductions* (44), it is necessary to review the information that is available on the natural history of the species in question to determine the species' critical needs, including habitat requirements, diet and feeding behaviour, breeding biology and behaviour, social behaviour, predators, disease and intraspecific variation and adaptations to local ecological conditions. For migratory species, it is important to consider the entire migratory route, not just proposed release areas. Accordingly, a review of the natural history of Fennoscandian LWfG, and particularly the population breeding in Norway, is presented in Annex 1 of this report.

The information provided in Annex 1 demonstrates that although there are knowledge gaps, a great deal of information is available on the natural history of Fennoscandian LWfG. The habitat requirements have been described at a number of key sites throughout the range. While the breeding biology and behaviour of LWfG has not been studied in great detail, the wealth of information that is available for other Arctic-breeding *Anser* species as well as captive LWfG can be interpreted for LWfG in the wild. The social behaviour and group composition of flocks is also well known for other Arctic-breeding *Anser* species and can be interpreted for LWfG. Food preferences at a number of key sites for LWfG have been established as well as feeding behaviour. There is also broad understanding of the predators and diseases which may affect LWfG, and monitoring, largely completed as part of the EU-LIFE Nature project, has provided good estimates of population size and locations of birds throughout the annual life cycle and migratory route, with some exceptions. Finally, some knowledge of the differences between the habitat requirements and diet preferences of the different LWfG populations allows for an understanding of intraspecific variations and adaptations to local conditions.

Table 4-6 lists the key knowledge gaps regarding the natural history of Fennoscandian LWfG, with emphasis on factors which may relate to the planning of a re-introduction/supplementation programme.

Table 4-6. Key knowledge gaps regarding the natural history of the Fennoscandian Lesser White-fronted Goose.

Category	Key knowledge gaps
Numbers, distribution and movement patterns (migratory habit)	▪ The locations of some key sites. ▪ The number of LWfG breeding on the Kola Peninsula, if any. ▪ The eastern migratory route through Russia and Kazakhstan, in terms of geography, timing, how many birds use the route and what factors contribute to route choice.
Habitat requirements	▪ Habitat requirements at unknown key sites and some known key sites. ▪ Habitat use, particularly the extent to which LWfG prefer natural habitats to agricultural fields and why this might be the case. ▪ The extent to which habitat could be artificially modified to attract LWfG, including for example by provision of food.
Diet and feeding	▪ Diet preferences at unknown key sites and some known key sites.
Breeding biology and behaviour	▪ The specific breeding behaviour of Fennoscandian LWfG, particularly how it might differ to that of other Arctic-breeding *Anser* species. For a supplementation programme, it would be particularly useful to know how readily a family would accept unrelated juveniles.
Social behaviour	▪ The timing and average age of pairing of Fennoscandian LWfG. ▪ The extent to which LWfG would be attracted to an area by the presence of other LWfG/decoys.
Predators	▪ The occurrence and effects of predation on the breeding grounds.
Diseases	▪ The occurrence and effects of disease.
Intraspecific variation and adaptations to local conditions	▪ The role and importance of genetics in adaptations to local conditions.

4.3 SOCIO-ECONOMIC, POLITICAL AND LEGAL CONSIDERATIONS

The socio-economic, political and legal aspects of a re-introduction/supplementation programme are critical to its implementation and outcomes. Many re-introduction/supplementation programmes overlook these factors and concentrate on biological and technical considerations, which has been suggested as the reason many programmes fail (78). Current species declines and extinction problems are often the result of socio-economic and political drivers. Thus it is vital that these factors are addressed by re-introduction/supplementation programmes.

A systematic examination of socio-economic, political and legal aspects is necessary to understand the values, attitudes, perceptions, and laws and regulations of the people, organisations and nations involved and that could potentially influence a re-introduction/supplementation programme.

Box 4-3. Recommendations from the IUCN *Guidelines for Re-introductions* (44) on socio-economic, political and legal considerations.

- Re-introductions are generally long-term projects that require the commitment of long-term financial and political support.
- Socio-economic studies should be made to assess impacts, costs and benefits of the re-introduction programme to local human populations.
- A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (*e.g.* over-hunting, over-collection, loss or alteration of habitat). The programme should be fully understood, accepted and supported by local communities.
- Where the security of the re-introduced population is at risk from human activities, measures should be taken to minimise these in the re-introduction area. If these measures are inadequate, the re-introduction should be abandoned or alternative release areas sought.
- The policy of the country to re-introductions and to the species concerned should be assessed. This might include checking existing provincial, national and international legislation and regulations, and provision of new measures and required permits as necessary.
- Re-introduction must take place with the **full permission and involvement of all relevant government agencies of the recipient or host country**. This is particularly important in re-introductions in border areas, or involving more than one state or when a re-introduced population can expand into other states, provinces or territories.
- If the species poses potential risk to life or property, these risks should be minimised and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered.
- In the case of migratory/mobile species, **provisions should be made for crossing of international/state boundaries**.

4.3.1 Local stakeholder support

Due to the fact that the Norwegian LWfG population breed in an isolated area of northern Norway, there are a relatively small number of stakeholders local to the breeding grounds. Local stakeholders include reindeer herders, hunters, fishermen, ecotourists, an ecotourism business and local communities and authorities in Finnmark (T Aarvak, JA Auran, T Bø, IJ Øien & Ø Størkersen *pers. comm.* 5–6 May 2009).

Gaining support and participation from local authorities in Finnmark is expected to be relatively easy considering the charismatic nature of LWfG. It may also be possible to gain support from hunters if restrictions on other species may potentially be lifted as a result of a significant increase in the LWfG population. It may be more difficult to gain support from local communities in Finnmark, reindeer herders and the ecotourism business operating in the breeding grounds. Some members of local communities in Finnmark may feel there are already too many protected sites in Finnmark, so if a re-introduction/supplementation programme required the protection of additional sites, there could be opposition in Finnmark. Reindeer herders may object to the installation of infrastructure along reindeer herding routes. A re-introduction/supplementation programme may require imposing movement restrictions on the ecotourism business which could cause problems both with the business and with the municipality of Alta which annually gives permission to the ecotourism business to use the breeding grounds (Ø Størkersen *pers. comm.* 5–6 May 2009).

Beyond the breeding grounds, consideration must be given to local stakeholders throughout the range. The stakeholders most likely not to give support to a re-introduction/supplementation programme are farmers whose agricultural fields may be affected by a significant increase in the LWfG population, although population modelling suggests this would not happen at least in the short-term.

Public awareness campaigns may be vital for gaining the necessary support. If such campaigns are run effectively and the re-introduction/supplementation programme is implemented in such a way that it is sympathetic to local stakeholders, there is little reason to believe that necessary support could not be gained.

4.3.2 Political support

DN is focussed on species conservation, has recently established a new threatened species unit and considers LWfG to be a key species for conservation (JA Auran, T Bø & Ø Størkersen *pers. comm.* 5–6 May 2009). Accordingly, there would likely be strong political support for an LWfG re-introduction/ supplementation programme in Norway using traditional migration routes.

Political support would probably also be provided by other members of the RECAP committee, including the governments of Sweden and Finland and can probably be gained from other key AEWA Range States, including Hungary and Estonia. Support should also be sought from non-AEWA Range States, including Kazakhstan, Russia and Greece.

The CMS Scientific Council has expressed concerns over using non-traditional migratory routes and non-traditional wintering sites, as reflected in Annex 4, and political support would likely be difficult to gain for such a programme from some Parties to CMS. As DN has determined that a re-introduction or supplementation in Norway would aim to use the traditional Fennoscandian LWfG migratory route, these concerns should not present a problem.

4.3.3 Organisational support

Both non-governmental and government organisations are likely to be supportive if the re-introduction/supplementation programme is planned and implemented according to the IUCN *Guidelines for Re-introductions* (44) and consultations are sought with relevant organisations when appropriate.

Organisations whose support may be particularly helpful include the Norwegian Ornithological Society; WWF Finland; Metsähallitus, Natural Heritage Services, Ostrobothnia, Finland; Metsähallitus, Natural Heritage Services, Lapland, Finland; BirdLife Finland; Finnish Environment Institute; State Nature

Conservation Center, Matsalu National Park, Estonia; Directorate of Hortobágy National Park, Hungary; and Hellenic Ornithological Society, Greece.

Other organisations whose support may be helpful, particularly regarding captive-breeding and release techniques, include Nordens Ark, the Wildfowl & Wetlands Trust, the Friends of the Lesser White-fronted Goose, Aktion Zwerggans, IUCN Conservation Breeding and Re-introduction Specialist Groups as well as many others. Past disagreements may hinder working with the Friends of the Lesser White-fronted Goose and Aktion Zwerggans.

Support will likely be greater for a re-introduction or supplementation programme that uses traditional migratory routes and occurs while LWfG are extant in Norway. The Norwegian Ornithological Society, for example, has expressed concerns about re-introduction after the species has become extinct in Norway and the traditional migratory route has been lost.

4.3.4 Laws and regulations

DN is the national wildlife authority in Norway and has the power to draft changes to laws and policies if required. So long as a re-introduction/supplementation programme is clearly justified and implemented according to the IUCN *Guidelines for Re-introductions* (44) it is unlikely such a programme could not conform to laws and regulations in Norway (JA Auran, T Bø & Ø Størkersen *pers. comm.* 5–6 May 2009).

If birds were to be released in a country other than Norway, the laws and regulations of that country would need to be considered.

A programme using traditional migratory routes would likely be more in line with existing laws and regulations than a programme using non-traditional migratory routes, because countries often have strict regulations regarding introductions of species not normally occurring within their borders.

4.4 RESOURCE CONSIDERATIONS

4.4.1 Financial resources

The total costs of a re-introduction/supplementation programme for LWfG in Norway cannot be determined at this point, considering the complexity of the programme and the range of available options. It is, however, likely that costs would be significant and long-term. For example, it will probably be necessary to build both breeding and release facilities, fund the salaries of a number of staff in these facilities and fund a long-term monitoring programme for released birds.

Table 4-7 provides an example of some of the costs associated with a programme that requires the construction of breeding and release facilities, involves releasing birds using the direct release technique over a period of 10 years, and maintaining a captive population for 20 years. These preliminary figures suggest that expenses for such a programme would be approximately 11,580,000 NOK without staff costs. It is estimated that three full-time staff members and six seasonal staff members would be required for between 10 and 20 years. Using annual staff salaries of 450,000 NOK for project management and 350,000 NOK for other staff, this adds 37,000,000 NOK staff costs, giving an overall project total of 48,580,000 NOK (7,504,592 USD). This total does not include costs associated with acquiring birds or eggs to found a captive population.

These figures are based on approximate costs for the UK. They have not been verified for Norway, and actual costs may therefore be quite different. The figures presented in Table 4-7 should not be used as a guide for future planning, but simply as an indication of the costs to consider in assessing the feasibility of such a programme.

Table 4-7. Example of costs associated with a supplementation programme that would require the construction of breeding and release facilities and involve releasing birds using the direct release technique over a period of 10 years with a captive population maintained for 20 years*.

Costs	Overall project	Breeding	Release	Post-release
Set-up costs				
Planning		90,000 NOK	90,000 NOK	90,000 NOK
Build		2,000,000 NOK	500,000 NOK	
Equipment		90,000 NOK	50,000 NOK	500,000 NOK
Disease risk assessment	100,000 NOK			
Demographic and genetic management plan	90,000 NOK			
Ongoing costs				
Maintenance		90,000 NOK (x 20 yrs)	50,000 NOK (x 10 yrs)	
Operations		90,000 NOK (x 20 yrs)	250,000 NOK (x 10 yrs)	90,000 NOK (x 10 yrs)
Staff	1 full-time (x 20 yrs)	2 full-time plus 2 seasonal (x 20yrs)	2 seasonal (x 10 yrs)	2 seasonal (x 10 yrs)
Miscellaneous costs				
External consultants	300,000 NOK			
CEPA	180,000 NOK			
Total	**670,000 NOK (102,545 USD) plus staff costs**	**5,780,000 NOK (884,644 USD) plus staff costs**	**3,640,000 NOK (557,099 USD) plus staff costs**	**1,490,000 NOK (227,874 USD) plus staff costs**

* Although presented in Norwegian Kroner with totals also in US Dollars, these figures are based on estimates for the UK and have not been verified for Norway. Figures were converted to Norwegian Kroner and US Dollars with an exchange rate of 0.107 GBP to 1.000 NOK to 0.153 USD.

DN would likely be the primary funding body and provide funding for a minimum of five years. As with any re-introduction/supplementation programme it would be beneficial to seek partnerships with a number of other organisations. As well as increasing funding opportunities, such collaboration would bring a number of other benefits, including enhanced expertise, transfer of skills, shared responsibility, and shared accountability. Administrative discontinuity is a common problem for re-introduction/ supplementation programmes, so it would be highly beneficial for more than one organisation to be committed to the programme in case the priorities or financial situation of any one organisation changes and the re-introduction/supplementation programme is no longer supported.

4.4.2 Technical resources

Technical expertise would be required for many aspects of the programme, particularly captive-breeding, releasing, monitoring of released birds and planning. For best results, a project team should be multi-disciplinary containing a wide range of expertise and experience.

Captive-breeding expertise exists in the organisations and individuals with experience breeding LWfG and other similar goose species. Nordens Ark and the Wildfowl & Wetlands Trust are obvious sources of this expertise, but many other organisations and individuals will also be able to contribute. Pentti and Kaija Alho who run the LWfG 'farm' located in Hämeenkoski, Southern Finland have considerable experience breeding LWfG.

Release expertise exists with the organisations and individuals with direct experience of releasing migratory birds that require migratory habit to be taught. Although Aleutian Canada Goose release projects occurred between 20 and 40 years ago, it may be possible to contact some of the individuals involved in those projects. The International Crane Foundation could provide significant expertise regarding the direct release technique as well as human-led release techniques. Aktion Zwerggans has expertise in using the ultra-light aircraft technique for LWfG. General release expertise could also be provided by various other organisations with experience re-introducing and/or supplementing birds of other species. As release will likely occur in remote Arctic areas, expertise with regard to operating in these areas will be required. The Norwegian Ornithological Society is well placed to provide this expertise.

The Norwegian Ornithological Society is also well placed to provide the technical expertise required for appropriate monitoring of released birds as well as designing a suitable monitoring programme.

Planning should be performed by individuals with direct technical and scientific knowledge relevant to the supplementation programme. Thus, the organisations and individuals with expertise in the various project areas should be involved in the planning process.

Additional expertise may be required for other activities, such as wild bird capture, behavioural training, public awareness activities, and international cooperation. Again this expertise can be found in a number of organisations with relevant experience.

4.5 TIMESCALE AND URGENCY

Timescale is an important factor to consider in assessing feasibility as it may have profound implications for many aspects of the programme.

As discussed, the Norwegian LWfG population is facing an immediate risk of extinction, and modelling has indicated that the probability of extinction is 50% by 2018–2027 and 90% by 2030–2040 (Figure 3-2). In addition, the small size of the population makes it vulnerable to deleterious genetic and ecological effects and environmental catastrophes.

For a supplementation that is intended to delay extinction risk by 10–20 years, the population would not only have to be extant in Norway but present in sufficient numbers for the direct release technique to be viable. The number of wild birds required to ensure at least some chance of success for the direct release technique is unknown, but it is estimated that the current size of the wild population is near the lower limit. The population would need to be large enough to allow for the capture of approximately 10 adult birds or 2–3 family groups to mix with captive birds immediately prior to release, or a reasonable concentration of birds (a flock of approximately 20 individuals) at a staging site where captive birds could be released.

Thus, if DN chooses to proceed with a supplementation programme, the programme should aim to release birds with utmost urgency. While good planning is an essential part of any supplementation programme, delays in planning should not delay the implementation of required immediate actions. Planning should be performed by individuals with direct technical and scientific knowledge relevant to a supplementation programme for LWfG in Norway, and should be flexible. Any delays in planning or implementation would make supplementation more difficult in the long-term.

Establishing a captive-breeding population that is capable of supplying birds for release could take a number of years depending on how the population is founded. Section 4.2.4 indicates that it may be possible to produce 20 birds for release by as early as 2012 if the Nordens Ark population can be used as a source population with further additions of wild birds from Russia. If a new population is required and only approximately eight birds per year can be obtained from Russia, 20 birds for release would likely not be available until 2016. Despite best efforts and substantial resources, the Norwegian population may decline to a level incapable of supporting a supplementation by the time a captive-breeding population can supply birds for release. Such a captive population could, however, serve as a source of birds for a future re-introduction, so may not be a waste of effort or resources.

To avoid set backs, it is vital that all available measures are taken to protect captive populations from factors which could result in catastrophic loss or render birds unsuitable for release, *e.g.* a disease outbreak. Strict biosecurity and predator-proofing measures should be in place at breeding facilities, and consideration should be given to splitting a captive population between more than one facility to reduce chances of losing the entire population as the result of a catastrophic event at any one facility. Past experience provides important lessons: avian tuberculosis incursion into the Hailuoto breeding facility in Finland resulted in the loss of many birds and, ultimately, the closure of the facility (49).

4.6 SUMMARY

Is a suitable source of animals available? The Norwegian population and the Western Main population provide sources of genetically suitable birds. The Norwegian population would provide birds potentially better adapted to local conditions, but the Western Main population would provide birds with greater genetic variability. Captive source populations could be established from either of these wild populations. The captive population established recently at Nordens Ark, Sweden, also represents a suitable source of animals, either for release into Norway or for establishing a new captive source population. Obtaining birds from the Western Main population and Nordens Ark will depend on the cooperation of authorities in Russia and the Swedish EPA, respectively.

If using captive animals, are captive-breeding techniques for the species known? Captive-breeding techniques for LWfG are well-established, and LWfG will breed readily in captivity under the right conditions. Whilst these techniques are largely not documented, the expertise for breeding and rearing LWfG can be readily provided by organisations and individuals experienced in breeding LWfG. It is estimated that 20 captive-bred birds for release could be available as soon as the summer of 2012 if the Nordens Ark population with the addition of birds from the wild are used as a source population.

Are release techniques for the species known? Direct release and human-led release are both potential release techniques for LWfG in Norway, and both have shown at least some success for LWfG or similar species. While human-led release has been used successfully to migrate geese south in the autumn with most birds returning to release areas the following summer, using the technique to establish migratory habit (autumn and spring migration at least twice) is not well-documented. Establishing migratory habit in geese using direct release has also not been well demonstrated. Knowledge of the species and past experiences with both release techniques may allow for suitable techniques to be developed for LWfG. An experimental approach may be required. For any release of LWfG, it would not be possible to fully control post-release movements and there would be a risk of the birds using sites not traditionally used by the wild Norwegian population. This risk would exist both for a re-introduction/supplementation programme using human-led release and direct release.

Is a suitable environment available in which to release the animals? Suitable habitat is available at breeding, staging and wintering sites, and this habitat is not considered to be saturated. Key sites have varying degrees of protection and are vulnerable to various threats. Habitat restoration and protection measures at these sites may be required as part of a re-introduction/supplementation programme.

Have the original causes of decline been sufficiently reduced or eliminated? Data suggest that the small breeding population in Norway is continuing to decline and therefore it cannot be concluded that the causes of decline have been eliminated or reduced to a level sufficient for natural recovery. Despite this, a supplementation may still be appropriate, as a means of maintaining the population while the causes of decline are addressed. Should the population be extirpated from Norway, however, there should be clear evidence that the causes of decline have been eliminated or sufficiently reduced before releases occur.

Is there sufficient knowledge of the species' natural history? While there are some knowledge gaps regarding the natural history of LWfG, a great deal is known about the species and in particular the Fennoscandian population. The critical needs of the species are known.

Does stakeholder support exist? Support could likely be gained from local authorities in Norway, hunters, non-governmental conservation organisations and government agencies assuming the re-introduction/supplementation programme is conducted in line with the IUCN *Guidelines for Re-introductions* (44) and effective public awareness campaigns are conducted. Support may be more difficult to gain from local stakeholders who would be impacted by restrictions in the breeding grounds, including reindeer herders and local communities in Finnmark.

Will the programme conform to laws and regulations? If birds are released in Norway, the programme would be in line with national laws and regulations. Problems may arise with municipal laws and regulations, but DN is confident such problems could be overcome. If birds are to be released outside Norway, the laws and regulations of the country in question would need to be considered.

Are sufficient financial resources available? The costs of a re-introduction/supplementation programme for LWfG in Norway cannot be determined at this point, considering the complexity of the programme and the range of options which exist. It is, however, probable that costs would be significant and long-term. A preliminary estimation of costs based on UK prices suggests that a 20 year programme could cost approximately 48,580,000 NOK (7,504,592 USD). DN would likely be the primary funding body and could provide funding for a minimum of five years. Collaboration with other organisations should be sought to increase funding opportunities and provide a range of other benefits.

Are sufficient technical resources available? Technical expertise would be required for many aspects of the programme, particularly planning, captive-breeding, releasing and monitoring of released birds. The required technical expertise exists between a number of organisations, and could be obtained through collaborations with relevant organisations both inside and outside of Norway. The expertise of the Norwegian Ornithological Society would be particularly important to programme implementation.

Timescale and urgency. Considering the small size of the remaining population and the high risk of extinction within the next 10–20 years, the planning of a supplementation programme and establishment of a captive-breeding population would need to begin immediately with releases as soon as appropriate. If releases cannot occur before the Norwegian population becomes too small to provide an adequate number of wild birds for released birds to mix with and follow on migration, the direct release method would not be appropriate as the chances of success would be minimal. Human-led release would not be constrained by the size of the Norwegian population, but would be more appropriate as a technique for re-introducing the species to Norway rather than supplementing the existing population. Re-introduction should not begin until there is confidence that the original causes of decline have been eliminated or reduced to a sufficient level to allow for natural growth of the re-introduced population.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 JUSTIFICATION

The conservation status of the Norwegian LWfG population, and the lack of significant recovery despite conservation measures, demonstrates the need for supplementation. This view is further supported by the results of population modelling. Indeed, supplementation should be considered a key conservation need to ensure that the conservation efforts in recent years at sites along the migratory routes are not wasted. Should the population be extirpated from Norway there would be a need for re-introduction.

Available information suggests that the potential negative impacts of such a programme would be minimal and would be outweighed by the potential benefits. The proposed aim, namely to improve the conservation status of the wild Fennoscandian LWfG population by enhancing the long-term survival of LWfG in Norway using traditional migratory routes, would be in line with the IUCN *Guidelines for Re-introductions* (44) as well as the goals of the ISSAP and Norway's National Action Plan.

A supplementation/re-introduction programme for LWfG in Norway fulfils the key justification criteria identified in this report (Table 5-1) with the exception of cost-effectiveness. Cost-effectiveness depends on the available resources and priorities of DN and therefore could not be fully-assessed as part of this report.

Table 5-1. Assessment of the key justification criteria for a supplementation/re-introduction of Lesser White-fronted Geese in Norway using the population's traditional migratory routes.

Key justification criteria	Answer
Conservation needs:	
▪ Is the species/population extinct or facing a high risk of extinction in the wild? Or has the species/population undergone a significant decline and is currently in a depleted state, either in terms of distribution or number?	Yes
▪ Are existing conservation measures insufficient for recovery within a reasonable timescale?	Yes
Benefits, costs and impacts	
▪ Would the programme's benefits outweigh potential negative impacts?	Yes
▪ Would the programme be cost-effective?	TBD*
Policy requirements:	
▪ Would the programme's aims and objectives be in line with existing, relevant conservation plans and policies, particularly the IUCN *Guidelines for Re-introductions* (44) and any existing Action Plans?	Yes

* Cost-effectiveness depends on the available resources and priorities of the Directorate for Nature Management, Norway.

Based on the above assessment, a re-introduction/supplementation of LWfG in Norway using traditional migratory routes can be considered justified assuming the programme is deemed cost-effective. This conclusion is based on available information and current circumstances. The justification assessment should be reviewed if additional information becomes available or circumstances change.

Any supplementation/re-introduction should only be undertaken as part of a wider conservation programme for LWfG, as only with the additional measures of such a programme will long-term survival of the population be achieved. Given that conservation measures are already being undertaken in parts of the range, a supplementation/re-introduction could be considered as necessary to ensure that those efforts in recent years have not been in vain.

The final decision with regard to justification will depend on the conclusions of DN with input as appropriate from other members of the RECAP committee. If allocating funds to a re-introduction/supplementation programme for LWfG would jeopardize other conservation programmes either for LWfG or other species, the potential impacts of this must be factored into decision-making.

5.2 FEASIBILITY

The feasibility of both supplementing and re-introducing LWfG within the range of the existing Norwegian population using traditional migratory routes was assessed by considering biological, environmental and technical factors; socioeconomic, political and legal factors; resource requirements; and time constraints.

Obtaining a suitable source of birds to release will depend on the cooperation of authorities in Russia and/or the Swedish EPA. Available information suggests that a captive source population is preferable to a wild source population considering the logistical difficulties of moving birds from the wild in Russia to suitable release sites. Captive-breeding techniques for LWfG are well-established and it may be possible to provide 20 birds for release as soon as the summer of 2012 if the Nordens Ark population with the addition of birds from the wild are used as a source population. Release techniques for the species are known but it is unclear how successful the techniques would be for LWfG in Norway, particularly with regard to establishing migratory habit in released birds such that the birds use the traditional migratory routes.

The critical needs of the species are known, and suitable habitat for released birds is available at known breeding, staging and wintering sites. These sites, however, have varying degrees of protection and are vulnerable to various threats. Available evidence suggests the original causes of decline at these sites have not been eliminated and have probably not been reduced to a level sufficient to allow for significant population increase.

It will likely be possible to gain stakeholder support for both a supplementation and a re-introduction if the programme is conducted in line with the IUCN *Guidelines for Re-introductions* (44) and effective public awareness campaigns are conducted. Possible exceptions could include stakeholders negatively impacted by restrictions at or near the existing breeding grounds. Available information suggests a programme would conform to laws and regulations in Norway, but if birds are to be released outside Norway, the laws and regulations of the country in question would need to be considered.

Significant financial resources would be required for a supplementation or re-introduction programme. A preliminary estimation of costs based on UK prices suggests that a 20 year programme could cost approximately 48,580,000 NOK (7,504,592 USD). Whilst DN is likely to be the primary funding body, consideration should be given to forming partnerships with other organisations to increase funding opportunities and reduce the risk of administrative discontinuity. The technical resources required could be provided by various organisations with expertise and experience in the relevant project areas.

Based on available information, the key feasibility criteria identified in this report have been scored from zero to five, separately for a supplementation (Table 5-2) and a re-introduction (Table 5-3). A score of five indicates complete fulfilment of a criterion, four indicates sufficient fulfilment, three indicates some fulfilment but that there may be significant associated difficulties. A score below three indicates insufficient fulfilment. For a programme to be considered feasible, it is suggested that each criterion should achieve a score of at least four. A programme scoring three or above on all criteria may be considered feasible assuming the identified problems can be overcome, and a programme scoring two or below on any criterion should not be considered feasible without further evidence. Although subjective, these scores can be used to aid decision-making in determining to what degree a supplementation/re-introduction programme is feasible and which areas, if any, require further attention.

Table 5-2. Assessment of the key feasibility criteria for a supplementation of Lesser White-fronted Geese in Norway using the traditional Fennoscandian migration route.

Key feasibility criteria	Score (/5)	Explanation
BIOLOGICAL, ENVIRONMENTAL AND TECHNICAL CONSIDERATIONS:		
▪ Is a suitable source of animals available?	3	Suitable birds exist but have not yet been secured. It is possible that a captive-breeding population capable of supplying birds for release could be established, but sufficient time may not be available considering a supplementation would have to take place before the Norwegian population reaches a critically low level.
▪ If using captive animals, are captive-breeding techniques for the species known?	5	Captive-breeding techniques are well-established.
▪ Are release techniques for the species known?	3	The direct release technique has been demonstrated successfully for cranes, but has had varying success for geese. An experimental approach may be required.
▪ Is suitable environment available in which to release the animals?	4	Suitable unsaturated habitat is available but key sites have varying degrees of protection and are vulnerable to various threats.
▪ Have the original causes of decline been eliminated or sufficiently reduced?	Not applicable*	A supplementation would likely serve to maintain the population while the causes of decline are addressed.
▪ Is there sufficient knowledge of the species' natural history?	4	Knowledge is probably sufficient. More information regarding social behaviour and methods to lure LWfG to particular areas would be beneficial.
SOCIO-ECONOMIC, POLITICAL AND LEGAL CONSIDERATIONS:		
▪ Does stakeholder support exist?	4	It is likely that support could be gained from the majority of stakeholders, but there may be some opposition among stakeholders in Finnmark.
▪ Will the programme conform to relevant laws and regulations?	5	The Directorate for Nature Management, Norway, would ensure compliance with laws and regulations in Norway. Problems are not anticipated in other range states.
RESOURCE CONSIDERATIONS:		
▪ Are sufficient financial resources available?	4	The Directorate for Nature Management, Norway, likely has funding for the programme depending on project design, but it would be beneficial to secure funding from other agencies/organisations to spread the risk of administrative discontinuity.
▪ Are sufficient technical resources available?	4	Technical resources exist but the involvement of relevant organisations has not yet been secured.

* Not applicable on the basis that the purpose of a supplementation of LWfG would be to maintain the population while the original causes of decline are addressed.

According to the above assessment, a supplementation programme for LWfG in Norway sufficiently fulfils seven of the ten feasibility criteria. The particularly problematic areas (criteria scoring three or less) for a supplementation of LWfG in Norway are the availability of source animals and knowledge of a suitable release technique. Both criteria score three, which does not indicate that supplementation should be considered unfeasible, but rather that significant difficulties may arise. Namely, it may be difficult to obtain a suitable number of birds for release given the limited amount of time available and, whilst direct release is a potential release technique, methods for applying this technique to LWfG in Norway are yet to be established. The criterion concerning the elimination or reduction of the original causes of decline is deemed not applicable in this assessment on the basis that the purpose of a supplementation of LWfG would be to maintain the population while the original causes of decline are addressed.

Table 5-3. Assessment of the key feasibility criteria for a re-introduction of Lesser White-fronted Geese in Norway using the traditional Fennoscandian migration route.

Key feasibility question	Score (/5)	Explanation
BIOLOGICAL, ENVIRONMENTAL AND TECHNICAL CONSIDERATIONS:		
▪ Is a suitable source of animals available?	4	Suitable birds exist but have not yet been secured. It is possible that a captive-breeding population capable of supplying birds for release could be established, and sufficient time would be available considering a re-introduction would likely only take place following extinction of the wild population.
▪ If using captive animals, are captive-breeding techniques for the species known?	5	Captive-breeding techniques are well-established.
▪ Are release techniques for the species known?	3	Human-led release techniques have been used successfully to lead LWfG and other migratory species on autumn migration, but it is unknown if this technique can effectively establish migratory habit (autumn and spring migration at least twice) in captive-bred LWfG.
▪ Is a suitable environment available in which to release the animals?	4	Suitable unsaturated habitat is available but key sites have varying degrees of protection and are vulnerable to various threats.
▪ Have the original causes of decline been eliminated or sufficiently reduced?	2	Although data are inconclusive, the population still appears to be declining suggesting the original causes of decline have not been sufficiently reduced. It is not yet clear if eliminating or sufficiently reducing the causes of decline is possible in the near future.
▪ Is there sufficient knowledge of the species' natural history?	4	Knowledge is probably sufficient. More information regarding migration and the locations of unknown staging and wintering sites would be beneficial.
SOCIO-ECONOMIC, POLITICAL AND LEGAL CONSIDERATIONS:		
▪ Does stakeholder support exist?	3	It is likely that support could be gained

Key feasibility question	Score (/5)	Explanation
		from the majority of stakeholders, but there may be some opposition among stakeholders in Finnmark and stakeholders who would consider a re-introduced population to be 'artificial' if human-led release was used to establish migratory habit.
▪ Will the programme conform to relevant laws and regulations?	5	The Directorate for Nature Management, Norway, would ensure compliance with laws and regulations in Norway. Problems would also not be anticipated in other range states.
RESOURCE CONSIDERATIONS:		
▪ Are sufficient financial resources available?	4	The Directorate for Nature Management, Norway, has funding for the project depending on programme design, but it would be beneficial to secure funding from other agencies/organisations to spread the risk administrative discontinuity.
▪ Are sufficient technical resources available?	4	Technical resources exist but the involvement of relevant organisations has not yet been secured.

According to the above assessment, a re-introduction programme for LWfG in Norway sufficiently fulfils seven of the ten feasibility criteria. The particularly problematic areas (criteria scoring three or less) for a re-introduction of LWfG in Norway are the elimination of or sufficient reduction in the causes of decline, knowledge of suitable release technique and stakeholder support. A score of two for causes of decline indicates that this factor would currently critically limit the success of a re-introduction programme. Before a re-introduction programme can be considered feasible, further evidence should be provided to indicate that the causes of decline have been sufficiently reduced. Scores of three for both knowledge of release technique and stakeholder support indicate there may be significant difficulties associated with addressing these factors. It may be difficult to gain support for a re-introduction that would require human-led release to establish migratory habit, and while human-led release is likely a suitable release technique, the technique has had limited success establishing migratory habit in geese and is unproven for LWfG. The technique has been used successfully to lead LWfG on autumn migration, but it has not been shown to establish migratory habit (autumn and spring migration at least twice).

Based on the above feasibility assessments, we conclude:

- A supplementation of LWfG in Norway can be considered feasible assuming the identified problems with regard to obtaining a source of birds and release technique can be overcome.
- A re-introduction of LWfG in Norway (following extirpation) cannot be considered feasible until further evidence is provided concerning the elimination of or sufficient reduction in the original causes of decline, and then only assuming any problems identified with regard to stakeholder support and release technique can be overcome.

These conclusions are based on available information and current circumstances. The feasibility assessments should be reviewed if additional information becomes available or circumstances change.

The final decision with regard to feasibility will depend on the conclusions of DN with input as appropriate from other members of the RECAP committee.

5.3 DECISION MAKING AND NEXT STEPS

While this report provides information for determining if a supplementation or re-introduction programme should be implemented in Norway and suggests a framework for decision-making, the final decision as to the feasibility of such a programme in Norway depends on the conclusions of DN. The decision should take into consideration the availability of resources, and the key issues and risks highlighted in this report:

- A re-introduction/supplementation alone will not change the trend of the Norwegian LWfG population. For re-introduction or supplementation to result in a long-term increase in the population, the original causes of decline must have been eliminated or reduced to a sufficient level. Thus, it is vital that re-introduction/supplementation is undertaken as part of a wider conservation programme if it is to result in a long-term change in the status of the population.
- Re-introductions and supplementations of migratory species are particularly complex, and establishing migratory habit in released birds will pose a significant challenge. There can be no guarantee that released birds will use traditional sites, and whilst measures can be taken to increase the chances of this, the possibility that released birds could establish a non-traditional migratory route or simply use non-traditional sites should be factored into decision making.
- Timescale is an important factor to consider, particularly for a supplementation. A supplementation would require the Norwegian LWfG population not only to be extant but present in high enough numbers for the direct release technique to be viable.
- Establishing a captive-breeding population with birds from the Norwegian population would pose some risk to the wild population. Establishing a captive-breeding population with birds from the Western Main population or birds from Nordens Ark will depend on cooperation with the relevant parties.
- As a re-introduction or supplementation of LWfG using traditional migratory routes will involve birds moving through a number of Range States, measures such as habitat protection and monitoring as well as public awareness activities may be needed in these Range States requiring international cooperation.
- Socio-economic, political and legal aspects would be critical to the implementation and outcomes of a re-introduction/supplementation programme and the importance of such aspects is often underestimated. Measures may be required to gain the support of local communities, organisations, government agencies and other stakeholders. Long-term financial and political support has been shown to be one of the most important factors in the success of re-introduction/supplementation programme.
- A re-introduction or supplementation would not be complete upon the release of birds. A range of post-release activities would be required, including monitoring, assessment of outcomes, reporting and possibly interventions. These activities should be factored into project planning and budgeting.
- A preliminary estimation of costs based on UK prices suggests that a 20 year programme could cost approximately 48,580,000 NOK (7,504,592 USD).

There are three potential outcomes of decision-making: (1) no actions should be taken until further information is available or circumstances change, (2) a supplementation programme should be implemented to maintain the population while causes of decline are addressed, or (3) a supplementation programme should not be implemented but a re-introduction should be planned for in case of extirpation from Norway.

If a decision is made to implement a supplementation programme, the following next steps are recommended in the short-term:

- Produce a project plan in consultation with relevant scientific and technical experts.
- Identify all stakeholders.
- Inform relevant stakeholders of the plan to implement a supplementation programme, including local and national authorities, AEWA and other international and national bodies concerned with the conservation of LWfG.
- Identify a project team and seek collaborations with organisations and/or individuals with relevant expertise.
- As far as possible, secure long-term financial and political support.
- Determine and secure a suitable source of birds, and establish a new captive-breeding population if needed.
- Undertake research to determine how best to proceed with the direct release technique:
    i. Explore methods of attracting wild Norwegian LWfG to specific areas within potential release sites.
    ii. Conduct monitoring of site usage at potential release sites.
    iii. Subject to considerations of possible disturbance, conduct monitoring of breeding LWfG to assess the feasibility of catching families on the breeding grounds, and to inform the planning of capture attempts and release site locations.
- Build capacity for a supplementation programme by training key personnel in the relevant skills.

If a decision is made not to implement a supplementation programme but to plan for a re-introduction programme following extirpation, the following next steps are recommended in the short-term:

- Conduct intensive research to fill the key knowledge gaps with regard to the natural history of LWfG. In-depth understanding of migratory routes and habitat usage is particularly important.
- Further study causes of decline. Eliminating causes of decline following extirpation will benefit from a clear understanding of the issues and their impacts before extirpation.
- Determine and secure a suitable source of birds, and establish a new captive-breeding population if needed. Explore the possibility of taking birds from the Norwegian population.

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ANNEX 1: SPECIES DESCRIPTION

A1.1 NATURAL HISTORY

The following describes the natural history of the LWfG in the wild (with emphasis on the Fennoscandian population) as far as can be established from available information. It is difficult to anticipate if LWfG released in Norway will exhibit the same natural history, but the following information provides a framework to inform the planning of a re-introduction/supplementation programme.

A1.1.1 Taxonomy

Phylum: Chordata
Class: Aves
Order: Anseriformes
Family: Anatidae
Tribe: Anserini (102)
Species: *Anser erythropus* (56)

The species is monotypic and shares the genus *Anser* with nine other species: Greater White-fronted Goose, Pink-footed Goose *Anser brachyrhynchus*, Swan Goose *Anser cygnoides*, Bean Goose *Anser fabalis*, Bar-headed Goose *Anser indicus*, Snow Goose *Anser caerulescens*, Ross's Goose *Anser rossii* Emperor Goose *Anser canagica* and Greylag Goose *Anser anser*.

While no subspecies have been recognised, genetic studies suggest that there are three distinct populations in the wild, which should be treated as three discrete management units for conservation purposes (80, 81): the Fennoscandian population (breeding in Fennoscandian Lapland and Kola Peninsula), the Western Main population (breeding in Bolshezemelskaya and Yamal Peninsula) and the Eastern Main population (breeding in southern Taimyr and eastwards).

The population breeding in Swedish Lapland and wintering in the Netherlands is at least in part descended from captive-bred birds released in Sweden between 1981 and 1999. The captive-bred birds that were released in Sweden as part of this programme are thought to be originally descended from the Fennoscandian and Western Main populations. Genetic studies of the captive populations which supplied birds for release have found evidence of genes from the Greater White-fronted Goose (5), suggesting that hybridisation may have occurred in the captive source flocks.

A1.1.2 Physical characteristics

LWfG is the smallest of the geese in the genus *Anser*, with the following approximate measurements:

- Length: 53–66 cm (17, 20)
- Wingspan: 128 cm (20)
- Weight: 1.7–2.3 kg (57, 1)

It is a small, grey-brown goose with a white patch at the base of a pink bill, a yellow eye-ring, and black belly patches in adults (17), which can be used for individual identification (72). In good observation conditions, an adult LWfG is easily distinguishable from other goose species except for the Greater White-fronted Goose, which also has a white patch at the base of its bill and black belly patches (64). The Greater White-fronted Goose is on average larger and paler with a proportionally larger bill and no yellow eye-ring (for a detailed description of distinguishing between the two species see 64).

Confusion between these two species has caused problems in areas where hunting of LWfG is banned but hunting of the Greater White-fronted Goose is not, as hunters often do not distinguish between the two species (59).

There are no known physical differences between the LWfG populations.

A1.1.3 Annual life cycle

As for many migratory birds, the annual life cycle of an adult LWfG includes five major stages: breeding/summering, moulting, autumn staging, wintering and spring staging. The annual life cycles of birds in each of the LWfG populations will differ only in terms of timing and locations.

LWfG generally arrive on the breeding grounds in Norway from early May to late June and depart between mid-July and September (90), depending on breeding success. Non-breeding birds leave the breeding grounds in mid-July for largely unknown moulting sites, where moult is thought to begin during the last 10 days of July (91). Breeding birds remain on the breeding grounds to moult and are thought to moult between mid-July and mid-August (V Morozov *pers. comm.* as cited in 46). The start and length of autumn migration varies greatly depending on breeding results and weather conditions, but typically occurs between mid-August and mid-November (see 46). Birds may remain at autumn staging sites into early winter in particularly mild seasons. Satellite-tracking and field observations suggest that LWfG typically arrive at their wintering grounds in the second half of November, remaining into late February or the first half of March, depending on weather conditions (75). Spring migration typically occurs from the second half of February to the end of May (see 46).

A1.1.4 Distribution and movements

LWfG are long-distance Palearctic migrants with a discontinuous breeding range in the sub-Arctic zone that extends from northern Fennoscandia to north-eastern Siberia (57). Presumably as a result of glaciations and/or population declines, the formerly continuous breeding range has been fragmented into geographically distinct areas (17, 57, 92) with one of the three LWfG populations breeding in each. Each population also has largely distinct migratory routes and wintering areas, which are not fully known.

In the early 20th century, the Fennoscandian population was estimated at 10,000 individuals breeding widely across northern Norway, Sweden and Finland and parts of north-western Russia (69). The population breeding in Norway is now estimated at only 20 pairs (or 60–70 individuals) breeding in a relatively small (600 km^2) area of northern Norway (3). Evidence of breeding has not been confirmed in Finland since 1995 (101). An unknown number of birds may still breed on the Kola Peninsula, Russia (94). There are approximately 10–15 pairs (or 100 individuals) breeding in Sweden but these birds do not use the traditional migratory route of the Fennoscandian population as a result of a release programme in the 1980s and 1990s (124).

LWfG breeding in Norway, and possibly the Kola Peninsula, winter mainly in north-east Greece (Evros Delta), adjacent to the Turkish border (3). There is also evidence that these birds visit the Turkish side of the Evros delta and/or sites in westernmost Turkey during the winter. The Swedish population breeds in Swedish Lapland, winters in the Netherlands and migrates over north-west Germany.

The Western Main population (8,000–11,000 individuals) breeds in the Bolshezemelskaya tundra and Yamal Peninsula, and is thought to winter around the northern Black Sea coast, the southern Caspian Sea, inland waters of Azerbaijan, and inland waters of Iran and Iraq (68 as cited in 17). The Eastern Main population (17,000 individuals) breeds in southern Taimyr and Putorana Plateau, and areas north of

Eastern Siberia and Chukotka, and is thought to winter mainly in China and Mongolia and possibly around the Caspian Sea (68 as cited in 17).

While it was previously speculated that each population had entirely distinct wintering grounds as well as breeding grounds, genetic studies have revealed that there has been recent mixing of the three populations using traditional routes (80, 81). Mixing may occur on the wintering grounds, where pairing may occur between geese from different populations with the female then leading the male to the traditional breeding grounds of the female's population.

The migratory routes of the populations are not fully understood. A great deal of information, however, on the route of the Norwegian population has been gathered through satellite-tracking, ringing and other monitoring studies. Best available evidence suggests that the Norwegian population uses two different autumn migration routes: the 'western route' and the 'eastern route' (71). On the western route, birds fly from their breeding grounds in the Fennoscandian mountains eastwards to the Kanin Peninsula, south-west presumably through western Russia (Lake Ladoga region), western Estonia, Poland and eastern Germany, and then south-east, via a major staging area in Hungary (Hortobágy) and Greece (Lake Kerkini) to wintering grounds in north-east Greece (Evros Delta), adjacent to the Turkish border. On the eastern route, birds travel from the Kanin Peninsula further eastwards to areas of Russia (*e.g.* Kolguev Island, the Taimyr Peninsula) to moult and then southwards along the Ob River valley to a central staging area in the Kostanay region in northern Kazakhstan and onwards to presumed Black Sea and Caspian Sea wintering areas, thought to be shared with the Western main population, or the Evros Delta, Greece. Satellite-tracking evidence suggests that successful breeders use the western route, while unsuccessful/non-breeders use the eastern route (71). Timing of breeding failure may also be a factor, *e.g.* birds that fail early in the breeding season may choose the eastern route, while birds that fail late in the season may choose to remain on the breeding grounds to moult and use the western route. Hunting pressure is thought to be higher on the eastern route. During spring migration, presumably, all birds use the western route directly back to the breeding grounds in Norway (and possibly the Kola Peninsula).

As a supplementation programme for the Norwegian population would most likely involve releasing captive-bred birds into a flock of wild birds at a specific site, knowledge of the numbers of birds at specific sites at specific times of year is vital for assessing the feasibility of release techniques. Thus, Table A1-1 presents a summary of the monitoring data collected by the EU Life-Nature project 'Conservation of Lesser White-fronted Goose on the European migration route' (April 2005 – March 2009) (95).

For a map of the migratory routes of Norwegian LWfG, see the final report of the EU Life-Nature project 'Conservation of Lesser White-fronted Goose on the European migration route' (April 2005 – March 2009) (95) – downloadable from http://www.wwf.fi/wwf/www/uploads/pdf/lesser_white_fronted_goose_final_report_2009.pdf.

Table A1-1. The numbers and timings of LWfG observed at known key sites for the Norwegian population between 2004 and 2008, adapted and interpolated from the final report of the EU-LIFE Nature project (95).

Site	Average total number of individuals (range)	Average maximum number of individuals (range)	Arrival range	Average peak time	Departure range	Average duration of stay	Ref.
BREEDING							
Finnish Lapland	Rumours of breeding in this area between 2004 and 2008, but no breeding confirmed. Last confirmed breeding event in 1995.						90
Mountain plateaus in northern Norway*	10–16 breeding pairs	10–16 breeding pairs	Early May to late Jun	N/A	Mid-Jul to Sep	N/A	90
Kola Peninsula, Russia	Breeding suspected in this area but unconfirmed.						94
Swedish Lapland	Last confirmed breeding activity of original wild population in 1998. The released Swedish population breeds in areas near the former breeding range.						46
AUTUMN STAGING							
Valdak Marshes, Norway	42 (27–66)	42 (27–66)	16 Aug	16 Aug – 10 Sep	10 Sep	26 days	2
Varangerfjord, Norway	No birds recorded 2004–2008.						90
Bothnian Bay coast, Finland	No birds recorded 2004–2008.						55
Kanin Peninsula, Russia	No birds observed 2004–2007. In 2008, one bird seen on 5 Sep and one on 9 Sep.						96
Tahu & Haeska, Estonia	3 (0–5)	3 (1–5)	22 Sep – 13 Oct	N/A	25 Sep – 13 Oct	5 days (1–11 days)	99
Hortobágy, Hungary	N/A	37 (31–54)	16–22 Sep	Early Oct	2–29 Nov	5–6 weeks	93
WINTERING							
Lake Kerkini, Greece**	50 (44–56) at both sites	41 (32–52)	28 Oct – 4 Nov	30 Oct – 30 Nov	6 Dec – 10 Feb	63 days	75
Evros Delta, Greece		49 (41–54)	29 Nov – 26 Dec	14 Jan – 1 Mar	27 Feb – 14 Mar	81 days	75
Unknown sites	The location of 50–100% of wintering Fennoscandian LWfG is unknown for two to more than four weeks each winter during Jan and Feb. These birds may be using unmonitored sites in Greece and/or Turkey.						75
SPRING STAGING							
Hortobágy, Hungary	N/A	42 (26–59)	5 Feb – 13 Mar	N/A	12–26 Apr	4 weeks	93
Nemunas Delta, Lithuania	One bird carrying a satellite transmitter in 2007 (18–24 Apr) and one bird with Greater White-fronted Geese in 2008 (19 Apr).						47
Tahu & Haeska, Estonia	26 (22–32)	13–32	16–24 Apr	N/A	8–19 May	18–19 days	99
Bothnian Bay coast, Finland	10 (6–17)	N/A (1–10)	27 Apr – 9 May	N/A	13–20 May	N/A	58
Tana River valley, Norway	2 (0–4)	2 (0–4)	15–16 May	15–16 May	15–16 May	1 day	90
Valdak Marshes, Norway	38 (30–43)	20 (16–29)	10–14 May	16–27 May	N/A	N/A	2

* Exact location not published for conservation reasons.

** While Lake Kerkini is included here as a wintering site, it could also be considered a staging site. There is little ecological difference between staging and wintering sites.

A1.1.5 Habitat requirements

The LWfG's habitat requirements vary between life cycle stages. Major habitat types used include tundra wetland systems, coastal meadows, and natural steppe and other grasslands. Although not all LWfG breeding, moulting, staging and wintering sites are known, a relatively large number are known and have been studied in some detail. Table A1-2 summarises the known LWfG habitat requirements during each annual life-cycle stage, with emphasis on the Fennoscandian population breeding in Norway.

Table A1-2. Summary of known habitat requirements of the Lesser White-fronted Goose.

Stage	Habitat requirements
Breeding	Breeds in the forest tundra and southern tundra belts of northern Eurasia, with a preference for bush tundra interspersed with bogs and lakes (123). Breeding habitat requirements are different in different parts of the distribution range. Finnmark, Norway: wetland system on mountain plateau (73). Kola Peninsula, Russia: mainly treeless tundra with many lakes, ponds, rivers and streams and no permanent human settlement (94). Basins of the Velt and Neruta rivers, Russia: river banks with herb vegetation, mosses, willow (*Salix*) shrubs and dwarf birch (*Betula nana*), sometimes with large mounds and sand-clay outcrops. The river bottom is usually stony, often with a wide, sandy shallow on the opposite bank giving way to wet grassland and willow shrubs (66). Polar Urals and Yamal Peninsula, Russia: rocky river cliffs and dwarf birch tundra on watershed slopes close to rivers, and sometimes mountain foothills (V Morozov *pers. comm.* as cited in 46). Siberia, Russia: grass or dwarf shrub heath, nests often on snow-free patches available early in the season, such as rocky outcrop or prominent hummock; often in proximity to open water or extensive marshy area (28, reported by 35).
Moulting	Kolguev Island, Russia (presumably used by LWfG from the Fennoscandian population): low-lying, flat tundra, dissected by ponds and small river valleys with slow-flowing streams. Vegetation dominated by shrub (dwarf birch *Betula* and willows *Salix*) and tussock tundra with palsa mires (89). Bolshezemelskaya tundra and Yamal Peninsula, Russia: riverine areas with flood-plain meadows and dense bushes/shrubs (67).
Staging	Valdak Marshes, Norway: extensive salt and brackish marshes (1). Varangerfjord area, Norway: low-growth coastal meadow (97). Nemunas Delta, Lithuania: coastal meadows (47). Matsalu and other areas in Estonia: coastal meadows (99). Bothnian Bay, Finland: coastal meadows (58). Hortobágy, Hungary: short, grazed grassland and stubble of wheat and maize fields, and fishponds for roosting (93). Kostanay region, Kazakhstan: freshwater lakes and other wetlands and surrounding grasslands. When key lakes not available, LWfG use small freshwater reservoirs with fringing reed marshes and surrounding cultivated grain and vegetable fields (see 46). North-west Black Sea coast of Ukraine: freshwater, saline and brackish lakes and other wetlands, and surrounding grasslands and winter wheat fields (see 46).
Wintering	Shallow bays, lakes and wetland complexes (freshwater, brackish water and saltwater) and surrounding cultivated land and semi-natural grassland (see 46).

A1.1.6 Diet and feeding

The LWfG's diet varies considerably throughout the year according to the availability of food in its different breeding, moulting, staging and wintering habitats (61). It is herbivorous and feeds mainly on land, where its relatively short, serrated bill makes it well suited for grazing on short tundra vegetation.

As a long-distance migrant, feeding conditions at various stages of the annual life cycle are vitally important for both survival and productivity. Like other migratory, Arctic-breeding geese, LWfG must deposit a large amount of body reserves prior to migration and thus rely on energy-rich feeding at staging sites. Moult is also a time of increased energy and nutritional demands, and food is important in order to withstand harsh weather conditions during winter. Female LWfG acquire energy stores in spring-staging areas before moving to breeding sites (61).

The diet of LWfG has a lot in common with the diets of other Arctic-breeding geese, with the exception that LWfG seem to prefer natural habitats more than other geese (61). At staging sites, LWfG prefer natural steppe or coastal meadow habitat, whilst Greater White-fronted Geese and Bean Geese in the same areas mostly graze in fields (61). LWfG do, however, supplement their diet with agricultural grains, especially during winter.

Given that the annual life cycle and western migration route of the Fennoscandian LWfG population breeding in Norway is relatively well-known, detailed information is available on the diet of LWfG at a number of key sites (see Table A1-3). As there are gaps in the knowledge of some sites used by LWfG, there is, however, a corresponding lack of detail concerning diet in some parts of its range and during some annual life-cycle stages, particularly the wintering period.

For a review of known LWfG diet preferences with special attention on the diet during spring migration, see 61. A summary of this information with some additions is presented in Table A1-3, with emphasis on the diet of the Fennoscandian population breeding in Norway.

Table A1-3. Summary of known diet preferences of the Lesser White-fronted Goose throughout the annual cycle.

Life cycle stage	Diet	Ref.
Staging	Studies at spring staging sites suggest that the spring diet of LWfG consists almost entirely of monocotyledons. During spring staging in Finland, LWfG prefer extensive meadows where their diet consists almost exclusively of monocotyledonous plants, frequently including *Festuca rubra*, *Phragmites australis* and *Calamagrostis stricta*. These species tend to be common in meadows at known staging sites and the LWfG is therefore not dependent on rare plant species. Where *Festuca rubra* and *Phragmites* are locally abundant, LWfG tend not to consume many other species. At Porsangerfjord, Norway (an important staging area including the Valdak Marshes), a grass, *Puccinella phryganodes* is normally the main diet. At a number of autumn staging sites, including Hortobágy and Kardoskut in Hungary, the main diet is again a grass, *Festuca pseudoina*.	61, 87, 88
Wintering	In Azerbaijan and Armenia, LWfG graze to some extent on wheat, barley and maize fields but they are said to prefer feeding in steppe grasslands where sheep grazing maintains low vegetation height. At East Dongting Lake, China, where more than 50% of the known	57, 60

Life cycle stage	Diet	Ref.
	world population of LWfG currently winter, LWfG mostly use grasslands (88%), where the dominant plants are sedges and grasses. The gizzard of one male LWfG, however, was found to contain only *Rorippa* sp., a dicotyledon. In the Evros Delta, Greece, grasses are the predominant diet of LWfG making up approximately three quarters of their total diet: non-cultivated grasses (68%) and cultivated grasses (6.9%). The importance of grasses at this wintering site is underlined by the fact that grasses are not the dominant plant species in most foraging areas. Other monocotyledons (5.4%) were also consumed by LWfG, and legumes, other forbs and halophytes were consumed in low proportion.	
Breeding/moulting (summer)	In summer, the fundamental difference compared with staging and wintering is the moulting and brood-rearing period, when LWfG are flightless. The summer diet is not as limited as in other parts of the year. Some 18 species have been identified in the diet of summering LWfG, including monocotyledons (*e.g. Carex bigelowii, C. aquatilis*, and *Eriophorum angustifolium*), dicotyledons (*e.g. Polygonum viviparum* and *Salix lanata*) and horsetails (*e.g. Equisetum palustre*). Grasses do not dominate the diet during summer as they do at other times of year.	61

A1.1.7 Breeding biology and behaviour

Although little information is available on the breeding biology and behaviour of LWfG in the wild, information on other similar goose species and LWfG in captivity can be used to fill knowledge gaps and develop a broad picture of LWfG breeding parameters.

A1.1.7.1 Pair formation

Arctic-breeding goose species are long-lived with long-term monogamy. Pair bonds often persist over many years. Divorce is rare and if re-pairing occurs, it is usually after the death of a partner (34, 18). The age at which birds pair for the first time determines the minimum age of first breeding. The timing of first pairing, both within a bird's lifetime and annual life cycle, is an important life history trait with direct effects on population development.

Pair formation of LWfG adults likely takes place on the wintering grounds as has been shown for many other Arctic-breeding goose species, including Greenland White-fronted Goose (105), Snow Goose (36), Barnacle Goose (19) and Canada Goose (76). Presumably little, if any, pairing occurs in summer, although studies of Barnacle Geese have shown that associations formed between yearlings on or near the breeding areas are important in determining the choice of future mates (74, 22). The timing of pair formation in a bird's annual life cycle may vary between age groups. Owen *et al.* (74) found that the first pairing of young Barnacle Geese occurs predominantly in spring (74).

The average age of first pairing in LWfG is unknown. The average age of pairing differs between other goose species and populations:

- Greenland White-fronted Geese: most birds form pairs in their third or fourth winter, but some even later (105).
- Svalbard Barnacle Geese: about half of the birds are paired by the age of two years and all are paired by the age of four years (19).

- Snow Geese from the La Pérouse Bay colony on Hudson Bay, Canada: almost all two-year-old birds are paired on the breeding grounds and up to 50% of them breed (25).
- Snow Geese from Wrangel Island in the Russian High Arctic: few are paired at the end of the second winter; the proportion of paired birds increases gradually throughout the third and fourth winters (36).

Based on this information, it is most likely that the majority of first pairing in Fennoscandian LWfG occurs during the third and fourth winters. It is possible, however, that a proportion of birds may first pair during their second winter or later than their fourth winter.

A1.1.7.2 Nesting

Geese, like other wildfowl, generally show a high degree of natal philopatry, with strong preferences for nesting sites or areas used in the previous year (37 38, 39). Arctic-breeding geese generally migrate to their nesting locations before snow and ice melt is complete, and regularly nest (lay first egg of clutch) 10–13 days after peak arrival (77). The resulting synchrony of hatching, presumably, ensures the availability of high protein grasses required for the growth of the young and reduces predation pressure (33, 79). Later nesting would leave insufficient time for moult and preparation for migration in the autumn (7, 23, 24).

Pairs of LWfG nest alone in widely dispersed nests. Nest placement varies between different habitats. In Siberia, LWfG tend to nest in grass or dwarf shrub heath, often choosing sites on snow and ice-free patches available early in the season, such as rocky outcrops or prominent hummocks; often in proximity to open water or extensive marshy areas (28, reported by 35). In the southern Siberian tundra LWfG tend to nest among turf hummocks near thermokarst lakes, often bordered by steep bluffs on the shoreline (27). In Norway, LWfG nest on mountain plateaus. Of the few nests that have been observed in Norway, most have been amongst willow (*Salix*) shrubs. Nests are generally shallow depressions lined with grass, other vegetation and down.

A1.1.7.3 Egg laying and incubation

Egg laying begins in late May or early June. The laying pattern of wild LWfG is not known but can be estimated based on information for other similar species. Lesser Snow Geese *Anser caerulescens caerulescens* lay eggs at one day intervals, although those laying clutches of four or more sometimes skip a day after the second or third egg (6, 33). For the Canada Goose, the average laying interval is 1.55 days (53). In captivity, LWfG produce single clutches of four to six eggs (exceptionally as few as one and as many as eight). Therefore, LWfG in the wild most likely lay eggs at intervals of at least one day and at the most two days.

Between 1994 and 2000, the mean brood size of wild LWfG recorded at Valdak Marshes (first autumn staging site) was 3.2 (1).

The eggs are pale yellow-white, about 76 by 49 mm in size and 100 g in weight (35). Egg size, clutch size and timing of laying are potentially constrained by the amount of energy and nutrients available to females before egg formation (29).

Incubation begins immediately after the final egg has been laid and lasts between 25 and 28 days. Incubation is performed by the female, with the male guarding.

A1.1.7.4 Hatching and rearing

All eggs within a nest hatch within 24 hours – a characteristic called synchronous hatching. LWfG chicks are precocial, *i.e.* covered with down and able to leave the nest and feed themselves almost immediately.

After hatching, goslings are brooded on the nest by the female until dry and then leave the nest. During 1994–2008, observed fledged brood sizes in the Norwegian breeding population (n = 142 broods) varied from 1 to 6, with a mean of 3.07.

Goslings are guarded and supervised normally by both parents. Juvenile LWfG follow their parents on autumn migration and often remain with them over the winter and accompany them to the breeding grounds in the following season.

A1.1.7.5 Summary

Table A1-4 provides a summary of the breeding parameters of LWfG.

Table A1-4. Summary of the breeding parameters of the Lesser White-fronted Goose.

Characteristic	Description
Sexual maturity	Males: two to three years. Females: two to three years.
Age of first pairing	On average, probably during the third or fourth winter, though possibly earlier or later.
Timing of pair formation	Usually during winter, but possibly during spring staging for young birds.
Pair-bonds	Long-term monogamy with bonds usually lasting from year to year.
Nesting behaviour	Single pairs nest alone, nests widely spaced.
Nest placement and structure	On grass or dwarf shrub heath, rocky outcrops, hummocks, amongst willow shrubs; often in proximity to water. Nests are generally shallow depressions lined with grass, other vegetation and down.
Number of clutches per year	One.
Number of eggs per clutch	Average three to six, range one to eight.
Egg description	Pale yellow-white, 76 by 49 mm, 100 g.
Laying chronology	One egg per one to two days.
Incubation length	25–28 days from the date last egg is laid.
Incubation behaviour	By female, male guarding.
Type and length of hatching	Synchronous, within 24 hours.
Condition of chick at hatching	Precocial.
Fledging	35–40 days.
Brood size at fledging	1–6, with a mean of 3
Rearing behaviour	Both parents guard, or female only when brood is small; young birds remain with parents at least to wintering grounds sometimes for much longer; filial imprinting.

A1.1.8 Social behaviour

A1.1.8.1 Intraspecific social behaviour

Like *Branta* and other *Anser* species, LWfG are gregarious, occurring in flocks except during nesting. Small flocks are likely made up of related individuals, which have bred in the same area with larger flocks occurring when these smaller flocks come together.

Family structure is important. Juveniles remain with their parents at least until their first winter, sometimes back to the breeding grounds the following summer, and possibly longer. Family associations are regularly maintained into the second year, often by families meeting up on the breeding grounds prior to migration or at wintering sites. Greenland White-fronted Geese *Anser albifrons flavirostris* regularly maintain parent-offspring associations for two to five years (104) and exceptionally for much longer (one parent-offspring association was recorded to last for 19 years (DA Stroud *pers. comm.* 20 Nov 2009).

Hierarchies are present within flocks, and although geese do not defend permanent territories (except when nesting) they defend the areas around them when feeding. Aggressive encounters are common in feeding flocks as the birds attempt to maintain their spacing (70). Generally, the larger a family is, the more dominant it is. Large families are more dominant than small families who are more dominant than pairs who are more dominant than unpaired individuals. The lowest status geese are usually individual juveniles who have been separated from their family group.

Parent geese will sometimes accept unrelated juveniles into their family groups. This behaviour increases the dominance both of the family group and the unrelated juveniles.

A1.1.8.2 Interspecific social behaviour

Although single-species flocks are the normal occurrence, LWfG, like other geese, are often found in mixed-species flocks at staging and wintering sites. Fennoscandian LWfG have been observed to mix with White-fronted Geese, Bean Geese and Pink-footed Geese, and to a lesser extent other *Anser* and *Branta* species. These flock associations are generally only temporary and occur simply because the geese are present in the same location. Individual or very small groups of LWfG, however, who join a flock of another species may stay with that flock for an extended period of time for the advantages gained by being a member of a large flock rather than a lone bird or small flock.

As discussed above, LWfG appear to prefer natural habitat more than other goose species, which may reduce the chances of LWfG mixing with other species compared with other geese.

LWfG have, on rare occasions, been known to mate with other goose species in the wild. In captivity, unpaired LWfG may pair with all other *Anser* geese as well as the smaller *Branta* species. For this reason, it is generally advised that LWfG are kept separate from other goose species in captivity. If the Norwegian LWfG population continues to decline, interspecies pairing in the wild may become more common.

A1.1.9 Predation

The impact of predation on the LWfG population is unknown, but it is not thought to have played a major role in population declines. A combination of scientific and anecdotal evidence suggests that predators on the breeding grounds include the Red Fox, Arctic Fox *Alopex lagopus*, American Mink, White-tailed Eagle, Golden Eagle *Aquila chrysaetos*, Great Black-backed Gull *Larus marinus* and possibly other gull species (46).

A number of these predators have spread to the breeding grounds relatively recently, so were not predators of LWfG historically. There is potential for predation to have major impacts on the small Norwegian LWfG population if predation causes significant disturbance at the breeding grounds. Predation may be higher in years when small mammals are less abundant – a phenomenon known to occur for many Arctic-nesting geese.

A1.1.10 Health and disease

Disease is generally defined as any condition that affects a bird's normal functioning, including responses to infectious agents such as viruses, bacteria and macroparasites; to malnutrition; and to external agents such as nutrition, toxins, climate and trauma.

The diseases most likely to affect LWfG are discussed below.

A1.1.10.1 Infectious agents

The prevalence and ecological significance of infectious disease in wild LWfG populations is largely unknown. There is, however, a large body of information on infectious diseases of wildfowl in general and LWfG can be presumed to be susceptible to the diseases normally affecting geese. In addition, evidence of disease susceptibility is available from studies of infectious disease events in captive LWfG populations.

Geese are known to be susceptible to a wide range of infectious diseases, including nematode, trematode, and cestode infections, avian tuberculosis, aspergillosis, coccidiosis, cryptosporidiosis, duck virus enteritis, avian cholera, mycoplasma infections, Newcastle disease, salmonellosis, and avian influenza. Presumably, some or all of these diseases may be present in wild LWfG populations.

Infectious agents and the associated diseases that have been reported in wild and/or captive populations of LWfG are listed in Table A1-5.

Table A1-5. Infectious agents and the associated diseases that have been reported in wild and/or captive populations of Lesser White-fronted Geese.

Agent	Disease	Description	Ref.
Syngamus sp. (gapeworm)	Gape worm infection	Parasitic nematode infecting the trachea. Disease mainly of juveniles, causing signs from cough and anaemia to severe respiratory distress and death.	41
Ascaridia sp. (ascarid)	Ascarid infection of intestines	Parasitic nematode infecting the intestines. Disease mainly of juveniles up to three months old; can cause weight loss, diarrhoea and anaemia. Heteraksis, a type of ascarid, has been found in LWfG. This nematode usually causes asymptomatic infection of the caecum; generally seen only as an incidental finding at post mortem examination.	63
Amidostomum sp. (gizzard worm)	Gizzard worm infection	Common parasitic nematode infection of the gizzard, which causes slow growth, debilitation, and other effects associated with poor nutrition.	106
Trematodes (flukes)	Intestinal trematode infection	Trematode infection of the intestines, usually non-pathogenic but occasionally associated with debility, diarrhoea, enteritis, emaciation and death.	63
Cestodes	Cestode infection	Usually subclinical. May be pathogenic in young or debilitated hosts.	63
Mycobacterium avium	Avian tuberculosis	A chronic debilitating bacterial disease.	41

A1.1.10.2 External agents

Disease responses that result from contact with external agents are varied and include everything from lead poisoning and hypothermia to foreign body entanglement. LWfG populations are known to be affected by these types of disease, particularly the trauma resulting from being shot (hunting), which has played and still does play a major role in population declines.

Common wildfowl diseases associated with external factors are presented in Table A1-6.

Table A1-6. Common wildfowl diseases associated with external factors and their agents (107).

Agent	**Disease**
Botulinum toxins	Avian botulism
Lead	Lead poisoning
Large structures in the environment, *e.g.* over-head power lines	Impact injuries, air sac paralysis, brachial paralysis, eye damage, etc.
Discarded items such as fishing tackle and plastic bags	Foreign body entanglement
Low temperatures	Ice entrapment, frostbite, hypothermia
Shooting	Impact injuries, air sac paralysis, brachial paralysis, eye damage, etc.

A1.2 THREATS AND CONSERVATION

A1.2.1 Conservation status

As described in the final report of the EU-LIFE Nature project, the Fennoscandian LWfG breeding in Norway and possibly the Kola Peninsula is the most endangered breeding bird species in northern Europe. It is widely considered to be facing an immediate risk of extinction. Table A1-7 lists the international conservation status of LWfG globally and within Europe.

Table A1-7. Summary of the international conservation status of the Lesser White-fronted Goose globally and within Europe – adapted from the ISSAP.

Conservation instrument	Listing	Description
IUCN Red List[1] global status	Vulnerable	Best available evidence indicates that it is facing a high risk of extinction in the wild.
IUCN Red List European status[2]	Endangered	Best available evidence indicates that it is facing a very high risk of extinction in the wild in Europe.
SPEC[3] category	SPEC 1	European species of global conservation concern.
EU Birds Directive[4]	Annex I	Species that shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution.
Bern Convention[5]	Appendix II	Strictly protected fauna species.
CMS[6]	Appendix I	Migratory species that have been categorised as being in danger of extinction throughout all or a significant proportion of their range.
AEWA[7]	Column A (1a, 1b, 2)	Category 1a: Species which are included in CMS Appendix I. Category 1b: Species which are listed as threatened in Threatened Birds of the World (BirdLife International 2000). Category 2: Populations numbering between around 10,000 and around 25,000 individuals.
CITES[8]	Not listed	

[1] 2009 IUCN Red List of Threatened Species
[2] Application of IUCN Red List criteria to LWfG in Europe (46)
[3] Species of European Conservation Concern (16)
[4] European Council Directive on the Conservation of Wild Birds (79/409/EEC, 2 April 1979)
[5] Convention on the Conservation of European Wildlife and Natural Habitats
[6] Convention on Migratory Species
[7] African-Eurasian Waterbird Agreement
[8] Convention on International Trade in Endangered Species of Wild Flora and Fauna

A1.2.2 International and national legislation

According to the ISSAP, the Principal Range States of the Fennoscandian LWfG, *i.e.* those in which they occur regularly, are Bulgaria, Estonia, Finland, Germany, Greece, Hungary, Kazakhstan, Lithuania, Norway, Poland, Russia, Sweden, Turkey and the Ukraine.

Some nine of these countries are members of the European Union (EU) and therefore bound by EU Directives and policies, including the European Council Directive on the Conservation of Wild Birds (79/409/EEC, 2 April 1979). Table A1-8 summarises Principal Range State membership to the EU, membership to international conservation conventions, and the existence of National Action Plans and working groups for LWfG.

Table A1-8. Summary of Fennoscandian Lesser White-fronted Goose Principal Range State membership to the EU and international conservation treaties, and the existence of National Action Plans and working groups for LWfG, adapted from the ISSAP.

Principal Range State	EU	AEWA	CMS	Bern	CBD	Ramsar	National Action Plan	National working group
Bulgaria	X	X	X	X	X	X		
Estonia	X	X	X	X	X	X	X	X
Finland	X	X	X	X	X	X	X	X
Germany	X	X	X	X	X	X		X
Greece	X		X	X	X	X	X	
Hungary	X	X	X	X	X	X		X
Kazakhstan			X		X	X		
Lithuania	X	X	X	X	X	X		
Norway		X	X	X	X	X	X	X
Poland	X		X	X	X	X		
Russia					X	X		X
Sweden	X	X	X	X	X	X	?	X
Turkey				X	X	X		
Ukraine		X	X	X	X	X		X

A1.2.3 Threats

The most important factors driving the recent declines are thought to be those factors that cause high mortality among fully grown birds, operating primarily on staging and wintering sites. Over-hunting is considered to be the primary threat and the single most important factor threatening the long-term survival of the population, despite LWfG being protected throughout most of its range.

While over-hunting is the only factor listed as critically important in the ISSAP, a number of other factors are also identified and rated according to their importance with the acknowledgement that there are fundamental knowledge gaps. As well as over-hunting, factors causing increased adult mortality are listed as poisoning (unknown importance) and human disturbance (medium importance). Factors causing reduced reproductive success are listed as human disturbance (possibly of local importance), predation by a variety of species, including Red Fox and American Mink (possibly of local importance) and genetic impoverishment (low importance). Factors causing habitat loss and/or degradation are listed as agricultural intensification (formerly of high importance, now probably of low importance), construction of dams and other river regulation infrastructure and wetland drainage (probably of medium importance), climate change (unknown importance), over-grazing (local importance), land abandonment (locally high importance) and pollution (unknown importance). According to the ISSAP, there is also a potential risk of genetic introgression of DNA from other goose species.

For a complete description of threats see the ISSAP.

A1.2.4 Conservation measures undertaken

As a result of its poor status, the LWfG has been the subject of a range of conservation measures in Europe in recent years, many of these occurring as part of the EU Life-Nature project titled 'Conservation of Lesser White-fronted Goose on the European migration route' (April 2005 – March 2009). This project included satellite-tracking and ringing to map key sites; preparation of National Action Plans for the species in Norway, Finland and Estonia; habitat restoration and management at staging sites in Estonia and Hungary; and public awareness campaigns.

In Norway, actions proposed in the National Action Plan have begun to be implemented including banning all goose hunting at the Valdak Marshes (important autumn staging site) and control of the Red Fox population in the breeding area.

In 2008, an International Single Species Action Plan (ISSAP) for the conservation of LWfG in the Western Palearctic was adopted by AEWA.

For a complete review of conservation measures undertaken for the Norwegian LWfG population see the ISSAP and the final report of the EU-LIFE Nature project (95).

A1.2.5 Current conservation needs

The stated goal of the ISSAP is to restore the LWfG to a favourable conservation status within the AEWA Area. To achieve this goal, the plan calls for the following results:

1. Reduction in mortality rates
2. Prevention of further habitat loss and degradation
3. Maximised reproductive success
4. Prevention of DNA introgression as a result of releases from captivity and minimised DNA introgression from already released birds
5. Filling of key knowledge gaps
6. Maximised international cooperation

The ISSAP lists 42 activities required to produce these results, including establishing a captive stock of wild Fennoscandian birds subject to the conclusions of a feasibility study. This activity is not included in the further lists of required national activities. Unlike the 1996 ISSAP (59), the 2008 ISSAP does not directly recommend re-introduction or supplementation.

Norway's National Action Plan for the LWfG identifies the following conservation needs:

1. Continued conservation of habitats
2. Continued and increased monitoring
3. Control of predators
4. Regulation of hunting of Greylag Geese in Finnmark
5. Increased focus on public awareness
6. Increased collaboration

For a complete description of the conservation needs of the Norwegian LWfG population see the ISSAP, Norway's National Action Plan, the final report of the EU-LIFE Nature project and other National Action Plans, including those of Finland and Estonia.

A1.3 HISTORY AND STATUS IN CAPTIVITY

LWfG are known to have been held in captivity since the early 1900s. The total number of captive LWfG currently registered worldwide with the International Species Information System (ISIS) is 219 individuals in 41 collections, with 31 of these collections in Europe (42). These numbers are likely to represent less than half of the true population of captive LWfG as many private breeders and other collections are not registered with ISIS.

Significant captive populations of LWfG were built up in Sweden and Finland to supply the re-introduction/supplementation programmes which released birds in Fennoscandia between 1981 and 1998. These populations were housed at the Öster-Malma Hunting and Wildlife Management School in Nyköping, Sweden; Nordens Ark Trust in Sweden; a farm on the isle of Hailuoto on the west coast of Finland; and Hämeenkoski farm in southern Finland.

While a proportion of the birds which founded the Öster-Malma collection was wild-caught in Fennoscandia and therefore of known wild origin, the majority of birds introduced into these collections were from existing captive collections of unknown wild origin and with a long history of captive-breeding.

Genetic analysis of blood taken from 15 birds in the Hailuoto collection in 1993 showed that four individuals (one of which had originated directly from the Öster-Malma collection) had mitochondrial DNA (mtDNA) typical of the Greater White-fronted Goose (5). The exact origin of this mtDNA has not been determined. While the most probable explanation for the mtDNA's presence in the Hailuoto LWfG is that hybridisation between the two species occurred at some point in captivity, it is theoretically possible that the mtDNA could be of wild origin either as a result of natural hybridisation in the wild or shared ancestry.

A genetic test sensitive enough to determine the exact hybridisation status of an individual LWfG does not currently exist. As a result, the genetic status of captive birds of unknown origin and their captive-breeding history cannot be assured. There is international consensus, as reflected in the November 2005 conclusions of the CMS Scientific Council (see Annex 4) and the final report of the AEWA negotiation mission in January 2007 (see Annex 4), that birds from captive collections of unknown wild origin should not be released into the wild.

To supply birds for a future re-introduction programme in Sweden, a new captive population has been established at Nordens Ark, Sweden, by the Swedish EPA. The population has been founded using birds from the Western Main population. Juvenile LWfG were captured on the Russian tundra (two juveniles from each brood) and moved to Moscow Zoo where they underwent a veterinary examination before being sent to Nordens Ark via Arlanda Airport in Stockholm. The first Russian geese arrived in 2006 with further arrivals in 2007 and 2009.

A1.4 PAST RE-INTRODUCTION/SUPPLEMENTATION ATTEMPTS

A1.4.1 1981–1999 release programme in Sweden using Barnacle Goose foster parents

An LWfG captive-breeding programme was established in Sweden by Lambart von Essen in the late 1970s and the first releases into the wild took place in 1981 (*e.g.* 103). The breeding stock was built up mainly with birds and eggs originating from captive collections in the UK and continental Europe. During the period 1981 to 1999, 348 captive-bred LWfG were released in Swedish Lapland. Barnacle Geese were used as foster parents and the released LWfG followed their foster parents to wintering grounds in the Netherlands. The birds using this non-traditional migration route, which avoided countries with unsustainably high hunting pressure, show a high survival rate. A total of 66 young fledged from breeding attempts in the release area between 1981 and 1999 (121 as cited in 46). The number of fledglings reared between 1999 and 2007 ranged from 13 to 20 annually, with a total for the nine-year period of 136 fledglings from 51 broods (46). The current population size is estimated at approximately 10–15 breeding pairs (or 100 individuals, 124).

A1.4.2 1987–1997 re-introduction in Finland

In 1986 a captive-breeding population was established in Finland (62). Between 1987 and 1997, about 150 captive-bred LWfG were released in Finnish Lapland, but high mortality occurred and no breeding attempts were made by the released birds. This re-introduction programme did not aim to modify goose migration routes (62). Releases were stopped in 1998 (62), though LWfG continued to be bred in captivity.

A1.4.3 1999 pilot re-introduction in Sweden using ultra-light aircraft

In 1999, 30–40 LWfG of mostly Belgian captive origin were released in central Sweden and guided by ultra-light aircraft to Germany. Most were recaptured when they returned to the release site, but a few remained free-flying and have been observed in coastal areas of Finland (occasionally also in Denmark and Germany) mainly together with Barnacle Geese. No breeding by these birds has been reported (L Kahanpää *pers. comm.* as cited in 46); there are recent observations of hybrid Barnacle and LWfG in the population of Barnacle Geese in South-West Finland (T Lehtiniemi *pers. comm.* as cited in 46).

A1.4.4 2004 release of one brood in Finland using Barnacle Goose foster parents

In July 2004, three LWfG goslings were released contrary to the moratorium in northern Finland together with their Barnacle Goose foster parents (46). One of the young LWfG was sighted among Barnacle Geese in the Netherlands in December 2004, though not in the company of its foster parents, or of re-introduced Swedish birds (46). There were plans to release between one and three similar families in 2005, subject to the outcome of a legal challenge over the legitimacy of the 2004 release, but a lack of suitable birds for release prevented this. (L Kahanpää *pers. comm.* as cited in 46, see also the website of the Friends of the Lesser White-fronted Goose www.math.jyu.fi/approximately kahanpaa/Kotisivut/AnserErythropus/LWfG.html).

A1.4.5 2009 release of one brood in Finland using Barnacle Goose foster parents

Similar to the 2004 release, one brood of LWfG goslings was released in northern Finland in summer 2009 with Barnacle Goose foster parents. The whereabouts of these birds are unknown.

ANNEX 2: SELECTED PRACTICAL GUIDANCE

The following sections briefly outline a selection of activities and plans likely to be required as part of a re-introduction or supplementation programme. The information is intended as a guide to inform planning. Actual plans and activities will vary greatly depending on timings, methods and resources.

A2.1 Identification of project team

The project team should include the following expertise:

- Socio-economic and legal
- Local knowledge
- Field skills in the relevant areas/habitats
- Bird capture and transportation
- Captive-breeding (aviculture)
- Re-introduction/supplementation
- Monitoring and data management
- Project management

The team should have diverse skills and experience. While it is not necessary for every team member to have experience of re-introduction/supplementation programmes, at least one person should have significant experience in this area. Considering the complexity of such programmes, effective project management is particularly vital. It would be beneficial to include team members from more than one organisation, which would further diversify available skills and experience.

A2.2 Required plans and protocols

Before project implementation begins, detailed plans for each stage of the project should be produced, but it should be expected that these plans may change significantly as implementation progresses. The following specific plans should be produced:

- Overall project strategy
- Public engagement plan
- Captive breeding plan, including demographic, genetic, behavioural and health management protocols
- Disease risk assessment
- Transport plan
- Biosecurity and screening plan
- Release plan
- Intervention plan
- Monitoring plan
- Reporting plan

These plans should be reviewed by experts. For example, members of the IUCN Re-introduction Specialist Group would likely be able to offer useful insights gained from experience with a large number of different re-introduction programmes.

A2.3 Required facilities

The following facilities may be required:

- **Breeding facility**
  This facility would house the captive-breeding population. Depending on its location, it would likely need an indoor area and an outdoor area large enough to accommodate the maximum expected size of the population. It should be possible to partition the outdoor area to provide separate areas for breeding pairs during the breeding season (the portable, wooden aviaries used by Nordens Ark are ideal for this purpose). The facility should be predator-proof and biosecure.
- **Rearing facility**
  This facility would be used to house birds being reared for release. It is vital that the design of this facility considers the rearing requirements, i.e. the need for birds to gain survival skills and the need for the birds to be reared without significant opportunity to imprint on human infrastructure. An indoor area would likely not be required. This facility should be predator-proof. It may be appropriate to combine this facility with the release facility.
- **Release facility**
  This facility would be used to house birds prior to release while they acclimatise to their release environment and potentially while waiting for wild LWfG to approach the release site. This facility may be relatively temporary and consist simply of a netted pen at the release site. Again, this facility should be predator-proof.

The locations of these facilities should be carefully considered and included in the plans listed above. The location of the rearing and release facilities could be particularly important depending on the chosen release strategy. It may be appropriate to locate the rearing facility near the desired breeding ground of the birds to be released, and to locate the release facility at a nearby staging site where wild LWfG are known to congregate.

The breeding facility could be located far from the proposed release site and even outside of Norway. The advantages of locating the breeding facility within Norway would be that it would minimise the distance the birds would need to be transported between breeding and rearing/releasing facilities, and it would likely be easier to gain support within Norway for a programme using birds bred in Norway. The advantages of locating the breeding facility outside of Norway would be that the facility could be located in a country with a less severe winter climate so birds could use outdoor spaces all year round, and it may be possible to make use of already existing breeding facilities, eliminating the costs of building a brand new facility.

A2.4 Key elements of a husbandry manual

To ensure high standards of captive management, a basic husbandry manual should be compiled by consultation with experienced breeders.

Husbandry standards will ensure the aims and objectives of the captive-breeding programme are underpinned by the highest possible animal welfare standards where these are considered in terms of the five 'freedoms/provisions', namely:

1. *Provision of food and water*: Food and water will be presented to maintain the birds' full health and vigour and in a manner and frequency commensurate with the species' natural behaviour as well as its seasonal nutritional requirements.

2. *Provision of a suitable environment*. An environment consistent with the species' biological requirements will be provided including shelter from rain, heat, cold and shade as appropriate, while ensuring hygienic conditions.

3. *Provision of animal healthcare*. Accommodation will be designed to minimise the risk of injury and allow birds to get away from each other. Curative and preventive veterinary medicine will be provided through rapid diagnosis and treatment of illness. Every effort will be made to provide a correct diet and suitably hygienic environment from which pathogens are excluded or controlled.

4. *Provision of an opportunity to express most normal behaviour*. The birds will be allowed the opportunity to express most normal behaviours by providing sufficient space and environmental enrichment.

5. *Provision of protection from fear and distress*. Birds will be managed in compatible numbers and sex ratios to allow for as much normal behaviour as possible, and provided with areas of escape from aggressive encounters. Enclosures will be predator proof to ensure birds' safety.

The husbandry manual should consider the following topics:

1. Housing/environment standards
   a. Aviary design and construction
   b. Ponds and water systems
   c. Vegetation
   d. Shelter and furnishings
   e. Feeding areas
   f. Aviary maintenance
   g. Predator and pest control measures

2. Health management
   a. Environmental hygiene
   b. Health assessment
   c. Diagnosis and treatment
   d. Isolation and rehabilitation
   e. Known health issues
   f. Death and post mortem examination

3. Nutrition and feeding standards
   a. Natural diet
   b. Adult captive diet and supplements
   c. Seasonal variation in feeding requirements
   d. Food storage
   e. Food presentation
   f. Rearing diet
   g. Presentation of chick food
   h. Nutrient composition of formulated diets

4. Capture, handling and transport requirements
   a. Capture and handling
   b. Transport requirements

5. Behaviour and holding management
    a. General behaviour in captivity
    b. Compatibility
    c. Introduction techniques

6. Breeding management
    a. Reproductive cycle
    b. Pair formation
    c. Nesting requirements
    d. Clutch size and laying
    e. Egg weights and measurements
    f. Natural incubation
    g. Parental care
    h. Genetic and demographic management

7. Artificial incubation
    a. Incubation facilities
    b. Egg collection, cleaning and storage
    c. Incubation parameters
    d. Monitoring embryo development
    e. Hatching

8. Hand-rearing

9. Rearing for release
    a. Insights from experimental research and previous bird re-introductions/supplementations
    b. Rearing facility requirements
    c. Criteria for selecting individual LWfG for release rearing
    d. Behavioural considerations, conditioning and adaptation training
        i. Training of predator recognition and anti-predator response behaviours
        ii. Flight training
        iii. Human contact
        iv. Water and feeding regime: captive diets and adaptation to wild items
        v. Utilisation of appropriate habitats
        vi. Testing of satellite or radio transmitters
        vii. Coordination and scheduling of adaptation training elements

10. Quarantine procedures
    a. Background
    b. Protocol : captive – captive transfer (basic requirements)
    c. Protocol : wild – captive

11. Record keeping standards
    a. Identification bands
    b. Sexing methods
    c. Individual records

A2.5 Release strategy

Release techniques for LWfG would need to be developed while LWfG are in a captive-breeding situation. An experimental approach and pilot releases may be necessary. These releases should be designed in consultation with experienced re-introduction practioners and developed as experience is gained.

The release strategy will depend on how many birds are required for release and the type of release planned.

The following principles should be taken into account when planning a release:

- Birds should be given an opportunity to acclimatise to their release site
- Soft releases are more successful than hard releases
- Release sites should be chosen according to established criteria, which will differ depending on the type of release
- Birds for release should be chosen according to established criteria, including physical and behavioural condition
- Optimum size of release groups should be determined
- Birds should undergo a final pre-release veterinary examination
- Protocols should be established for transporting birds between breeding/rearing facilities and release site/facility
- Short-term habitat measures at the release site may be required
- Provision of water and supplementary feeding post-release may be required (an intervention strategy should be produced prior to release

ANNEX 3: PROVISIONS IN INTERNATIONAL LEGAL INSTRUMENTS RELEVANT TO LESSER WHITE-FRONTED GOOSE RE-INTRODUCTION/SUPPLEMENTATION

This annex provides the provisions from a selection of key international legal instruments that reference re-introduction, supplementation, introduction or other closely related activities. For a list of provisions more broadly relevant to LWfG conservation see the ISSAP (46).

A3.1 European Council Directive on the Conservation of Wild Birds (79/409/EEC)

LWfG is listed in Annex I of the Directive.

> "The species mentioned in Annex I shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution. Member States shall classify in particular the most suitable territories in number and size as special protection areas for the conservation of these species, taking into account their protection requirements in the geographical sea and land area where this Directive applies."

Article 11 may also be relevant to re-introduction/supplementation of LWfG:

> "Member States shall see that any introduction of species of bird which do not occur naturally in the wild state in the European territory of the Member States does not prejudice the local flora and fauna."

A3.2 Pan-European Biological and Landscape Diversity Strategy

Article 9 states that as a measure of *ex situ* conservation each Contracting Party shall, as far as possible and as appropriate, and predominantly for the purpose of complementing *in situ* measures:

> "Adopt measures for the recovery and rehabilitation of threatened species and for their re-introduction into their natural habitats under appropriate conditions."

A3.3 European Council Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC)

Article 22 states that each Member State shall:

> "Study the desirability of re-introducing species in Annex IV that are native to their territory where this might contribute to their conservation, provided that an investigation, also taking into account experience in other Member States or elsewhere, has established that such re-introduction contributes effectively to re-establishing these species at a favourable conservation status and that it takes place only after proper consultation of the public concerned."

> "Ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native flora and fauna and, if they consider it necessary, prohibit such introduction. The results of the assessment undertaken shall be forwarded to the committee for information."

A3.4 Convention on Migratory Species (Bonn Convention, 1979)

Article V provides guidelines for Agreements that indicate each Agreement should provide for but not be limited to a set of criteria including:

> "Where it appears desirable, the provision of new habitats favourable to the migratory species or re-introduction of the migratory species into favourable habitats."

As LWfG is included in Appendix I of the Convention on Migratory Species the provisions of Articles III.4 to III.7 apply:

> "III.4. Parties that are Range States of a migratory species listed in Appendix I shall endeavour:
> a) to conserve and, where feasible and appropriate, restore those habitats of the species which are of importance in removing the species from danger of extinction;
> b) to prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities or obstacles that seriously impede or prevent the migration of the species; and
> c) to the extent feasible and appropriate, to prevent, reduce or control factors that are endangering or are likely to further endanger the species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species.
>
> III.5. Parties that are Range States of a migratory species listed in Appendix I shall prohibit the taking of animals belonging to such species. Exceptions may be made to this prohibition only if:
> a) the taking is for scientific purposes;
> b) the taking is for the purpose of enhancing the propagation or survival of the affected species;
> c) the taking is to accommodate the needs of traditional subsistence users of such species; or
> d) extraordinary circumstances so require; provided that such exceptions are precise as to content and limited in space and time. Such taking should not operate to the disadvantage of the species.
>
> III.6. The Conferences of the Parties may recommend to the Parties that are Range States of a migratory species listed in Appendix I that they take further measures considered appropriate to benefit the species.
>
> III.7. The Parties shall as soon as possible inform the Secretariat of any exceptions made pursuant to paragraph 5 of this Article."

A3.5 Agreement on the Conservation of African-Eurasian Waterbirds (an Agreement of the Bonn Convention)

Paragraph 2.4 of AEWA's Annex 3 (Action Plan) states that:

> "Parties shall exercise the greatest care when re-establishing populations listed in Table 1 into parts of their traditional range where they no longer exist. They shall endeavour to develop and follow a detailed re-establishment plan based on appropriate scientific studies. Re-establishment plans should constitute an integral part of national and, where appropriate, international single species action plans. A re-establishment plan should include assessment of the impact on the environment and shall be made widely available. Parties shall inform the Agreement secretariat, in advance, of all re-establishment programmes for populations listed in Table 1."

A3.6 Central Asian Flyway Action Plan for the Conservation of Migratory Waterbirds and Their Habitats

Paragraph 2.5.1 of the Central Asian Flyway Action Plan requires that Range States exercise great care when executing re-establishment projects, develop detailed plans, include re-establishment in National and International Action Plans, and report all re-establishment projects to the UNEP/CMS Secretariat.

"Range States shall exercise the greatest care when re-establishing populations listed in Table 2 into parts of their traditional range where they no longer exist. They shall endeavour to develop and follow a detailed re-establishment plan based on appropriate scientific studies. Re-establishment plans should constitute an integral part of national and, where appropriate, international single species action plans. A re-establishment plan should include assessment of the impact on the environment and shall be made widely available. Range States shall inform the Secretariat, in advance, of all re-establishment programmes for populations listed in Table 2."

A3.7 Convention on Biological Diversity (Biodiversity Convention, Rio de Janeiro, 1991)

Article 8:

"Each Contracting Party shall, as far as possible and as appropriate:
(a) Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;
(c) Regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;
(d) Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;
(f) Rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, *inter alia*, through the development and implementation of plans or other management strategies".

A3.8 Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979)

LWfG is included in Annex II 'Strictly protected species' as last revised on 1 March 2002.

Article 6:

"Each Contracting Party shall take appropriate and necessary legislative and administrative measures to ensure the special protection of the wild fauna species specified in Appendix II. The following will in particular be prohibited for these species:
a. all forms of deliberate capture and keeping and deliberate killing;
b. the deliberate damage to or destruction of breeding or resting sites;
c. the deliberate disturbance of wild fauna, particularly during the period of breeding, rearing and hibernation, insofar as disturbance would be significant in relation to the objectives of this Convention;
d. the deliberate destruction or taking of eggs from the wild or keeping these eggs even if empty;
e. the possession of and internal trade in these animals, alive or dead, including stuffed animals and any readily recognisable part or derivative thereof, where this would contribute to the effectiveness of the provisions of this article."

Article 8:

"...in cases where, in accordance with Article 9, exceptions are applied to species specified in Appendix II, Contracting Parties shall prohibit the use of all indiscriminate means of capture and killing and the use of all means capable of causing local disappearance of, or serious disturbance to, populations of a species, and in particular, the means specified in Appendix IV."

Articles 9.1 and 9.2:

"Each Contracting Party may make exceptions from the provisions of Articles 4, 5, 6, 7 and from the prohibition of the use of the means mentioned in Article 8 provided that there is no other satisfactory solution and that the exception will not be detrimental to the survival of the population concerned:

- for the protection of flora and fauna;
- to prevent serious damage to crops, livestock, forests, fisheries, water and other forms of property;
- in the interests of public health and safety, air safety or other overriding public interests;
- for the purposes of research and education, of repopulation, of re-introduction and for the necessary breeding;
- to permit, under strictly supervised conditions, on a selective basis and to a limited extent, the taking, keeping or other judicious exploitation of certain wild animals and plants in small numbers."

"The Contracting Parties shall report every two years to the Standing Committee on the exceptions made under the preceding paragraph. These reports must specify:

- the populations which are or have been subject to the exceptions and, when practical, the number of specimens involved;
- the means authorised for the killing or capture;
- the conditions of risk and the circumstances of time and place under which such exceptions were granted;
- the authority empowered to declare that these conditions have been fulfilled, and to take decisions in respect of the means that may be used, their limits and the persons instructed to carry them out;
- the controls involved."

Article 10.1:

"The Contracting Parties undertake, in addition to the measures specified in Articles 4, 6, 7 and 8, to co-ordinate their efforts for the protection of the migratory species specified in Appendices II and III whose range extends into their territories."

Article 11.2 (b):

"Each Contracting Party undertakes to strictly control the introduction of non-native species."

Article 11.2 (a):

"Each Contracting Party undertakes to encourage the reintroduction of native species of wild flora and fauna when this would contribute to the conservation of an endangered species, provided that a study is first made in the light of the experiences of other Contracting Parties to establish that such reintroduction would be effective and acceptable."

Recommendation 58 (1997) on the reintroduction of organisms belonging to wild species and on restocking and reinforcing populations of such organisms in the environment (Adopted by the Standing Committee on 5 December 1997):

"Recommends that the Contracting Parties;

1. regulate the procedures and conditions for operations to reintroduce organisms belonging to wild species and to restock and reinforce populations of organisms belonging to wild species in the environment;

2. introduce legislation and regulations to protect species which have been reintroduced and which have been included in operations for restocking and reinforcing populations;

> 3. consider carefully, for the purposes of implementing the Convention, the suggested measures listed in the Guidelines appended to this Recommendation, in so far as they are appropriate to the specific conditions prevailing in their territory;
>
> 4. notify the Secretariat of any relevant measures adopted or envisaged so that it may in turn inform the other Contracting Parties."

The Annex to Recommendation 58 contains guidelines. These can be downloaded from https://wcd.coe.int/ViewDoc.jsp?id=1487297&Site=DG4-Nature&BackColorInternet=DBDCF2&BackColorIntranet=FDC864&BackColorLogged=FDC864.

A3.9 IUCN Guidelines for Re-introduction

The Guidelines state the aims and objectives of re-introduction as follows:

> "The principle aim of any re-introduction should be to establish a viable, free-ranging population in the wild, of a species, subspecies or race, which has become globally or locally extinct, or extirpated, in the wild. It should be re-introduced within the species' former natural habitat and range and should require minimal long-term management. The objectives of a re-introduction may include: to enhance the long-term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain and/or restore natural biodiversity; to provide long-term economic benefits to the local and/or national economy; to promote conservation awareness; or a combination of these."

Guidelines are provided on Pre-project Activities (biological, socio-economic and legal); Planning, Preparation and Release Stages; and Post-release Activities. These guidelines can be downloaded from http://www.iucnsscrsg.org/download/English.pdf.

These guidelines are currently (as of May 2010) being revisited and developed by members of the IUCN/SSC Re-introduction Specialist Group. For further information contact Frederic Launay (frederic.launay@awpr.ae) or Mark Stanley Price (mark.stanleyprice@zoo.ox.ac.uk).

ANNEX 4: STATEMENTS AND OPINIONS RELEVANT TO LESSER WHITE-FRONTED GOOSE RE-INTRODUCTION

A4.1 Conclusions and recommendations made by CMS Scientific Council at the 13th Meeting of the CMS Scientific Council, Nairobi, Kenya, 18 November 2005

Prepared based on a dossier submitted by BirdLife International which took into account the views expressed at the Lammi Workshop and the draft SSAP. Some stakeholders felt that the dossier was incomplete and/or did not accurately represent the actual situation. Thirteen stakeholders contributed additional information to CMS Scientific Council.

The following are the Scientific Council's conclusions (numbered for clarity, but otherwise quoted verbatim):

1. It is desirable to have a wide genetic diversity among wild Lesser White-fronts.

2. There appears to be no undisputed answer at present to the question of whether the Fennoscandian population (as represented by the birds breeding in Norway) is genetically distinct from the nearest breeding birds to the east, in northern Russia. Given the uncertainty, we take the cautious approach that there might be a potentially valuable genetic distinction, and that we should not deliberately interfere with it (for instance, by boosting the Fennoscandian population with wild birds from elsewhere), unless or until such interference may become inevitable.

3. Given the small size of the wild Fennoscandian population, if possible, a captive-breeding population of birds from this source should be established and maintained as a priority. We recognise that there are risks involved in taking eggs and/or young birds from the wild population, but that careful use of a known surplus (that is, those birds that would have died or been killed in their first winter) may be a practical conservation option.

4. We consider that every effort should be made to conserve the Fennoscandian birds down their traditional migration routes into southeastern Europe and the Caspian/Central Asian region. We recognise that this is a major challenge. We endorse the current LIFE project that aims to safeguard the birds and their habitats along the western route. It is our opinion that all appropriate efforts should also be made to conserve the wild populations of the species in its other flyways.

5. We consider that doubts do remain about the genetic make-up of the existing free-flying birds, originally introduced into the wild in Fennoscandia, and which winter in the Netherlands. It does seem to us that not all, but a large part, of the scientific community will never be completely satisfied concerning the level of genetic contamination from the Greater White-fronted Goose *Anser albifrons* and other species, which many will regard as impossible to eliminate. Despite genuine efforts to improve the genetic purity of existing captive flocks we consider that these flocks are not to be regarded as potential sources for release to the wild.

6. Given the possibility that the above-mentioned free-flying birds, or their descendants, may pose a risk to the genetic make-up of the wild Fennoscandian population, the Scientific Council is of the opinion that these birds should be caught or otherwise removed from the wild. We do not say this lightly, nor underestimate the practical and other difficulties involved. We recommend that a feasibility study be undertaken as a matter of urgency.

7. We believe that there is nothing against establishing a group in captivity of purebred Lesser White-fronts from the wild, western Russian stock, and it may well prove valuable to have such a group in the

future. However, we do not believe that it is appropriate to release such birds to the wild now or in the immediate future.

8. For the present, we do not support the introduction of Lesser White-fronts into flyways where they do not occur naturally. We have borne in mind the powerful argument concerning the improved safety of birds in these flyways, as well as practical considerations, such as current proposals that could quickly be put into effect. However, we consider that modifying the natural behaviour of Lesser White-fronts in this respect, as well as unknown ecological effects in the chosen new flyways, and other such considerations, make this technique inappropriate until such time as it may become essential, particularly when major disruption or destruction occurs of key components of the natural flyways. We do not believe that to be the case at present. We give due weight to arguments about the continuing decline of the very small Fennoscandian population, and to the estimates of how long it may continue to be viable, but we are not persuaded that such a fact alone is enough to justify radical action.

9. We consider that it would be appropriate to re-examine the issues once more in five years.

A4.2 Conclusions of the AEWA negotiation mission to find consensus among stakeholders

The CMS Scientific Council's conclusions were not acceptable to all Range States. In January 2007 the AEWA Secretariat undertook a series of consultations with representatives of the governments of Finland, Germany, Norway and Sweden, with the aim of securing a consensus.

The following are the verbatim conclusions of the negotiation mission, as drafted by the AEWA Secretariat and supported by the parties (governments) concerned. They constitute the basis for dealing with issues of captive-breeding, re-introduction and supplementing ('supplementation') of the Fennoscandian population in the framework of the SSAP.

1. The parties agree that the main priority for the conservation of the LWfG is the preservation of the wild populations breeding in Fennoscandia and Russia and that the work on the SSAP and any decisions should follow the code of transparency and accountability so that they can be subject to scientific scrutiny at any time. The parties will be considering support for conservation on the ground along their flyways. Particular attention shall be paid to mortality due to hunting and urgent targeted measures should be implemented to reduce the magnitude of this threat, the success of which shall be promptly and regularly reviewed and evaluated. Supplementation with captive-bred birds should be considered if other conservation measures are not as quickly efficient as needed and should populations continue to decline. As with any other captive-breeding, re-introduction or supplementation initiatives this project will be subject to consideration by the Committee for LWfG captive-breeding, re-introduction and supplementation in Fennoscandia (see conclusion 3 below). The efficiency of conservation measures is to be assessed by the International LWfG Working Group (see conclusion 2 below).

2. The parties agree that an International LWfG Working Group should be established, consisting of governmental representatives of all Range States, who would be free to bring in their own experts and use their support. The group will be chaired by the AEWA Secretariat (efficient chairmanship would be possible only if additional support staff (coordinator for the SSAP) and supplementary budget are made available to the Secretariat) and will operate in accordance with ToR developed by the AEWA Secretariat, approved by the Range states and endorsed by the AEWA Technical Committee.

3. The parties agree on the establishment of a Committee for LWfG captive-breeding, re-introduction and supplementation in Fennoscandia, consisting of governmental representatives of Sweden, Finland, and Norway, who would be free to bring in their own experts and use their support. The Committee will be chaired by the AEWA Secretariat (efficient chairmanship would be possible only if additional support staff (coordinator for the SSAP) and supplementary budget are made available to the Secretariat) and will

operate in accordance with ToR developed by the AEWA Secretariat, approved by the three states and endorsed by the AEWA Technical Committee.

4. The parties agree that a captive stock of wild Fennoscandian birds should be established, subject to the conclusions of a feasibility study. The long-term future of all captive-breeding programmes will be reviewed by the Committee for LWfG captive-breeding, re-introduction and supplementation in Fennoscandia.

5. The parties agree that the Swedish captive-breeding programme could carry on as long as it is based on wild birds only. The long-term future of all captive-breeding programmes will be reviewed by the Committee for LWfG captive-breeding, re-introduction and supplementation in Fennoscandia.

6. The parties agree that the current free-flying flock, breeding in Sweden and wintering in the Netherlands, will remain in the wild, subject to genetic screening and refinement, *i.e.* removal of apparent hybrids, which will be undertaken following the conclusion of a feasibility study. Furthermore the dilution with purebred birds is considered a principally viable option. The long-term future of all re-introduction and supplementation programmes will be reviewed by the Committee for LWfG captive-breeding, re-introduction and supplementation in Fennoscandia taking full account of, amongst others, the success of conservation actions, including revival of the wild Fennoscandian population, and other pertinent factors. Decisions regarding the Swedish free-flying population should also take into account the conclusions of the independent review and evaluation of available LWfG genetic studies (see conclusion 8 below).

7. The parties agree that the implementation of the pilot experimental project of the NGO 'Aktion Zwerggans' will be postponed by three years. As with any other captive-breeding, supplementation or re-introduction initiatives this project will be subject to consideration by the Committee for LWfG captive-breeding, re-introduction and supplementation in Fennoscandia.

8. The parties agree that a review and evaluation of the existing genetic LWfG studies by an independent expert(s) with proper scientific expertise and experience (ideally in molecular DNA analysis of birds, conservation genetics and statistical proficiency) should be undertaken. This work will be commissioned by the AEWA Secretariat to an independent expert(s) selected by the Secretariat too. The conclusions of this independent evaluation will be submitted to the Committee for LWfG captive-breeding, re-introduction and supplementation in Fennoscandia and the International LWfG Working Group for their consideration.

A4.3 Additional independent comments by Dr Robert C. Lacy, November 2005

Comments on the genetic issues related to re-introduction

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Chair
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I will preface my remarks by stating that I have not before been involved in any of the discussions or analyses of the LWfG or any related species. My comments below are in response to the set of documents sent to me by Sergey Dereliev of the UNEP/AEWA Secretariat.

My background is that I was trained as an evolutionary biologist, with work in population genetics, ecological genetics, and behavioural genetics. I have worked for the past 20 years as a conservation geneticist for the Chicago Zoological Society, with adjunct faculty positions at the University of Chicago and University of Illinois. My research has included: experimental studies of the effects of inbreeding and intercrossing on Peromyscus mice; analyses of the genetic changes and inbreeding effects that occur in captive breeding programs for wildlife species; development of statistical techniques for pedigree analysis and the management of breeding programs; and development of computer simulation models for population viability analysis for assessing threats to wildlife populations and testing the likely impacts of proposed management actions. I have taught short courses to wildlife managers and zoo biologists on the genetic management of endangered species. For the past 3 years, I have served as the chairman of the IUCN/SSC Conservation Breeding Specialist Group – the network of experts who provide technical assistance on matters related to use of captive breeding programs to serve species conservation, and related programs of intensive population management. I have provided advice to government agencies on the genetic management and recovery plans for whooping cranes, Puerto Rican parrots, and three penguin species, and also for many species of mammals (*e.g.*, black-footed ferrets, beach mice, and Florida panthers in the USA, eastern barred bandicoots and Leadbeater's possums in Australia, and all five extant species of rhinoceros), and a few reptile and amphibian species.

It is not clear to me if the primary disagreement about the genetic issues related to conservation actions for the LWfG is due to different opinions about the genetic data and analyses, or to different interpretations of the implications of those data for conservation, or to both the data and the conservation implications. With respect to the data themselves, it seems to me that with the most recent molecular genetic analyses, the genetic characterization of the LWfG is becoming clear (although I expect that some of those involved in the debates may still disagree with parts of my description of the information now available).

The mitochondrial DNA data show that two divergent clusters (each with a primary common type and a number of variants that differ only by one or two mutations of likely recent origin) of mtDNA haplotypes occur in the wild populations of LWfG, and an additional two general types occur in the birds in the captive breeding programs for the LWfG. The two general types (West and East) found in the wild LWfG both exist in all wild populations, but at different frequencies, although some sub-types (slight variants that would represent recent evolutionary changes) of the W and E types are unique to one region or the other. The other two general forms of mtDNA observed in the captive geese have been found to be typical of the Greater White-fronted Goose (GWfG) and the Greylag Goose. The sampling of LWfG from wild populations has been sufficiently extensive so that it is very unlikely that both the typical (E and W) LWfG and the typical GWfG forms of mtDNA are prevalent in the natural populations of LWfG (as could have occurred if both forms persisted in the LWfG from an ancestral population that preceded the evolutionary split between the LWfG and the GWfG).

In addition, although the numbers of LWfG in the wild populations has been in decline, the numbers are not so low that it would have been possible that once common mtDNA haplotypes would have been lost from the wild populations but still persisted in nonhybridized captive flocks. Even if the wild populations had lost some mtDNA haplotypes that persisted in captive flocks, it is not plausible that all the types characteristic of the GWfG (and the Greylag Goose) would have been lost – loss of haplotypes from small wild populations would be expected to have been more random. Thus, the mtDNA data do show that the captive stocks of LWfG have been hybridized with two other species.

Mitochondrial DNA are inherited only from the maternal parent, so the data on mtDNA haplotypes can show that hybridization occurred, but not how much occurred. Birds labelled as LWfG would show mtDNA haplotypes characteristic of other species only if their maternal lineage (mother, grand-mother, etc.) descended from the other species. Breeding between a male GWfG (or a hybrid) and a female LWfG would not be detectable by this method.

Variants of nuclear genes can be used to detect ancestry through the paternal side, and can be used to quantify the average amount of genetic ancestry in a hybrid population that descends from each source species. The RAPD technique can reveal species-typical DNA patterns. However, the technique relies on non-specific DNA probes (*i.e.*, sequences of DNA that bind, with uncertain fidelity, to unknown numbers of genes in each species), so that the repeatability and interpretation of those data are often uncertain. For these reasons, most geneticists are willing to use RAPD data to suggest possible patterns, but are unwilling to use them to provide rigorous quantitative estimates of population parameters – such as the degree of divergence between two populations or extent of hybridization in a possibly mixed population.

Microsatellite DNA markers (sections of repeated short sequences of DNA) provide more repeatable and precise estimates of population differences, because – if proper precautions are taken – we can confirm that the variants at each scored locus are simple alleles that follow Mendelian inheritance. The recent work by Ruokonen *et al.* assessed 10 microsatellite loci – sufficient to document that a number of captive LWfG (including some that had an mtDNA haplotype typical of LWfG) contain evidence of GWfG ancestry. Considering both types of genetic evidence, at least 36% of the captive LWfG that were analyzed were shown to have some hybrid ancestry. The close evolutionary relationship and consequent overlap of nuclear genetic alleles prevented the researchers from quantifying the proportion of GWfG ancestry in the captive stocks, but the above numbers support the view of Ruokonen *et al.* that the present captive stocks are "unsuitable for further re-introductions or supplementation."

Rigorous testing of the mtDNA and microsatellite DNA of captive birds (with, preferably, an increase in the number of microsatellite loci scored) could allow selection of birds in the captive stocks that have low probability of hybrid ancestry, but without at least 3-4 diagnostic nuclear loci (none are yet known) or good pedigree records (apparently not available for the captive stocks), it would not be possible to select a subset of captive birds that exclude all hybrid ancestry.

The combination of mtDNA and nuclear DNA data are now showing a clear pattern of moderate but not strong genetic divergence among wild populations of LWfG. The lack of sharp discontinuities in the allele frequencies and the estimated numbers of migrants that would result in the observed differences in allele frequencies indicate that there is (or recently has been) enough movement of LWfG between eastern, central, and western parts of the species range to have prevented evolutionary divergence and also to have prevented extreme loss of genetic diversity and accumulated inbreeding within any population segment. Thus, the populations do not appear to be genetically isolated to the extent that they would be considered to be evolutionarily significant units or subspecies. The populations may have diverged partially with respect to traits adapted to local conditions, but the genetic mixing makes it unlikely that important adaptive differences have become "fixed" in (*i.e.* unique to) segments of the species range. Thus, dispersing or translocated individuals may have lower fitness because they may more often have genotypes best suited for a different habitat, but each population probably still contains the range of genetic variability necessary to adapt to local conditions.

The populations in Fennoscandia appear to have some reduction in genetic variation relative to more eastern populations, but there is not yet evidence of problems arising from inbreeding, and such problems would not be likely to accumulate rapidly, given the evidence for some genetic connections to the larger populations to the east. Thus, it does not seem to me that it is necessary at this time to release individuals in Fennoscandia in order to "rescue" the population from a lack of genetic diversity.

Although I do not think that the evidence suggests a current need to provide genetic rescue of the Fennoscandian population of LWfG, I do not agree with the suggestion that restoration of genetic variation should wait until the Fennoscandian population is extinct. Release of birds from other sources (whether from captive flocks of documented origin or translocations from other wild populations) may shift allele frequencies, but given the genetic closeness of the LWfG populations in different regions it is hard to see how such releases could disrupt local adaptations to the extent that it would damage the prospects for the population. Instead, the effects of such releases would be to restore genetic variants that could have been lost from the small population and to reverse local inbreeding. Moreover, the extent of disruption of any local adaptations would be greatest if the remnant population is allowed to become nearly extinct before genetic management was resumed. Waiting until the local population is extinct would actually ensure that any local adaptations that did exist would be lost, instead of remaining within a more variable gene pool that could continue to adapt to local conditions.

In contrast to the lack of evidence of notable genetic isolation of the Fennoscandia population, the extent of divergence of frequencies of genetic alleles does indicate that interpopulational dispersal is rare enough that the populations are demographically independent (or nearly so) and should be considered to be separate conservation "management units." Thus, the movement of individuals into the Fennoscandia population is not sufficient to provide significant demographic reinforcement of a declining population; nor reestablishment of a population following regional extirpation. This is especially so if, as suggested from the mtDNA patterns, most dispersal between regions is by males, with females being more philopatric. Dispersing males are as useful as are females for preventing genetic isolation and inbreeding, but they have little demographic impact. The fact that the population in Fennoscandia continues to decline is evidence that natural dispersal among regions is not sufficient to support that population if it is not protected as an independently vulnerable management unit.

There is a difference of opinion among the experts regarding whether the small and declining wild population in Fennoscandia is doomed to extinction if it is not supplemented. I have been involved with developing and assessing population viability models for a number of endangered species (but not for the LWfG). The probability of population recovery – after the causes of decline are removed – is a function of the population size, with very small populations being more likely to experience inbreeding depression, locally imbalanced sex ratios and other difficulties in finding mates, vulnerability to disease epidemics or other local catastrophes, and other problems intrinsic to small populations. The size of population below which extinction becomes likely varies among species, based on life history, habitat characteristics, evolutionary history, and other factors. It is perhaps misleading to consider any given number to be a "critical" population size, as smaller populations are at greater risk, but there is no size below which a certainty of persistence changes to a certainty of extinction. However, for any given species and environment, the relationship between population size and extinction probability is amenable to analysis.

For relatively long-lived vertebrates (such as geese and most birds), I do not believe that the numbers that currently exist in the wild population of LWfG in Fennoscandia would allow classification of the population as either "doomed" or "safe" (*i.e.* both sides of the debate seem to have overstated their case). Many populations have recovered from even lower numbers, such as the whooping crane recovering steadily from a low of only N=15, after protective measures were implemented. However, the whooping cranes did suffer a significant loss of genetic diversity, and this is likely a cause of the observed high rate of genetic anomalies of development and high susceptibility to some diseases. If the current population of about 20-30 breeding pairs of LWfG is so low as to make damaging genetic impoverishment inevitable, then almost all captive populations of wildlife species would have to be considered to have no conservation value, as rarely are the captive stocks founded with more than 25-30 breeders. Fortunately, not very much genetic diversity is lost when a population goes through a bottleneck of about 20 pairs for one or a few generations. For example, 25 randomly breeding pairs would lose about 1% of its gene diversity (heterozygosity) per generation, allowing it to persist for 10 generations before it lost the 10% of gene diversity that has often been considered to be level of concern for stocks of wildlife or domesticated species. (Often, however, some pairs are much more productive than others, rather than there being a random distribution of breeding success, so actual losses of genetic diversity might be about twice this rate.)

On the other hand, we should not have confidence that the population of LWfG in Fennoscandia can recover without assistance. First, the current steady decline must be stopped, or else all other conservation actions will provide at best only temporary assistance. After stopping the decline due apparently to hunting mortality, the existing population may or may not be able to recover without supplementation. The persistence to today of apparently a single remnant male ivory-billed woodpecker and other examples of presumed species losses that have been avoided (or delayed) should not be taken to be evidence that that species or any species can recover from very low numbers. Florida panthers declined to perhaps only 10-20 breeding individuals for several generations, and the severe inbreeding effects were reversed only after intercrossing with another population. Black-footed ferrets had been presumed to have been rescued after a decline to only about 10 unrelated animals (and their offspring), but they are now showing declining reproductive success that most likely results from the inbreeding that occurred in the population bottleneck. The wild population of LWfG is approaching the level at which we might soon see dangerous effects of inbreeding, but the population should still be recoverable, especially if occasional natural or manipulated immigration from central and eastern populations occurs.

If a captive stock is used for supplementation of the wild LWfG, it would be wise (in light of the data discussed above) to initiate that stock with birds that are "pure" LWfG. Starting new stocks from birds captured in Fennoscandia or more eastern populations might be costly, but perhaps no more so than the extensive genetic testing that would be needed to derive a pure or largely pure population from existing captive stocks. In addition, existing captive stocks have not been managed to minimize genetic changes, so they may have adapted genetically to captivity in ways that include loss of species-typical breeding preferences that serve as isolating mechanisms. After a population is established, monitoring and genetic management of a captive population is not much more difficult or costly than maintaining a population without attention to the pedigree, and can increase the genetic effectiveness of a breeding population several-fold relative to a stock that is not managed genetically (*i.e.*, a stock managed with the methods used for wildlife species in well managed breeding programs can lose genetic diversity as slowly as would an unmanaged population that is two or three times larger).

Perhaps the most difficult issue facing the conservation and management authorities is to decide what to do with already released birds (and their descendants) that carry non-LWfG genes. It may not be possible to remove these birds or the hybridized genomes from the wild, especially if they have already further interbred with the remnant wild population. It is possible that species-isolating mechanisms have broken down in the hybrids, so that the released birds and their descendants might now provide a path for continued introgression of genes from GWfG into LWfG populations. Otherwise, the extent of introgression of non- LWfG genes into Fennoscandian populations is probably not so great that it will do long-term damage to the ecological and evolutionary future of LWfG in Fennoscandia. A very small amount of gene flow from closely related species is not an uncommon occurrence in natural populations. Future releases of documented LWfG, occasional immigration from central and eastern populations, and natural selection could all serve to slowly reduce the level of genetic contamination of the LWfG and restore the species to a genetically more natural condition.

ANNEX 5: A POPULATION VIABILITY ANALYSIS FOR THE FENNOSCANDIAN LESSER WHITE-FRONTED GOOSE POPULATION AND THE IMPACT OF POPULATION SUPPLEMENTATION

A5.1 AIM OF THE POPULATION MODELLING

The aim of the modelling exercise was to adequately simulate the demography, and hence population change, in the LWfG population breeding in Norway, and to use this as a tool to examine the likely impacts of a supplementation programme on this population.

The steps taken were:

1. Development of the population model, using knowledge of goose population biology, empirical data from the population breeding in Norway, and data from congeneric species where necessary.
2. Testing of the model's ability to hindcast recent trends in the population, and adjustment to the model as necessary.
3. Running the corrected model into the future, to examine predicted trajectories of the population under current conditions.
4. Running the model under a set of scenarios in which varying numbers of fledgling geese are released into the population in autumn over a varying number of years, and examining the consequences for the population size over time.
5. Examining the consequences for the Norwegian breeding population of removing fledglings for development of a captive population.

The model outputs allow the mean population growth rate to be calculated for each scenario, but also, and very importantly, the probability of population extinction within a given timeframe. Note that even populations that are, on average, increasing, can go extinct due to chance variations in demographic rates.

Given the many assumptions made in the model (see below), it would be very unwise to treat the absolute values of the model outcomes (*e.g.* probability of extinction within a particular number of years) as hard predictions. Rather, attention should focus on the relative differences between the different scenarios as a guide to the likely efficacy of different management options. Nevertheless, even given its limitations as a predictive tool, a quantitative modelling approach that captures the main features of the population's biology and ecology is a substantial improvement on an approach that does not use modelling.

A5.2 INTRODUCTION TO THE MODEL

A discrete-time, age-structured, stochastic population model was developed using Visual Basic for Applications (VBA) in Microsoft Excel. Where possible, observed demographic rates from the existing Norwegian breeding population between 1994 and 2008 were used (95). Where these were not available, data from other well studied *Anser* species were used.

The model simulates the Norwegian LWfG population through a series of steps that summarise the annual demographic cycle. The parameters we chose to estimate – and hence the model structure – were based on data availability and the features of the life cycle that are relevant to conservation management possibilities. For example, we broke 'productivity' into several separate steps, because this could allow the impact of Red Fox control to be modelled in detail in future.

We did not, however, separately estimate nest survival and gosling survival, since no data were available. Similarly, we separately estimated survival for the two different migration routes, despite a lack of good empirical data, because the differential survival on the two different routes has important implications for extinction risk and management options.

The model incorporates inter-annual variation in the values of most of the parameters (Table A5-1). This simulates environmental variation between years (*e.g.* in weather conditions, predator abundance) causing variation in population mean demographic rates. This was achieved by, for each year of a model run, picking random values from a distribution around the mean observed, or inferred, value`. The variances were estimated empirically from the Norwegian breeding population, or from congeneric species (see below for details).

Similarly, we incorporated demographic stochasticity by assuming that, for each variable in a given year, the value realised by the population would be the outcome of a series of independent (usually binomial) trials with the probability for each trial being the population-level mean for that year as previously calculated.

Accounting for environmental and demographic stochasticity in this way is very important because, in a small population such as this one, irrespective of mean values of the demographic variables, environmental fluctuations and chance events in demography can greatly increase the risk of population extirpation. One of the main benefits of a supplementation programme, by increasing the population, could be to substantially reduce the likelihood of such random events causing population extirpation. It is not possible formally, however, to separate process error from measurement error, and demographic from environmental stochasticity in the empirical data available for this species. Our methods are a simple approximation of such a distinction.

The model is age-structured, but in a relatively simplified manner. Annual survival is estimated separately for 0-year olds (*i.e.* for the period between fledging and the following summer as a 1-year old) and all other ages. Breeding propensity is estimated separately for 1, 2 and 3+ year olds. There is some evidence from other species that clutch size, breeding success and survival may vary over more age-classes than this, but for the sake of simplicity, and in the absence of direct evidence of such effects in this population, we ignored this.

The model is female-based in the sense that productivity is based on female numbers and age-distribution. However, males in the population are modelled, because sex ratios (and random fluctuations therein) and the possibility of females being unable to find a mate, are important factors in extinction risk of small populations. In addition, for this population, the existence of unpaired females is a potential mechanism for immigration of males from the Western Main population, and this may be an important factor.

For each scenario (set of assumed model parameters), the model outputs the number of birds in each sex and age-class in each year for 100 years from the start of the 'run'. Because this is a stochastic model, each scenario is run 1,000 times to capture the variability of the outcomes that result from environmental variations and demographic stochasticity.

A5.3 PARAMETERS ESTIMATED IN THE MODEL

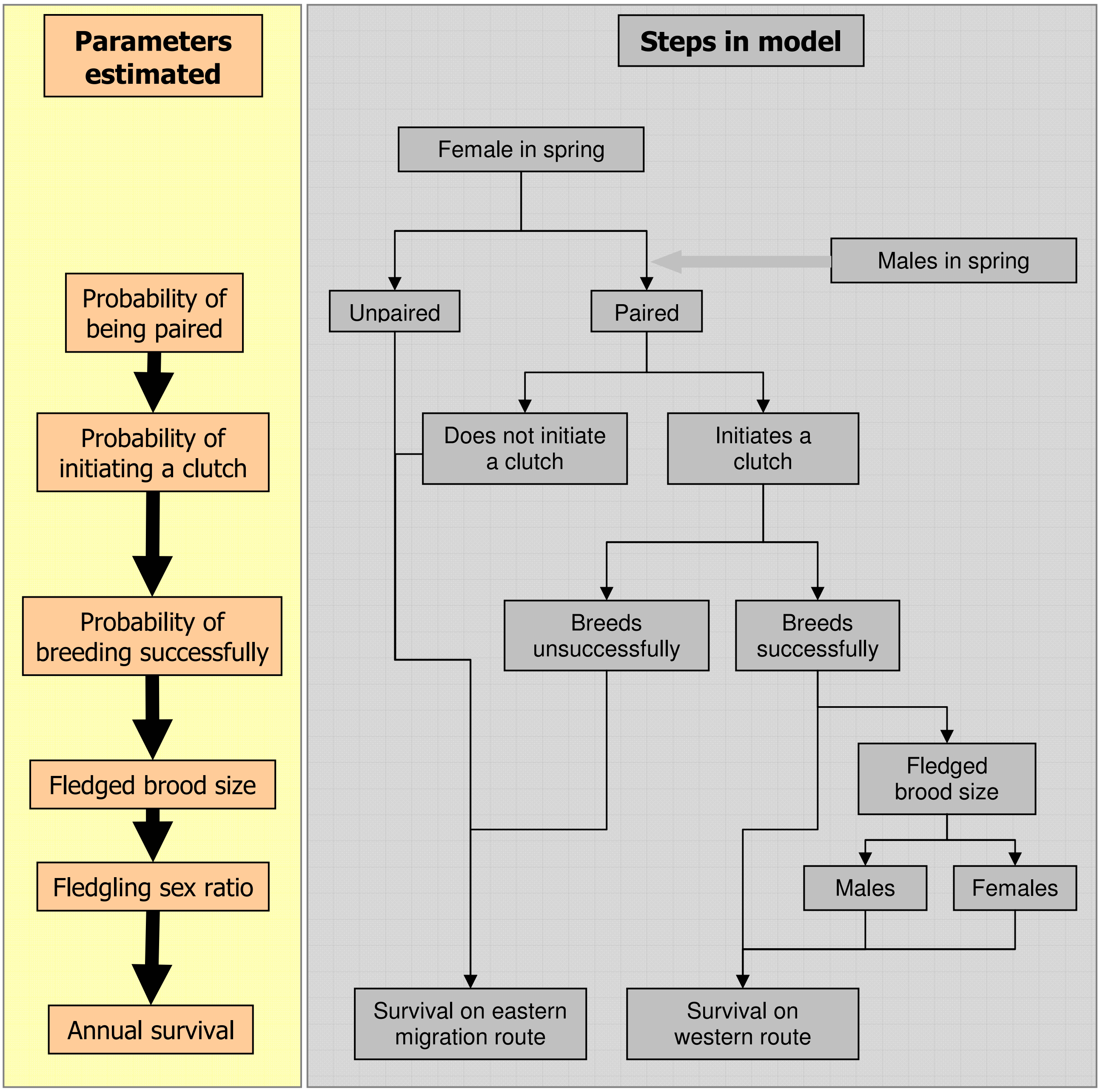

Figure A5-1. Outline of model structure and parameters estimated.

A5.4 MODEL ASSUMPTIONS

The model makes many simplifying assumptions in relation to age- and sex-specificity of parameter values, and the parameter estimates themselves are based on small data-sets, or data-sets that are not derived directly from the population in question.

It also assumes no effect of inbreeding on demographic rates. This is considered realistic because of the clear evidence of substantial immigration, at least of males, from the relatively large Western Main population.

The model assumes no density-dependence and no Allee effects, other than demographic stochastic processes. Density-dependence seems unlikely to play an important role in this population at present or while the population remains very small, since it is vastly below historic levels. There may be Allee effects on survival or emigration due to small flock sizes on migration/wintering, but we have no empirical data with which to estimate these.

The model assumes no senescence (age-related decline in demographic parameters), in common with most wildfowl population models.

A5.5 DETAILED MODEL DESCRIPTION – PARAMETERS ESTIMATED

A5.5.1 Probability of being paired

A5.5.1.1 The age-specific probability of a female, present at Valdak Marshes in spring, being paired, and therefore potentially able to lay a clutch of eggs

In very small populations of monogamous species, the probability of some females being unpaired – and thus non-reproductive – due to a sex ratio that is biased due to demographic stochasticity becomes significant. This factor was incorporated into the model by allocating, at the start of the breeding season, all available 2+ year males firstly to adult females (3+ year old, *F3*), and subsequently to sub-adult females (2-year old *F2*). If females were still unpaired when all males had been allocated (*i.e.* there are more females than males in the population) then remaining females remain unpaired. This generates age-specific probabilities of being paired, $ppair_2$ and $ppair_3$ for *F2* and *F3*, respectively). We assume that 1-year old females do not breed, so pairing is not estimated for these birds.

Thus the outcome of this step is a calculated age-specific number of paired females ($rpair_2$ and $rpair_3$).

A5.5.2 Breeding propensity

A5.5.2.1 The age-specific probability of a paired female making a breeding attempt (laying a clutch)

Breeding propensity was modelled as 0.5 for 2-year old females and 0.85 for 3+ year old females, (as assumed by 81) based on data for Snow Geese.

In the absence of empirical data on (inter-annual) environmental variation in breeding propensity, but assuming, based on Arctic goose biology (25), that such variation exists, for each year of a run we randomly picked age-specific values from a normal distribution with mean age-specific values as above, and SD = 0.05, with values >1 truncated at 1, to give predicted propensity pp_x for age-classes 2-year old (pp_2) and 3+ year old (pp_3). To separately simulate individual demographic stochasticity in breeding success, the realised breeding propensity rp_x of the population in each year was determined as a series of n binomial trials, where n is the number of pairs, and the prior probability of success = pp_x.
Thus this step produces an estimate, for a given age-structured population of paired females, of the number that lay a clutch of eggs.

A5.5.3 Breeding success

A5.5.3.1 The probability of a laid clutch producing ≥1 fledgling

Breeding success in the default model was estimated as 0.47 (SD of annual values = 0.12). Note that the model does not separately estimate hatching success and fledging success. No empirical data are available on this for the study population.

Empirical values of breeding success are available for the Norwegian breeding population, 1994–2008, in the form of a spring pair count and an autumn fledgling count at Valdak Marshes. We accounted for non-breeding (*i.e.* those birds that were paired but did not lay a clutch, see previous section), by adjusting the pair-count in each year downward, according to the age-specific model values of breeding propensity (see above), to derive an adjusted value of breeding success.

Because it is very difficult to age 2-year old birds following moult, there are no data on the relative breeding success of 2-year old *vs.* 3+ year old birds, although it is possibly lower in the former group. In this model, we assume no age-related differences in breeding success.

There is substantial between-year variation in breeding success (generalized linear model with success/failure of each pair as a binary variable and logistic link-function indicates that a model containing a categorical year factor is significantly better than an intercept only model, Chi-sq test $P<0.001$). To simulate this environmental variation, in each year of a model run, a value was picked at random from a normal distribution to represent the predicted population-level breeding success, *ps*. To simulate individual demographic stochasticity in breeding success, the realised breeding success, *rs*, of the population in each year was determined as a series of n binomial trials, where n is the number of pairs, and the prior probability of success = *ps*.

Thus this step gives, for a given number of females that laid a clutch, the number that successfully fledged at least one chick.

A5.5.6 Fledged brood size

A5.5.6.1 Number of fledglings in successful breeding attempts (*i.e.* those where ≥ 1 fledgling was produced)

Observed fledged brood sizes in the Norwegian breeding population, 1994–2008 (n = 142 broods), were used to generate mean brood size and its variance. Brood sizes varied from 1 to 6, with a mean of 3.07, and a probability distribution shown in Table A5-1.

There is no evidence of systematic between-year variation in fledged brood size (ordinal logistic regression with brood size as response variable, models with year as categorical factor and with intercept only, NS). Therefore no inter-annual variation in brood size was simulated. Individual demographic stochasticity in brood size was simulated by randomly picking, for each successfully breeding pair, values from within the observed probability distribution of brood sizes, and these values combined for each year to give *rb*, the annual mean brood size.

Table A5-1. Distribution of fledged Lesser White-fronted Goose brood sizes in the Norwegian breeding population from observations at Valdak Marshes, 1994–2008.

Size of successful brood	Frequency
1	0.141
2	0.254
3	0.233
4	0.169
5	0.169
6	0.035

Thus the outcome of this step is a number of 0-year old fledglings, in autumn.

A5.5.7 Fledgling sex ratio

Hatching sex ratios in wildfowl are typically approximately 50:50, and we assume that this is the ratio of fledglings in our model population. To allow for potential random variations in sex ratio, for each cohort of *n* 0-year old birds, the realised number of males and females is calculated based on a series of *n* binomial trials where probability of being female = 0.5, giving, for each year, the proportion of males and females among the fledglings (p_{male}, p_{female}).

Thus the outcome of this step is a number of 0-year old male and female fledglings, in autumn.

A5.5.8 Immature, sub-adult and adult annual survival

A mark-recapture analysis of ringed individuals in the Norwegian breeding population was conducted in Program MARK (Aarvak and Øien unpublished data). This analysis suggested average annual survival of 1+ year old birds was 71.5% (SE 5.96%). There was insufficient power to test for age- or sex-related differences in survival, and so constant survival across age-classes and sexes was assumed, though this is likely to be a simplification (108, 109, 81, 111).

In MARK analyses, a model including time-dependent survival (*i.e.* annual environmental variation in probability of survival) was rejected. However, substantial inter-annual variation in survival probability is the norm in Arctic goose populations, and is likely to occur in this population. The failure to detect it is likely a result of very small sample sizes, which is inevitable in a population of this size.

In addition, current information suggests an important additional factor in survival calculations. It is believed that there are two discrete migration routes followed by this LWfG population. Failed breeders (or at least, those that fail relatively early in the breeding season) along with non-breeders (including 1-year old immatures) take an 'eastern route', undertaking a lengthy moult migration to Arctic Russia, followed by migration through Russia and Kazakhstan. Successful breeders and their offspring take a 'western route' through Eastern Europe. All birds are thought to have a common wintering area, centred on, and a common return route through Europe. Birds on the eastern route are believed to be subject to higher hunting mortality, and hence lower survival probability. The crucial upshot of this is that survival is likely to be correlated with breeding success at the annual level, since in years of poor breeding success more birds will take the eastern route. This tends to increase extinction risk, and hence it is important to include it in the model.

To account for these two issues, we modelled survival as follows:

During the years 1998–2008, 1+ year old survival was estimated as 71.5%.

During this period, we assumed that approximately 31% of the 1+ year old population would have migrated on the 'western route', by assuming that only successful breeders do so (in reality this is likely to be an underestimate of unknown magnitude, because some birds whose nesting attempt fails late in the breeding season probably also take the western route).

Based on data from other goose populations under varying degrees of hunting pressure (110, 108, 109), we estimated that survival on the western route with rather low hunting pressure was 15% higher than survival on the heavily hunted eastern route. This is an arbitrary and currently untestable value.

By combining the estimated survival, proportion on the two respective migration routes and the assumed survival difference between routes, we separately estimated mean survival for the eastern and western routes as $psad_w$ = 68.3% and $psad_e$ = 78.63%, respectively, which gives an observed whole population-level survival of 71.5% for 1998–2008.

To simulate inter-annual variation in survival, for each year of a model run we picked a random value from a normal distribution with mean = $psad_x$ and SD = 5%, with the standard deviation being broadly in line with observed inter-annual variation in large populations of Arctic geese (109, 111). Note that in each year the random values were separately estimated for the eastern and western routes, since it is reasonable to assume that factors affecting mortality rates on the two different routes are at least partially separate.

To simulate individual demographic stochasticity in survival, for each year of the run, the realised survival for each migration route ($rsad_w$ and $rsad_e$) was calculated based on a series of *n* binomial trials, where *n* was the number of birds using that route, with probability of survival = ps_x.

A5.5.9 Juvenile survival

Survival of 0-yr olds (*i.e.* survival between fledging and 1-year old) was estimated by directly relating the spring Valdak Marshes count of 1-year old birds to the previous autumn's count of fledglings, and assuming no net immigration/emigration (Table A5-2), giving a mean value of 27.3%. Note that all juveniles are believed to use the western migration route, and consequently there are no separate survival estimates for this age-class. In the absence of empirical data, survival was assumed to be the same for both sexes.

Table A5-2. Counts of autumn Lesser White-fronted Goose fledglings and 1-year old birds in the succeeding spring, Valdak Marshes, 1994–2008.

Year (of hatching)	Number of autumn juveniles	Number of 2nd calendar year birds next spring	Survival
1994	33	10	0.30
1995	67	10	0.15
1996	23	7	0.30
1997	32	5	0.16
1998	31	7	0.23
1999	17	6	0.35
2000	2	0	0.00
2001	38	14	0.37
2002	34	9	0.26
2003	27	13	0.48
2004	12	3	0.25
2005	16	10	0.63
2006	23	2	0.09
2007	33	10	0.30

A generalised linear model (survival probability = year (categorical factor), with a binomial distribution and logit link function) indicated that there is significant inter-annual variation in juvenile survival (Chi-sq = 24.3, df = 13, P = 0.04). Consequently, we estimated predicted *psjuv* in each year of the run by picking at random from a normal distribution with mean = 27.3% and SD = 16% (the observed level of variation).

To simulate individual demographic stochasticity in survival, for each year of the run, the realised survival (*rsjuv*) was calculated based on a series of *n* binomial trials, where *n* was the number of birds using that route, with probability of survival = *psjuv*.

The outcome of the survival step was an estimate of spring numbers of birds in all age-classes and for both sexes.

A5.5.10 Immigration and emigration

The Norwegian breeding population comes into contact with the much larger Western Main population of LWfG, via the use of a common moulting site and the eastern migration route by failed/non-breeders from the Norwegian breeding population. This gives considerably opportunity for exchange between the populations. The numbers of birds involved their age and sex-distribution, and the intrinsic and extrinsic factors that affect the rate of population exchange are poorly known. However, DNA studies indicate that a substantial proportion of the Norwegian breeding population's males may be of Western Main origin (Aarvak & Øien unpublished data). Goose biology indicates that male immigration into (and emigration from) Norway is much more likely than female, because females tend to be strongly philopatric, whereas males will follow their mates (which may be acquired on the moulting or wintering grounds) to a breeding site. Analysis of the observed Norwegian population trends and age-structure 1998–2008, in relation to the observed productivity and estimated survival, indicate that considerable (as a proportion of the population) immigration needs to be invoked to explain some abrupt short-term increases in the population. However, nothing is known about the sex ratio of immigrants, or whether there genuinely is a periodic 'pulse' of immigrants rather than annual exchange, or about the factors which caused the apparent immigration. One explanation might be that immigration is large when a skewed sex ratio among Norwegian birds leads to a high proportion of unpaired females at moult sites in Russia, which acquire Russian mates.

Immigration from the Western Main population is important to the model outcomes, because in some situations immigration might have an important 'rescue' effect on the population. In the absence of detailed information, we assumed male-only immigration whereby any unpaired 2+ year old females in the Norwegian population that take the eastern route acquired a Western Main population mate in autumn (thus retaining the potential for either the female or the immigrant male to subsequently die before the next breeding season).

A5.5.11 Correlations between parameters

Correlations between separate demographic parameters have important implications for demographic rates and extinction risk. There was no correlation between annual probability of successful breeding and mean brood size (Pearson correlation, $r = 0.18$, $P = 0.53$, $n = 15$ years). We have no empirical data on breeding propensity, so we cannot model a correlation between propensity and other breeding parameters.

We expect (but current data are insufficient to demonstrate) a positive correlation between breeding success and adult survival, because successful breeders tend to take the western migration route, which results (it is believed) in higher survival. Our model incorporates such a correlation, by using separate survival estimates for the western and eastern migration routes, and estimating the proportion of birds taking each route directly from the breeding success data.

It is likely that there are positive correlations between juvenile survival and adult survival (at least on the western route which is the one which juveniles are believed to take). However, in the absence of empirical data, we have assumed no correlation in the model.

A5.5.12 Model outputs

In each year of each model run, the following values are calculated:

M_0 (0 year males) = $(F2 \times rpair_2 \times rp_2 \times rs \times rb \times p_{male}) + (F3 \times rpair_3 \times rp_2 \times rs \times rb \times p_{male})$

F0 (0 year females) = $(F2 \times rpair_2 \times rp_2 \times rs \times rb \times p_{female}) + (F3 \times rpair_3 \times rp_2 \times rs \times rb \times p_{female})$

M1 (1 year males) = $M_{0(t-1)} \times rsjuv$

F1 (1 year females) = $F_{0(t-1)} \times rsjuv$

M2 (2 year males) = $M1_{(t-1)} \times rsad_e$

F2 (2 year females) = $F1_{(t-1)} \times rsad_e$

M3 (3 year males) = $(M2_{(t-1)} \times (rpair_2 \times rp_2 \times rs) \times rsad_w) + (M2_{(t-1)} \times (M2_{(t-1)} - (rpair_2 \times rp_2 \times rs)) \times rsad_e) + (M3_{(t-1)} \times (rpair_3 \times rp_2 \times rs) \times rsad_w) + (M3_{(t-1)} \times (M3_{(t-1)} - (rpair_2 \times rp_2 \times rs)) \times rsad_e) + ((F2 - rpair_2) \times rsad_e) + (F3 - rpair_3 \times rsad_e)$

F3 (3 year females) = $(F2_{(t-1)} \times (rpair_2 \times rp_2 \times rs) \times rsad_w) + (F2_{(t-1)} \times (F2_{(t-1)} - (rpair_2 \times rp_2 \times rs)) \times rsad_e) + (F3_{(t-1)} \times (rpair_3 \times rp_2 \times rs) \times rsad_w) + (F3_{(t-1)} \times (F3_{(t-1)} - (rpair_2 \times rp_2 \times rs)) \times rsad_e)$

Where t is the year of the model run, $ppair_x$ is the age-specific probability of being paired, rp_x is age-specific realised breeding propensity, rs is realised breeding success, rb is realised brood size, p_{male} is the proportion males and p_{male} the proportion of females among fledglings, $rsjuv$ is 0 year survival, $rsad_x$ is the migration-route specific 1+ year survival.

A5.6 RESULTS

A5.6.1 Initial values, stable age structure and model validation

The model was initially run with default values for all parameters, and creating an initial population with the same population age-structure as the spring 1998 Valdak Marshes count (2). Unpaired sub-adult or adult birds were assumed to be males, and 1-year birds were assumed to have a 50:50 sex ratio.

This model scenario produced a population trajectory that was similar to the observed trajectory for 1998-2008 (Figure A5-2); all but one value of the observed population lay within the 95% confidence limits for the model population. However, there was a tendency for the model population to systematically underestimate the observed population during 2003-2008. This may indicate that the demographic rates of the population have changed favourably during this period, although none of the measured parameters have noticeably done so. Alternatively, it may simply reflect random variations in the trajectory.

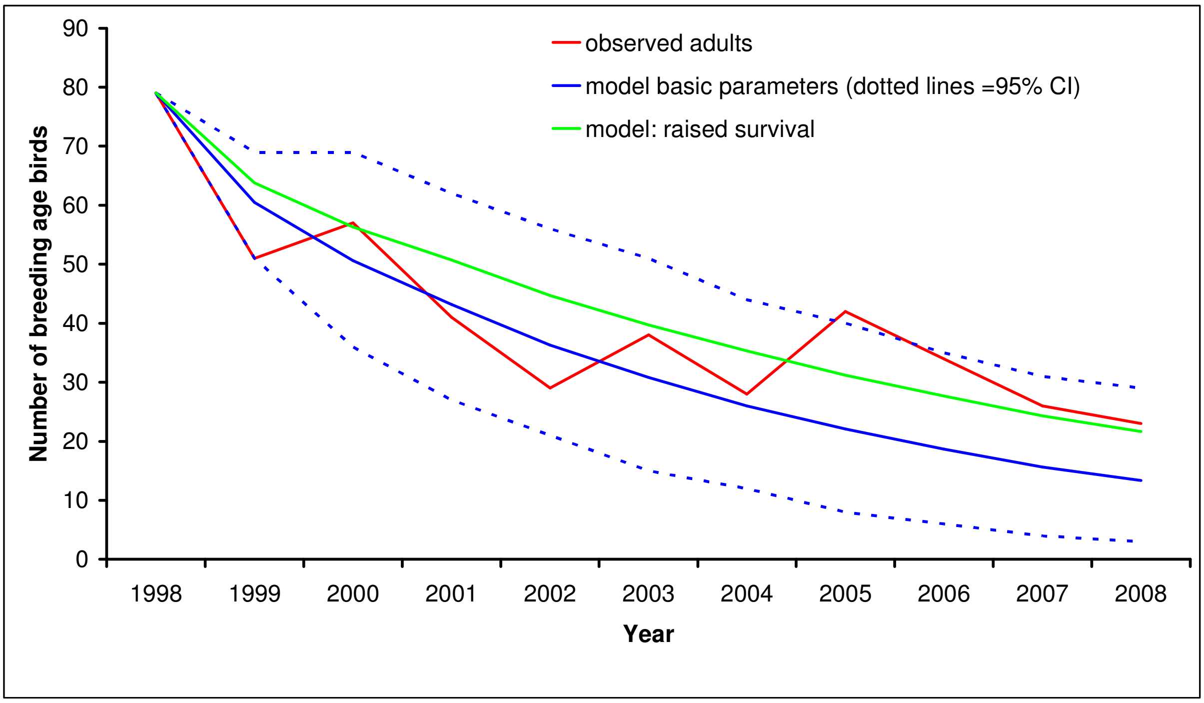

Figure A5-2. Norwegian Lesser White-fronted Goose population size and model validation runs. Adult birds are all 2+ year olds. Modelled values represent the mean of 1,000 model runs with a given parameter set.

The difference between observed and modelled values is important for such a small population. The parameters determining productivity are directly measured, and unlikely to be inaccurate. However, survival values are more crudely estimated, and immigration is largely unknown. Therefore, in order to achieve a model trend that most closely matches the observed trend, we multiplied all survival values by 1.05, giving adjusted default values of 0.287, 0.717 and 0.825 for 0-year survival, adult survival on the eastern route and adult survival on the western route, respectively (see Figure A5-2).

In order to examine population sizes and extinction risk under different management scenarios, we needed to create an initial population size and structure which approximates the current Norwegian breeding population as a start point for model runs. To do this, we started all model runs in 1998. To account for the undetected birds in spring counts at Valdak Marshes, we multiplied the number of birds detected in spring 1998 by 1.3 (3, p74). We divided these among age classes by taking the stable age structure from years 6-10 of a trial run of the model (15% 1-year old, 12% 2-year old, 73% 3+ year old) and created an even sex ratio. Thus, there were eight 1-year old males, eight 1-year old females, seven 2-year old males, seven 2-year old females, 40 3-year old males and 40 3-year old females at the start of each run.

The probability of extinction over the next century in these basic models was assessed (Figure A5-3). The model indicates that there is a 50% probability of extinction by approximately 2018 to 2027 (depending on whether the basic or adjusted parameter values are chosen, see above), and that extinction is highly likely (90%) by approximately 2030 to 2040.

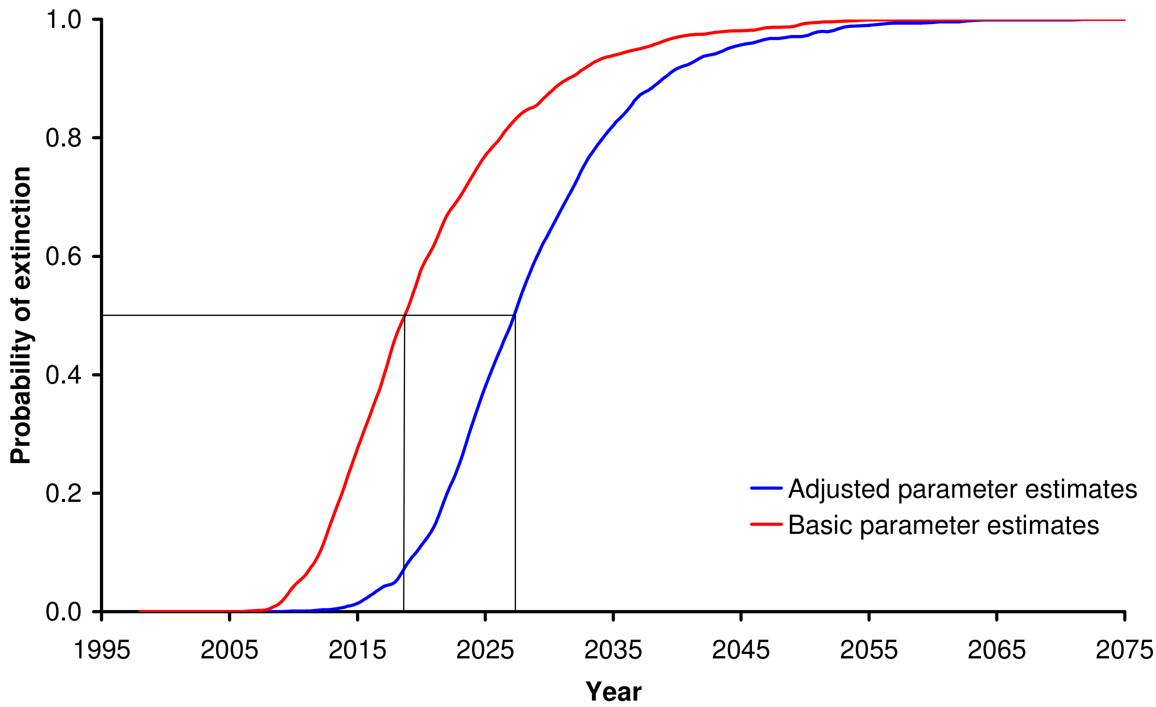

Figure A5-3. Probability of extinction of the Norwegian breeding population of Lesser White-fronted Goose at current demographic rates.
Probabilities represent the proportion of 1,000 model runs that had reached quasi-extinction (zero remaining females) by a given time. 'Basic parameter estimates' are the demographic parameter values empirically calculated, and slightly over-estimate the 1998-2008 population decline rate (see text). 'Adjusted parameter estimates' are the basic parameter estimates, with survival values multiplied by 1.05 to achieve a population trend similar to the observed 1998-2008 trend.

The survival values needed to reach a relatively stable (*i.e.* not rapidly increasing or decreasing) population size in the model were assessed. We assumed constant productivity equal to the values in the default model, and multiplied the three different survival values (0-year old survival, survival of 1+ year olds on western route, survival of 1+ year olds on the eastern route) by a constant, until population stability was reached. The required annual survival values were 0.32, 0.93 and 0.81, respectively. Combining the 1+ year old survival rates for the two different migration routes and the modelled proportion of birds taking the two different routes gives a required whole-population survival of 0.86. These values represent an 18.5% proportional increase over the empirically calculated values for the population.

These values of 1+ year old survival are within the range of observed Arctic goose annual survival values, but appear to be rather high for a population that is not increasing (112, 108, 109, 111, 113, 114, 115, 116, 117, 118, 119, 120). The most likely explanation for this is that the values of 0-year survival that we use are rather low, relative to most goose populations – note that our 0-year old survival estimates are based on raw count data, and not on a capture-mark-recapture analysis, and take no account of detection probabilities.

We then examined the combinations of juvenile and adult survival that would deliver a relatively stable population size at the observed productivity (Figure A5-4). These values indicate that if juvenile survival is substantially underestimated, the population would be relatively stable (at the observed productivity) with annual adult survival of approximately 0.80.

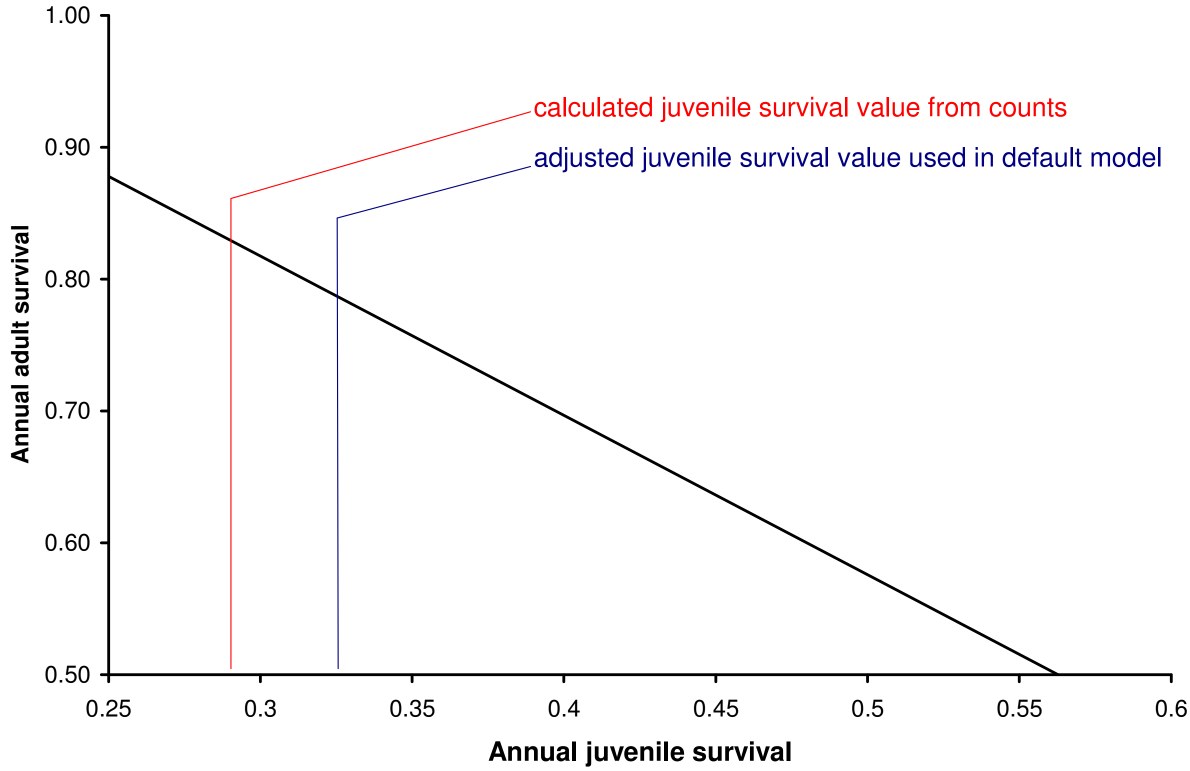

Figure A5-4. Combinations of 1+ year old and juvenile Lesser White-fronted Goose survival that deliver population stability.

These initial model tests indicate that the adjusted model performs reasonably well at simulating the recent dynamics of the Norwegian breeding LWfG population, and agrees reasonably well with demographic models of other Arctic goose populations. Nevertheless, we stress that the parameter estimates in the model are subject to several major assumptions and considerable imprecision, and that these assumptions have not formally been tested. The model outcomes should be seen as giving an impression of the relative differences between different scenarios, rather than as absolute predictions of timescales and population sizes.

A5.6.2 Population supplementation

We examined the impact of supplementing the population with captive-bred 0-year old birds, comparing the effect of releasing different numbers of birds over a constant number of years, and releasing the same number of birds over different time periods.

In all supplementation scenarios, the released birds are assumed to have a 50:50 sex ratio, and to have 0-year old survival and subsequent productivity equal to that of wild-bred birds of the same cohort. It is very important to note that the model does not evaluate the likelihood or the proportion of released captive-bred birds successfully integrating into the wild population, whether in the short-term (*i.e.* migrating with wild birds in their first autumn) or in the long-term (*i.e.* behaviourally capable of pairing and breeding in the wild). In effect this means that the number of released birds can be considered the 'effective' number that do integrate with an (unknown) additional number needing to be added to the release cohort to achieve this result.

Supplementing the population for eight years with 10-50 birds per year essentially provides a temporary, unsustained boost to the adult population, and provides approximately 10-20 years before the population decreases to the level observed at the start of the supplementation programme in 2012 (Figure A5-5).

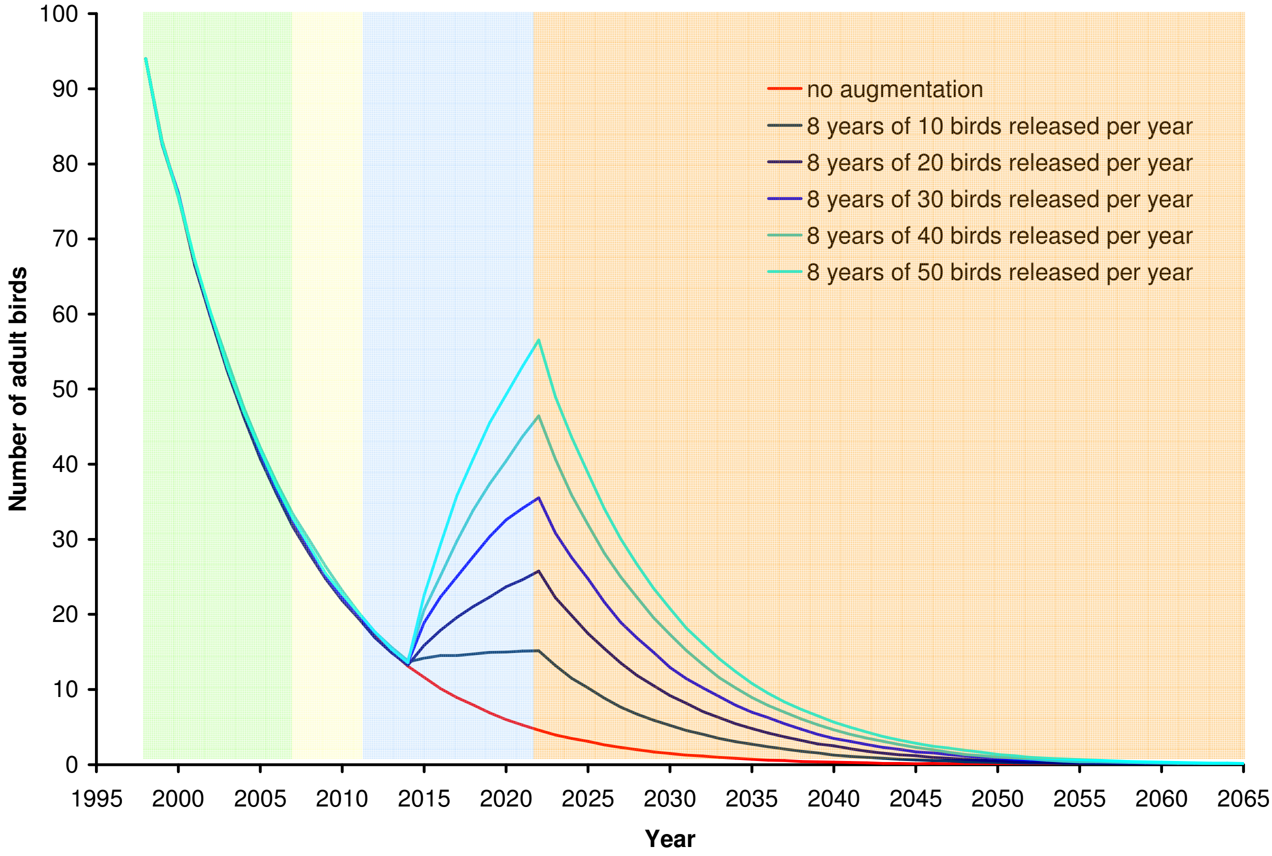

Figure A5-5. Effect of eight years of supplementation on the size of the Norwegian breeding population of Lesser White-fronted Goose for different numbers of released birds.
Green section represents the period from model start (1998) to present (2008); yellow section represents pre-release phase of supplementation programme (2008–2012); blue section represents supplementation period; and brown section is post-supplementation.

Similarly, this supplementation effectively postpones extinction by approximately 10–20 years, depending on the number of birds released (Figure A5-6). Although the duration of the boost to the population is greater for greater numbers of birds released, there are quite strongly diminishing returns.

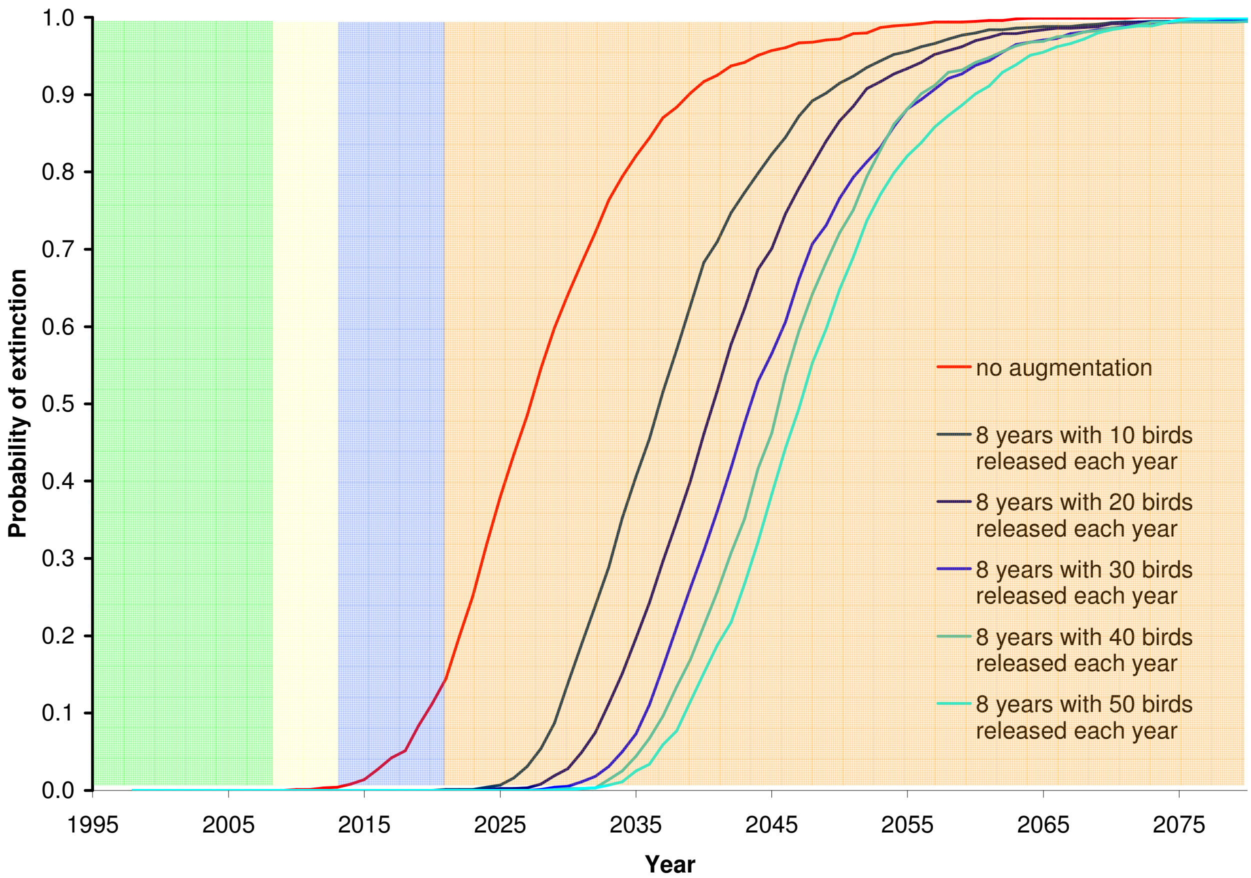

Figure A5-6. Effect of eight years of supplementation on extinction risk of the Norwegian breeding population of Lesser White-fronted Goose, for different numbers of released birds. Green section represents the period from model start (1998) to present (2008); yellow section represents pre-release phase of supplementation programme (2008–2012); blue section represents supplementation period; and brown section is post-supplementation.

For a constant number of birds released, the duration over which the releases take place has relatively little effect on the outcome for the population (Figure A5-5, Figure A5-6): releasing 160 birds over eight years marginally prolongs the time to extinction, and increases the population at a given time point, compared to releasing 160 birds over four years.

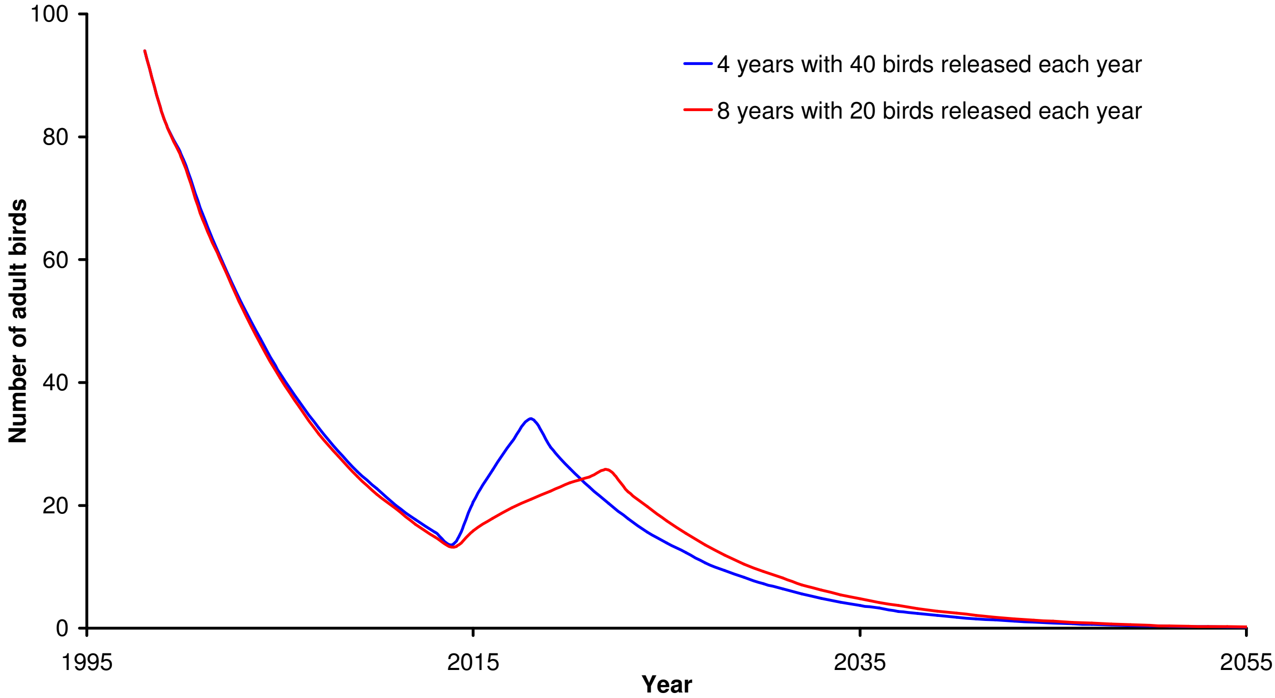

Figure A5-7. Number of adult birds as a function of duration of supplementation programme.

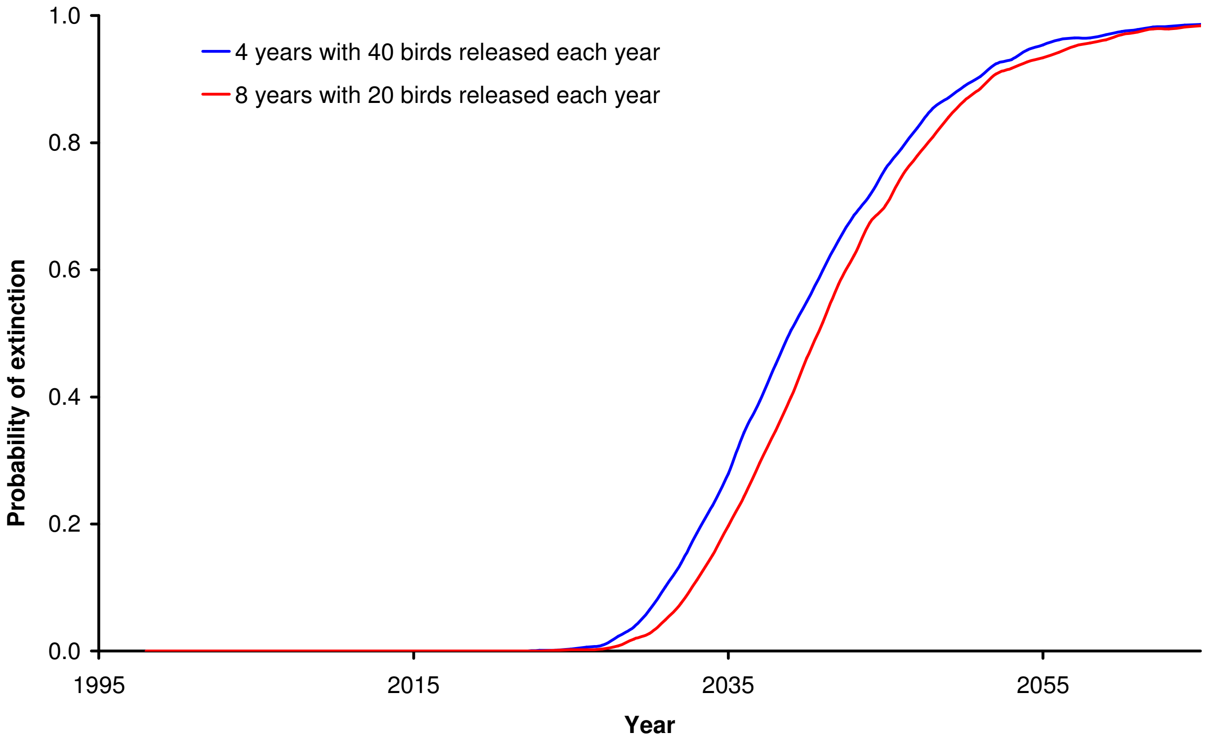

Figure A5-8. Probability of extinction as a function of duration of supplementation programme.

Supplementation has rather little effect on population outcomes beyond an immediate increase in the population, because it does not fundamentally change any of the demographic rates in the population. This is a key message of the model: without *in situ* conservation action to improve demographic rates, the population will continue to decline regardless of a supplementation programme. The benefits of the supplementation programme lie in its potential to lengthen the time to extinction, and consequently provide time for *in situ* action to take effect.

In addition, the avoidance of more extreme Allee effects might be an important benefit of supplementation. In general the model does not capture this process. The potential for demographic rates to worsen as the population gets smaller is clearly considerable, but unquantified, except in respect of one, relatively small, indirect effect. The model captures the lower reproductive output of the population as it decreases, which results from potentially higher proportions of unpaired birds. In this particular model population, the effect is relatively slight, because we assume that unpaired females tend to pick up immigrant males from the Russian population. Nevertheless, it is a detectable effect (Figure A5-9).

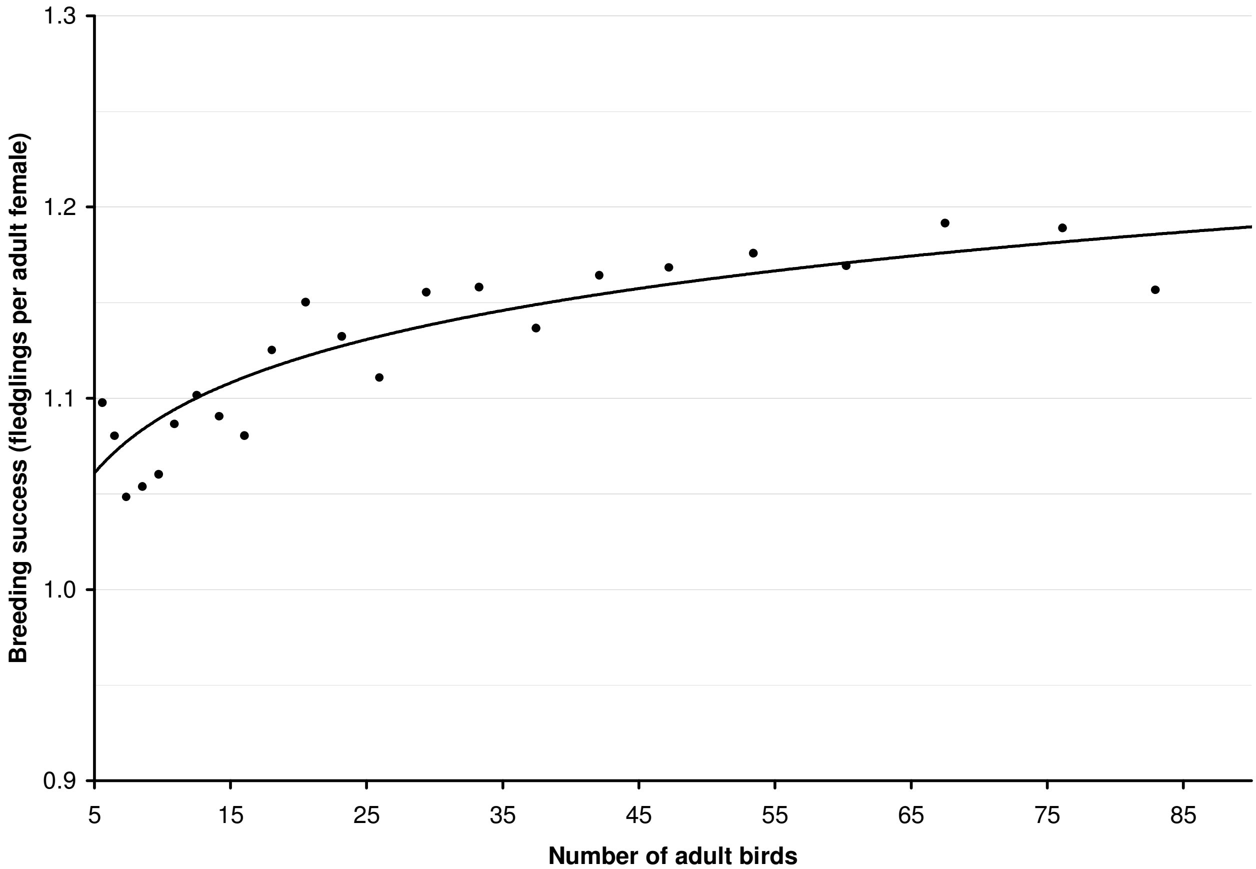

Figure A5-9. Relationship between productivity and population size in the model Lesser White-fronted Goose population.
Values are average values from 1,000 runs for different years (with different population sizes) of the default model with no population supplementation.

A5.6.3 Supplementation in a stabilised population

We modelled the effect of simultaneously stabilising the wild population by improving survival, and supplementing the population with releases of 0-year old birds. These scenarios help to examine whether, if the population trend can be stabilised, supplementation might significantly improve the conservation status of the population, or conversely, whether, if the population is stabilised, supplementation is largely immaterial.

Figure A5-10 shows that by 2013 the adult population is only approximately 20 birds. If survival in this population is increased to a level that delivered a relatively stable population when the population was approximately 90 adult birds (juvenile survival = 0.32, adult survival = 0.86), the population continues to decline very slowly, because reproductive output tends to fall at very low population levels (Figure A5-9). Supplementing this very small population at the same time as improving demographic rates produces a slowly increasing population of approximately 100 birds.

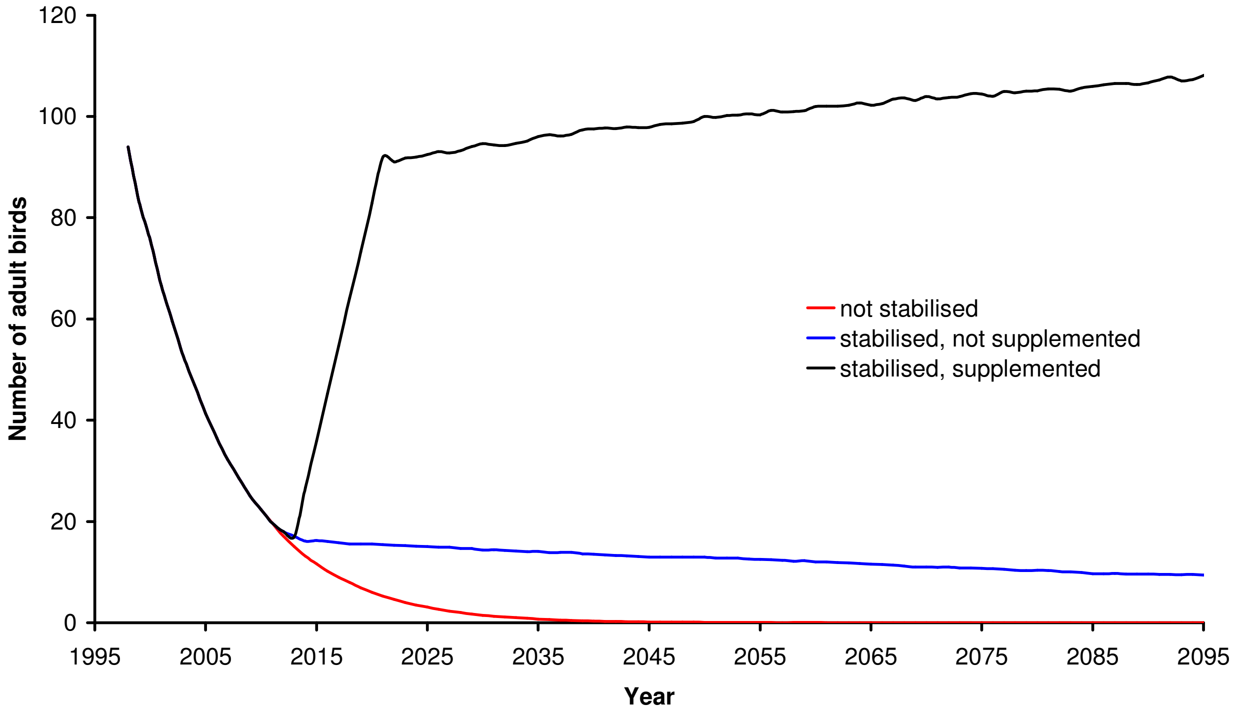

Figure A5-10. The effect of supplementation on size of the Lesser White-fronted Goose population breeding in Norway if the original population had stabilised.
Population trajectory from 1998 to 2013 based on the default adjusted model values (see Annex 5). After 2013, the red scenario is a continuation using the default adjusted values, the blue scenario depicts an increase in survival to a level that delivers a relatively stable population at approximately 90 birds (juvenile survival = 0.32, adult survival = 0.86), and the black scenario shows the same increase in survival, combined with a supplementation programme of eight years at 40 birds per year.

This has a major effect on the extinction risk of the population (Figure A5-11). The stabilised population that is not supplemented continues to run a substantial risk of extinction, by virtue of its continued small size, whereas the stabilised and supplemented population has a negligible risk of extinction by the end of the century. Note that the positive effect of supplementation might be underestimated here, because the model does not capture Allee effects which might occur when the population is very small.

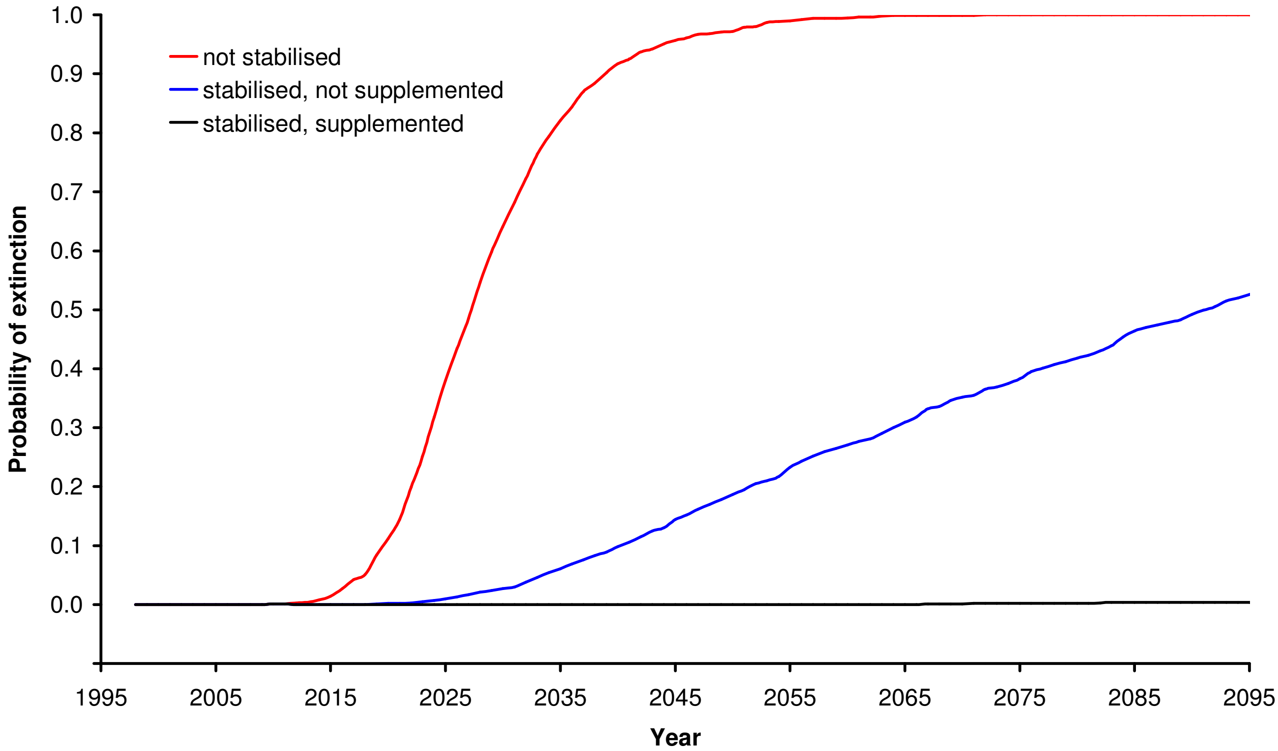

Figure A5-11. The effect of supplementation on extinction risk for the Lesser White-fronted Goose population breeding in Norway if the original population had stabilised.
Population trajectory from 1998 to 2013 is based on the default adjusted model values (see Annex 5). After 2013, the red scenario is a continuation at the default adjusted values, the blue scenario represents an increase in survival to a level that delivers a relatively stable population at approximately 90 birds (juvenile survival = 0.32, adult survival = 0.86), and the black scenario shows the same increase in survival, combined with a supplementation programme of eight years at 40 birds per year. Probability of extinction is the proportion of 1,000 model runs that have zero remaining females.

A5.6.4 Releases to create a new subpopulation

One option for a supplementation programme would be to release the captive-bred birds in such a way that they form a separate sub-population to the Norwegian breeding population. Theoretically, this might reduce the overall extinction risk of the population, by spreading the risk of sub-population extinction. This would occur if the demographic rates of the two sub-populations are not strongly correlated, such that negative fluctuations in one of the sub-populations are not necessarily repeated in the other. However, no data are available on the extent to which this decoupling might occur. Qualitatively, we suggest that the decoupling would be relatively weak; environmental fluctuations likely to affect this population are likely to include winter severity, intensity of hunting pressure, timing of spring thaw, abundance of predators – and these factors will tend to vary primarily at the flyway level, rather than very locally.

A5.6.5 Impact of removing birds from the wild population on population viability

The impact on the remaining wild population of removing fledglings to form the nucleus of a captive breeding population was also modelled. We used a realistic scenario in which eight fledglings (four males, four females) were removed from the Norwegian breeding population in each of three years (2010-2012). Figure A5-12 shows that the effect is remarkably small, causing a minor decrease in adult

population size (already critically small) and a leftward shift in extinction risk of just approximately two years.
Although strong Allee effects are not modelled here (see above), the conclusion is probably relatively robust, since the proportional reduction in numbers of *breeding age birds* is relatively minor.

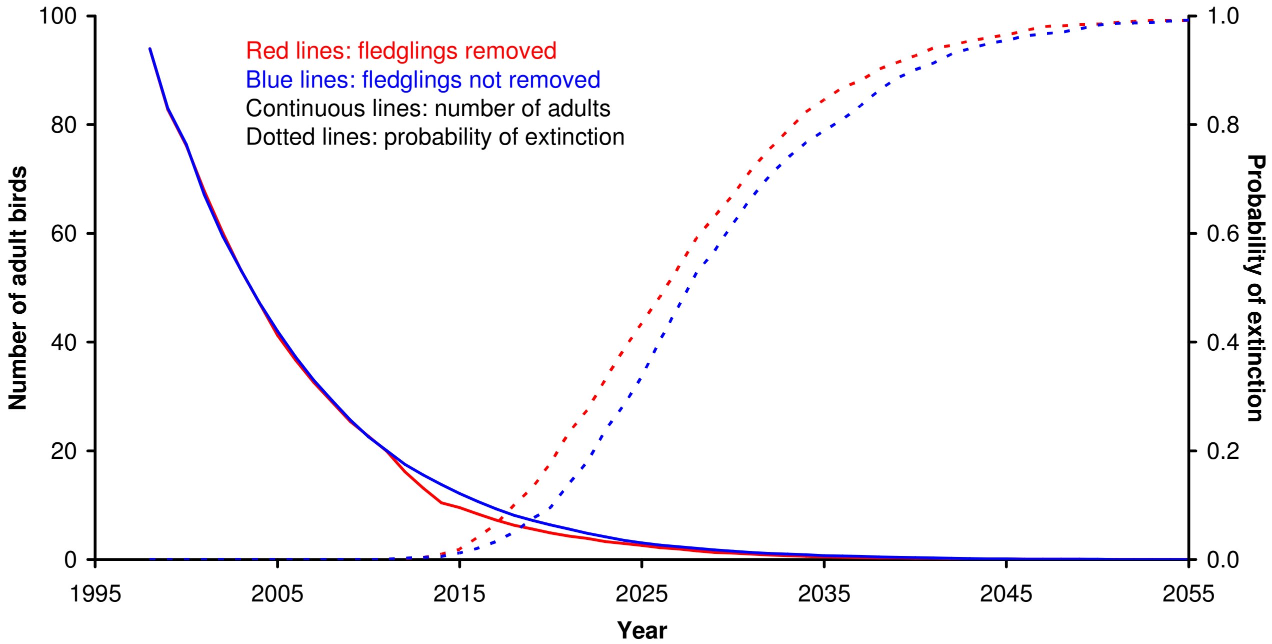

Figure A5-12. Impact of removing fledglings to create a captive population on the wild Norwegian breeding population.

A5.6.6 Impact of increasing breeding success by Red Fox control

Control of Red Foxes in the breeding areas might be one means of managing the wild population to create a relatively stable or increasing population by improving demographic rates. The possibility that fox control would have multiple effects is particularly important: it would primarily increase breeding success (proportion of nesting attempts that are successful) by reducing nest predation. It would also cause some reduction in mortality of nesting females, and perhaps some increase in mean brood size through reducing predation of goslings. Most interestingly, by reducing the number of nesting failures, it might increase the proportion of birds taking the high survival western route, since the western migrating birds are believed to be those that are successful, or which fail late in the breeding attempt. It would be possible to model the effect of improved breeding success on overall breeding productivity (which is also influenced by breeding propensity and brood size), on survival, and ultimately on population growth rate. However, such scenarios are heavily contingent on several parameters which are poorly understood or not included in the model. Firstly, in the absence of empirical data, the model does not currently distinguish the timing of the failure of nesting attempts (*i.e.* incubation *vs.* chick-rearing) and it allows only successful breeders to migrate on the western route, rather than including late-failing birds. Secondly, the survival differential between western and eastern routes is critical to this analysis, but in the absence of any data, in the model we assume a realistic but essentially arbitrary value. Filling these parameter gaps, including obtaining some real values for the effect of fox control on breeding success, is necessary – and would be very valuable – before this management action's impact can be modelled.