Review of Irish Golden Eagle Reintroduction Project: donation of Scottish birds under licence issued by SNH

Background

The recent reintroduction of golden eagles to Ireland has been one of the highest profile environmental projects in Ireland and is an important part of Ireland's new millennium celebrations. It has relied on the donation of chicks from Scotland, and has involved a high degree of cooperation between government agencies, NGOs, scientists and volunteers in the two countries. Reports of the poisoning of one of the birds released in Ireland has triggered concerns about the environmental 'security' of the release area, and given rise to broader concerns about the prospects for the project and its potential impact on the Scottish golden eagle population. SNH issues the licence, which authorises the taking of golden eagle chicks from Scottish eyries.

The current review has been prompted by the above issues but has also been undertaken as part of a regular review of progress, and as such looks at issues of golden eagle conservation management and survival in Scotland.

The Irish Golden Eagle Reintroduction Project is managed by the Golden Eagle Trust Limited in partnership with the National Parks and Wildlife Service of the Department of Environment, Heritage and Local Government (DEHLG), Ireland. The project seeks to re-establish a viable, self-sustaining breeding population of golden eagles in north-west Ireland after an absence of almost 100 years. The main financial Sponsors of the project are: The Department of Environment, Heritage and Local Government, Ireland; EU LIFE Nature; and The Heritage Council. Background details of the project are available on: http://www.goldeneagle.ie/portal.php

The project was conceived in 1989, and was initiated and funded by the Irish Government as part of its National Millennium Celebration. The project was founded on the donation of golden eagle chicks from Scotland. Consequently, it was given a rigorous assessment by SNH in order to be satisfied that that project met the IUCN reintroduction guidelines. The SNH Scientific Advisory Committee endorsed the project, noting the support of four raptor experts: Professor Ian Newton, the late Dr Jeff Watson, Roy Dennis and Dr Duncan Halley.

In June 2001, in cooperation with the Scottish Raptor Study Groups, the project

began taking golden eagle chicks (5-6 weeks old) from nests in Scotland, under special licence from SNH (the licence provided for up to 12 chicks per year; 75 chicks in total, with strict conditions regarding locations and brood sizes from which chicks could be taken; no chicks were taken from nests with single chicks, nor from SPAs). The young birds were transported quickly to county Donegal and placed in specially designed avian cages, which contained artificial nest platforms and perches. The birds were fed, and then released after which they were followed using radio tracking and observations of wing-tagged birds.

Fifty-three golden eagles have been released in Glenveagh National Park. Many of the birds have dispersed widely, and up to six home ranges in Donegal have been occupied by birds. Two pairs bred in 2007 (with one nest producing a fledged chick); in 2008 one pair produced an egg (which did not hatch); and in 2009 one nest has produced two chicks.

The need for a review in spring 2009

The project has made a promising start, and a significant amount of work and cooperation has got the project to its current position. A number of issues have, however, emerged during the progress of the project. In particular, there are concerns about the lack of information on some released birds, and the possible role of poisons killing an indeterminate number of birds. In February 2009 a poisoned female bird was found in Donegal, giving rise to significant Irish Ministerial and media concerns about the extent of the use of poisons in the countryside, and the potential hazards these presents for birds of prey and other carrion feeders (see example of media interest: **http://news.bbc.co.uk/1/hi/northern_ireland/foyle_and_west/7923439.stm**).

The wide dispersal of released golden eagles, and limited resources for tracking and monitoring the birds, has meant that data on dispersal and survival are patchy. One of the birds taken to Ireland died in captivity, and two others were not released because they were incapable of flying. Studies of raptor reintroductions have now developed improved techniques for raising younger chicks, and if practiced for the project, there could be a greater pool of twins from which to take birds for donation. Additionally, there is the possibility of providing some supplementary food for some donor nests in order to ensure that the chicks are in good condition when taken.

The publication in 2008 of the scientific report *'A conservation framework for golden eagles: implications for their conservation and management in Scotland'*

(SNH Commissioned Report No. 193, referred to as the golden eagle conservation framework) has highlighted concerns about the favourable conservation status of golden eagles in parts of Scotland. Two constraints, lack of live prey in the western Highlands and Lochaber region, and persecution in the central and eastern Highlands, have raised concerns about the sustainability of the Scottish golden eagle population as a source of birds for release in Ireland.

These and several other matters referred to above necessitated a review of the Scottish input to the Project, timed to advise SNH before the removal of any chicks in spring 2009.

Terms of Reference and Review Group

In April SNH established a Group to review the licence for taking golden eagle chicks in Scotland (see **Annex 1**). Noting that the project is subject to periodic reviews in Ireland, the Review Group sought to consider the impacts of the project on the Scottish golden eagle population, and to advise on the future of licensed removal, transfer and release of golden eagle chicks from Scotland.

As part of the review, SNH commissioned a scientific review of the Irish golden eagle project (*Review of the Irish Golden Eagle Reintroduction: donation of Scottish birds*, presented in **Annex 2**). Much of the content of this review will be referred to below, as a cross-reference to Annex 2. The Review Group sought information from The National Parks and Wildlife Service, DEHLG, Ireland regarding the suitability of the release environment for golden eagles, and this is given as a letter in **Annex 3.**

The Review Group noted that the Scottish Gamekeepers' Association had raised several concerns regarding the project; some of these were addressed during the second meeting held by the Review Group. The Group agreed that it would be helpful to make available a formal commentary in relation to these and other comments made; this briefing paper is provided in **Annex 4.**

Findings of the review

a) Growth of the Irish golden eagle population

The original application for approval to remove golden eagles from Scotland for donation to Ireland noted that if 65-70 birds could be released in Donegal between 2000-04, it was cautiously anticipated that in excess of 30% of released

birds would survive to breeding age at 5 years old, and result in an initial breeding population of 7-8 pairs. In fact, in 2009, five years on from 2004, by which time 35 birds had been released, 8 territories were established (see Annex 2, Table 1).

The Review Group notes that the indicator of successful establishment was based on a minimum 40% pre-breeding survival figure, which Whitfield et al (2006; see Annex 2) specified as the lower limit for a population to achieve favourable conservation status. The actual number of pairs established (7 pairs in 2007, and 6 pairs in 2008) closely matches the predicted number based on 40% pre-breeding survival estimate (6 pairs in 2007, and 8 pairs in 2008), suggesting that the reintroduction is on track to meet its aims.

To date five released birds are known to have died (one poisoned, the others dying naturally) and the Project team considers that a minimum of 15-20 birds are still alive (see Annex 3). **The Review Group concludes that the project appears to be on track to meet its aims for population re-establishment**. The Group notes that published reviews of numbers of birds released as part of reintroduction programmes point to the importance of sustaining the number of released birds over the duration of the reintroduction programme (see Annex 2). The Group notes that the SNH licence provides for the taking of up to 75 chicks in total until 2010, which could be taken over a longer timescale than originally envisaged, if deemed necessary. However, the Group considers that it is important meantime to sustain the year on year level of chick donation to keep the Irish population on its upwards trajectory.

The Group notes that the project had aspired to complete the release of birds from Scotland in 2005, but by that year an insufficient number of chicks was collected. In 2006 the project leader applied for an extension to permit a further collection of birds to reach the original target of 60-75 individuals. The application was passed to Ornithology advisers in SNH who reviewed it in light of the (then) draft golden eagle conservation framework document. The outcome of this was that conditions were imposed on licences to prevent collection of chicks from Natural Heritage Zones (NHZs) with unfavourable conservation status for eagles. For one of these NHZs these restrictions were relaxed in 2008 following further consideration of the conservations status of golden eagles in that area, and potential effects of removing chicks from there.

b) Quality of released birds

The Review group noted concerns about the potential quality of some golden eagle chicks. The Annex 2 report provides a detailed review of the literature on this matter. In 2008, two of the five chicks were in poor condition: one of the birds died shortly after arriving in Ireland (with PM analysis indicating a number of underlying ailments suggesting susceptibility to *Coli septicaemia)*; the other chick was not released because it did not develop an ability to fly.

The Review Group considers that this matter should be investigated further, and **advises as part of licensed routine checks of golden eagle nests in Scotland that all dead golden eagle chicks should be collected for PM analysis.**

c) Decline in numbers of twins from which chicks can be taken

The SNH licence condition states that chicks may only be taken from nests with twins (where in many golden eagle nests only one chick will fledge). The Annex 2 report presents important and significant new information (based on an earlier SNH commissioned report) indicating that over the period 1988-2006 the proportion of golden eagle pairs fledging twins has declined significantly in recent years, and this may be related to increases in May rainfall (there is a highly significant inverse correlation between % pairs fledging twins in Skye and mean May rainfall).

The Review Group is concerned about these new findings, and advises that additional work is needed to look at the source areas for chicks, noting the decline in numbers of twins available.

d) Practices for increasing the availability of donor chicks

The Annex 2 report provides a detailed and important review of the literature and experience employing supplementary feeding of adults and chicks in order to try and improve survival prospects of birds.

Noting this detail, the **Review Group advises that supplementary food should not be put out in an attempt to increase chick survival,** but noted important scope for further research. Clearly, across some parts of the breeding range there is a shortage of live prey for golden eagles, and it is noted that in some areas nests rarely produce fledged young (details given in the golden eagle conservation framework). The Group noted the summary findings for the main

donor population of golden eagles (124 potential donor ranges covering three areas). Whilst 20% of successful breeding attempts produced twins (and 14% of successful nests fledge twins), a disproportionate percentage are from a limited number of ranges (over one study period, 69 ranges fledged 94 sets of twins, with 61% fledged from just 13% of these ranges). Furthermore, as noted above, the proportion of nests with twins is declining. **The Review Group is concerned to note the evident shortage of live prey and poor breeding success in some ranges, and notes work is on-going to investigate this.**

The Group noted the potential benefits of taking younger chicks, and rearing these in captivity before release; this would considerably increase the potential number of birds for donation. After careful consideration, **the Review Group advises that further consideration should be given in the future to collecting younger chicks for rearing and release.** The Group advises that a trial approach should be adopted, where for five nests which have not produced fledged twins, one of the twins should be taken aged 3-4 weeks old (currently, chicks are taken aged 5-6 weeks old).

e) Impacts on Scottish population, and further areas for donating chicks

The Annex 2 report (and supporting studies reported therein) indicated that the numbers of chicks taken had a negligible impact on the favourable conservation status of Scotland's golden eagle population. Specifically, the removal of 12 chicks for donation to Ireland might have reduced the number of fledged young in Scotland by up to 6 birds. Taking into account the known survival of young birds in Scotland, the **Review Group advises that the numbers of chicks taken to date in Scotland represents a negligible impact on the breeding population**.

However, the Group noted comments in the Annex 2 report regarding the potential of some further Natural Heritage Zones (NHZs) for donation of chicks. **The Group agreed that SPAs would not donate chicks, but that there was potential for donation of chicks from some NE Highland territories (where more twins were reared compared with some other regions of Scottish Highlands).** The Group noted that there is uncertainty here about the survival and dispersal of young birds from the NE Highlands; specifically, fewer territories were occupied, and fewer adult birds were in the breeding population than predicted on the basis of the high productivity of territories there. According to the golden eagle conservation framework, persecution appears to be a key factor limiting the favourable conservation status of the population in this area.

However, other than the presence of abandoned territories across high quality habitats and the low proportion of breeding adults in the population, much of the evidence of the direct effects of persecution is based on correlative analyses. Accordingly, the **Review Group advises that a study should be undertaken involving the satellite tagging of young golden eagles in the NE Highlands, and this should be linked with on-going comparable studies in other parts of Scotland to determine a better understanding of the relationships between golden eagle densities, productivity and survivorship/dispersal of young birds.** The Review Group suggests that a costed proposal should be taken to the Partnership Against Wildlife Crime Group for consideration. The proposal should consider the merits of employing satellite tags compared with other markers/tracking devices (such as wing tags, dye marking and radio tracking).

f) Suitability of the release environment

The Review Group considered the information provided by DEHLG, Ireland in Annex 3 (and further information provided in Annex 4), as well as advice given to the Group at the meetings, and previously.

The Group noted that new legislation is about to be put in place in a concerted attempt to ban the use of poisoned baits in the Irish Countryside; that further actions are being taken to tackle wildlife crime (with closer cooperation between the Irish and Scottish Police forces, including advisory visits); and the vigorous media campaign adopted to highlight the concerns and impacts of the use of poisoned baits. The Group also noted that there had been poisoning incidents involving white-tailed eagles and red kites in Ireland, and in this regard the threats to raptor reintroduction programmes were similar to those in Scotland (where the red kite population growth in the north Highlands is well below predicted estimates because of high mortality in young and adult birds, arguably due to persecution).

The Group noted that the environment, in terms of the prey base, is comparable with extensive areas of the west and north Highlands, with rabbits, hares, seabirds and carrion providing much of the food supply. However, the group felt there was a lack of detailed information on the movements of individual, released birds (whilst noting the considerable effort put into surveys and monitoring using limited resources available).

The Review Group is satisfied that once the new legislation, regarding use of poisoned baits (see Annex 3), is in put in place the environment should be more suitable for the further release of golden eagles.

The Review Group wishes to see an enhancement to the monitoring effort, and in particular the further use of satellite tagging to monitoring the release birds. This would provide important information on dispersal, survival and habitat use.

Conclusions

On the basis of the discussions and materials presented to the review, and noting the scientific publications referred to in the Annex 2 report (including the golden eagle conservation framework), the Review Group has reached a number of judgements regarding the situation in Scotland and Ireland.

Scotland

a) The planned donation of chicks is now 75% complete. The number of birds taken for release should be sustained under the existing licence conditions, of up to 12 chicks each year (noting further comments below), taking the total donated to 75 chicks by 2011;
b) No more than seven chicks should be taken in 2009 (representing the average number taken each year during 2001-08). SNH Licences 7892 and 9056 gives details of the areas where collection of chicks is permitted (outwith SPAs, and outwith the Cairngorms with the exception of areas specified confidentially in the licences). Released chicks would be satellite tagged to increase their detection in the wild;
c) Detailed discussions should be held in autumn 2009, involving specialists in the UK and Ireland, to identify trials which could be undertaken to take chicks at a younger age for rearing and release in 2010 and 2011;
d) A concerted effort is needed within the Scottish Partnership Against Wildlife Crime (PAW) to develop an action plan for further research, survey, monitoring, and awareness raising in relation to golden eagles. The proposal to satellite tag young eagles in the NE Highlands is considered to be highly important, and will be taken to the PAW for consideration;
e) Further work is needed in relation to the NE Scottish Highlands to look at the prospects for donating chicks from that region in 2010 and 2011, involving estates and Scottish Raptor Study Group members.

Consideration of the suitability of that region may need to be predicated on the outcome of the satellite tagging study;

Ireland

f) The actions outlined by the DEHLG, Ireland should be implemented as a matter of urgency to increase the suitability of the release environment. In particular, the Review Group has noted the active proposal to ban the use, except under licence, and only in exceptional circumstances, of poisons/anaesthetic baits;
g) An enhancement to the monitoring effort is needed, notably involving further satellite tagging of released birds to determine their movements and survival; and
h) Early in 2010, following further discussions between Irish and Scottish Government officials and agencies, informed by specialists' advice, further recommendations would be taken to the Scientific Advisory Committee of SNH for consideration regarding the taking of chicks at a younger age and further developments in reducing risks of persecution.

Acknowledgements

The Review Group thanks the advisers, observers, SNH Scientific Advisory Committee members and staff for their comments on drafts of this report. The group thanks Dr Paul Haworth for providing the Annex 2 report. Finally, the group thanks the Irish authorities for so helpfully providing additional information for the report: Loran O'Toole and Dr Ciaran O'Keeffe have made strenuous efforts to provide supporting materials.

Annex 1. Terms of reference for review, and members, advisers and observers connected with the review.

The following Terms of Reference were set for the review:

a) Note the operations and practices supporting the project in Scotland and Ireland, and advise on relevant matters regarding the viability of the released birds;
b) Review the impacts of the project on the Scottish golden eagle population; and
c) Advise on the future of licensed removal, transfer and release of golden eagle chicks from Scotland.

The Review Group, supported by advisers and observers, will report to the Scientific Advisory Committee of SNH in early June 2009. It will meet twice (on 21 April and 19 May 2009) to discuss the project, to identify any further work required, and to provide advice to SNH.

The following people were invited to join the Group as members, advisers or observers:

Members of Review Group
Dr Ron Macdonald, Head of Policy and Advice, SNH (Chair)
Professor Des Thompson, Policy and Advice Manager, SNH (Secretary)
Dr Colin Shedden, SNH Scientific Advisory Committee and Director BASC Scotland

Advisers/Observers
Hugh Dignon, Scottish Government (Observer)
Dr Ciaran O'Keeffe, Director Science and Biodiversity, National Parks and Wildlife Service, DEHLG, Ireland (Observer)
Dr Alan Fielding, Manchester Metropolitan University, adviser to the Project (Adviser)
Professor Jeremy Wilson, Head of Research, RSPB Scotland (Adviser)
Lorcan O'Toole, Project Leader (Adviser)
Alex Hogg/Calum Kippen, Scottish Gamekeepers' Association (Adviser)

Annex 2. The report *Review of the Irish Golden Eagle Reintroduction: donation of Scottish birds.*

SNH Species Call-Off Arrangement: Review of the Irish Golden Eagle Reintroduction: donation of Scottish Birds

Haworth Conservation, Bendoran Cottage, Bunessan, Mull, PA67 6DU

April 2009

Summary

Despite the difficulty of obtaining the number of planned releases the population trajectory is on track as measured against the initial definitions of success and a population in a favourable conservation status.

There is clear evidence that the long term success of any reintroduction is largely dependent on releasing sufficient individuals. Therefore, the release of additional birds up to the original target of 75 is essential. Spreading the releases over a longer time period will, if anything, be beneficial to long term success.

Surveys of the release site prior to the re-introduction programme indicated that numerous potential nest sites were available and that prey abundance was greater than many areas in the west of Scotland. There would appear to be ample prey bearing in mind the recent breeding success and the very young age of the eagles.

Contract Request No. 1 *Modelling the impact of taking chicks at different stages of development (including rearing 1 to 3 week old chicks in captivity, and fostering 1 to 2 week old chicks to suitable nests in Ireland).* The original population modelling (O'Toole *et al* 2002) demonstrated that the removal of 15 **fledged** young from the Scottish population would have no impact on the donor population's future trajectory. Eaton *et al* (2007) noted, in their summary of the 2003 national census data, "*12 chicks were taken from nests for translocation to Ireland. Given that of 22 eagle pairs that were known to have hatched two eggs without subsequent chick collection, 11 (50%) reared both chicks, it is possible to postulate that approximately half the birds removed would have survived to fledging; six more birds might have fledged in Scotland*". Therefore, the removal of 15 fledged young, as modelled for the original impact assessment, is equivalent to the removal of up to 30 young birds. Since it is difficult to imagine a scenario under which even half this number could be obtained as donors it is clear that modifications to the licence conditions, that would increase the supply of donor birds, would not result in a significant impact on the Scottish population.

There is good evidence from Germany that there are potential advantages to removing birds at a very young age. Consequently, it would be worthwhile testing nestling manipulation on a limited number (<5) of birds. Ideally, these would be obtained from nests with two chicks that have never fledged twins. Adopting this precautionary approach should help to ensure that there is no, or at most a very small, impact on the Scottish population. It would also provide useful lessons for the future.

Given the paucity of data for all of the haematological parameters in golden eagles and, in particular, little understanding of how these parameters may be affected by various environmental influences, it seems unwise to rely on these measures as a judge of bird quality. Nonetheless, it is recommended that haematological data are collected so that the results can be added to the existing sparse data and be used to aid *post hoc* interpretations of the short and long term fates of released birds.

The current licence conditions which restrict access to potential donor birds make it very difficult to obtain sufficient birds. The continuing decline in the proportion of twins, which may be related to spring weather, suggests that this situation may not improve in the short term.

Consequently, it is important that other strategies, or licence amendments, are adopted to increase the potential supply of donor stock.

The mechanisms bringing about brood reduction in golden eagles are not well understood. There is strong evidence that productivity shows considerable annual variation and that weather, during the nestling stage, can play an important role in determining the productivity of the Scottish golden eagle population, possibly by influencing the frequency of brood reductions.

Contract request No. 2 *Modelling the impact of providing supplementary food at some eyries from which chicks may be taken (to improve survival of twins and thereby enabling older chicks to be taken).*

Contract request No. 3 *A review of where supplementary feeding of large raptors has been successful elsewhere in increasing productivity*. The rationale and practical details of any supplementary feeding experiment for golden eagles in Scotland needs to be carefully thought out in advance of its initiation. It is important to distinguish between an experiment which aims to demonstrate that prey is limiting productivity in some ranges and a treatment which aims to provide short term increases in productivity. Evidence from Spain is equivocal about the population-level advantages of supplementary feeding.

Contract request No. 4 *Assessing the impact of taking up to 3 chicks per year in total from the four previously restricted NHZs.*

Contract request No. 5 *Irrespective of the point above, whether there should be any restrictions on the number of birds taken from any geographical area, including restrictions of taking any birds (other than SPAs - where there will continue to be a presumption against chick collection).* We found no strong ecological reasons that should prevent the removal of young birds from eastern NHZs which are currently assigned an unfavourable status. The logic for this statement is that (a) the NHZ boundaries do not represent boundaries for golden eagle populations and (b) young birds fledged in these NHZs appear to have low survival rates and are unlikely enter the breeding population so their lawful removal should have no impact on the national, or even, regional population. As long as the total number removed (from all NHZ) was below the threshold for any significant impact there should be no additional population consequences arising from the geographical origin of donor birds.

1. Numbers released and population trajectory

The original application, to SNH, for approval to remove birds from Scotland (O'Toole, 2000) noted that "We would like to release 65-70 Golden Eagles in Donegal between 2000-2004. In the absence of any proven juvenile survival rate figures, we have taken the cautious view that 30% of the released birds will survive till breeding age at 5 years old and result in an initial breeding population of 7-8 breeding pairs". Even though only 35 birds had been released, and would be old enough to breed, there is evidence that this number of territories had been established by 2007. This exceeds the first measure

of success proposed by O'Toole et al (2002) "the first measure of success will be a minimum 25% survival from release to age 4, hopefully leading to four occupied ranges by 2007". Table 1 lists the details of the releases and the number of pairs. The numbers of surviving birds in Table 1 are theoretical values based on the minimum 40% pre-breeding survival that Whitfield et al (2006) specified as the lower limit for a population to achieve favourable conservation status. The actual number of pairs closely matches the theoretical value, suggesting that the reintroduction is on track to meet its aims.

Table 1. Numbers of released birds by year and the number of identified occupied ranges. Also shown are (a) the expected number of four year old birds surviving if the survival rate was 40% over the sub-adult period and (b) the number of occupied ranges based on the estimated number of males and females from (a).

	Males						Females				Pairs	
	Released		Released		Surviving		Released		Surviving			
Year	Year	Total	Year	Total	Cohort	Total	Year	Total	Cohort	Total	Possible	Actual
2001	6	6	3	3			3	3				
2002	8	14	4	7			4	7				
2003	11	25	5	12			6	13				
2004	10	35	2	14	1.2	1	8	21	1.2	1	1	1
2005	7	42	5	19	1.6	3	2	23	1.6	3	3	3
2006	4	46	2	21	2.0	5	2	25	2.4	5	5	5
2007	4	50	3	24	0.8	6	1	26	3.2	8	6	7
2008	3	53	3	27	2.0	8	0	26	0.8	9	8	6
2009					0.8	9			0.8	10	9	

However, despite this initial success, with fewer than the number of planned releases, there is still a need for considerable caution. There are several studies which have shown that the total number of individuals released is the most important influence on the chance of success rather than the rate of introduction, (e.g. McCarthy 1994, Legendre *et al* 1999, Sarrazin and Legendre 2000). Similarly, Green (1997), using data from 47 introductions into New Zealand, demonstrated that the probability of successful establishment was strongly influenced by the number released. The release period did not appear to be important. Fielding and Haworth (2007) modelled various release scenarios for the reintroduction of white-tailed eagles into Ireland and, on the basis of extensive population modelling simulations, endorsed the importance of the

number of releases as a factor influencing the potential success of a reintroduction. Although the pattern of release, for example two releases of 50 birds compared with ten releases of ten birds, does not appear to affect the success of a release programme there is evidence that extended releases may have genetic advantages. Robert and Couvin (2004) investigated the fitness consequences of different release scenarios using a genetic context. This is because there is evidence (e.g. Griffith *et al*. 1989, Haccou and Iwasa 1996) which suggests that fluctuations of the demographic rates in wild populations, arising from environmental stochasticity, tends to improve the efficiency of a multi-release reintroduction compared with a single release. Robert and Couvin (2004) found that the reintroduction rate has a strong influence on the change in mean population fitness, which may have an important impact on long-term persistence. Their conclusion is particularly relevant to a possible Irish golden eagle population since they conclude that "*from a genetic view-point, the progressive release may be recommended for reintroduced populations with long-term effective size smaller than 50–100*".

Recommendation 1

Despite the difficulty of obtaining the number of planned releases the population trajectory is on track as measured against the initial definitions of success and a population in a favourable conservation status. However, because there is clear evidence that the long term success is largely dependent on releasing sufficient birds the release of additional birds up to the original target of 75 is essential. Spreading the releases over a longer time period will, if anything, be beneficial to long term success.

2. Quality of released birds and haematological monitoring

Some concern has been expressed about the quality of some birds brought over to Ireland for the reintroduction. For example, in 2008 there were problems with two of the five birds. One chick from the Uists died shortly after arriving in Ireland. A post mortem showed it had a number of underlying ailments in several organs suggesting some form of *Coli septicaemia*, which appeared to have developed shortly after hatching. A second bird from Skye was not released because it never developed any flying ability. Veterinary analysis identified a low level of calcium in this chick, which may have been one of the causes for its inability to fly. Consequently it has been suggested that some haematological monitoring is needed to provide additional information about bird quality.

It is clear that if a bird has a poor body condition it may be suffering from nutritional deficiencies, for example starvation can lead to decreased erythropoiesis (Campbell 1994 cited in Fair *et al* 2007) and some nutritional deficiencies, such as a lack of iron and folic acid, can result in a non-regenerative anaemia (Harrison and Harrison 1986 cited in Fair *et al* 2007). Various studies (e.g. Ferrer and Dobado-Berrios 1998 and Handrich *et al* 1993) have shown that some of the metabolic responses to fasting and re-feeding can be measured and may be similar to those found in other raptors. For example, Ferrer and Dobado-Berrios (1998) showed how measurements, such as uric acid, can be used to measure the effects of supplementary feeding. For example, they give figures of 11.16 ±1.22 mg dl^{-1} for undernourished Spanish imperial eagle sub-adults and 6.23 ±0.79

after a three week refeeding procedure. Dawson and Bidwell (2005) showed that Calcium supplementation resulted in tree swallow *Tachycineta bicolor* nestlings having longer feathers and tarsi and there was evidence that some nestlings receiving the extra calcium were heavier at 16 days old. As offspring that have faster growth, or are in good condition at fledging, often survive better after leaving the nest, these results suggest that calcium availability can limit fitness. Dawson and Bidwell (2005) describe the work of Blancher and McNicol (1991), whose research in an acidified landscape, showed that tree swallows fledged more young, and offspring grew better, as the wetland pH increased. Dawson and Bidwell (2005) conclude that the role of calcium in limiting the reproductive performance of avian species may be more pervasive than previously thought. Handrich *et al* (1993) showed that plasma uric-acid levels, in starved barn owls, went through three phases and the levels showed a five-fold increase towards the end of the starvation period. Consequently, it would appear that some haematological monitoring may be useful.

However, one of the problems is that relatively little data are available for golden eagles (see Table 2 for some values) and it is clear that a knowledge of local and age-specific values is essential to understanding the possible consequences of a particular value. For example, Ferrer and Dobado-Berrios (1998) investigated the influence of sex, age, nutritional state and local environment on 19 plasma variables in the Spanish Imperial Eagle *Aquila adalberti*. They found no significant differences between sexes but age had a significant effect on a number of values. For example, uric acid values (mean ± se mg dl-1) were 11.01±0.74 in free living chicks, 9.24±0.7 in captive sub-adults and 10.2±1.10 in captive adults. They were able to compare values from free-living chicks from two geographic areas and found significant differences in a range of values that may be related to quantitative and qualitative differences in their respective diets. For example, uric acid values (mean ± se mg dl-1) were 10.2±0.63 in Doÿana birds and 14.2±2.41 in Madrid birds.

Fair *et al* (2008) undertook an extensive review of the validity of one of the commonly used indicators of condition in wild birds. The haematocrit or packed cell volume is the proportion (usually expressed as a percentage), by volume, of the blood that consists of red blood cells. Their review of over 300 papers supported the view that caution is needed when interpreting haematocrit values since the evidence suggested that changes could be caused by a number of different natural factors including age, parasitism and nutrition. Haematocrit has been shown to increase with age so that adult birds generally have greater haematocrit values. Their meta-analysis of 36 studies showed no difference in haematocrit between the sexes. Critically they conclude that the use of haematocrit as a sole indicator of bird condition or health could lead to incorrect conclusions if natural factors that can affect haematocrit are not taken into consideration. The Fair *et al* (2007) review found that studies relating haematocrit and nutritional deficiencies "*were inconclusive and too sparse to conclude that haematocrit value is a reliable indicator of nutritional deficiencies in wild birds*".

Table 2. Haematological values from three studies

Balsh *et al* (1976)		**Nazifi *et al* (2008)**		**Polo *et al* (1992)**	
Values are mean (±SD)		**Values are mean (±SE)**		**Values are mean (±SD)**	
n	2		21		5
Hb (g/ 100 ml)	12.02 (±0.81)	Hb (g/l)	91.73 (±1.52)	Hb (g/ 100 ml)	13.8 (±1.3)
Erythro (x10)	2.51 (±0.09)	RBC (10^{12}/l)	1.63 (±0.11)		2.56 (±0.54)
MCV ($ÿ^3$)	159.78 (±5.86)	PCV (l/l)	0.47 (±0.009)	MVC ($ÿm^3$)	168.2 (±18.6)
MCH (pg/cell)	47.98 (±1.48)			MCH (pg/cell)	44.0 (±12.7)
MCHC (%)	30.06 (±2.03)			MCHC (g/100ml)	32.8 (±0.3)
Glucose (g/100ml)	254.0 (±12.7)	Glucose (mmol/l)	16.42 (±0.73)	Glucose (mmol/l)	16.8 (±1.6)
Total glucides (mg/100ml)	262.5 (±41.7)			Total glucides (mg/100ml)	
Protein (mg/100ml)	1825.3 (±224.6)	Total Protein (g/l)	49.76 (±1.35)	Protein (mg/100ml)	33 (±2)
Urea (mg/100ml)	14.0 (±2.5)	Uric acid (mmol/l)	457.67 (±97.46)	Urea (mol/l)	1800 (±1100)
pre-albumin %	22.2 (±2.7)			pre-albumin (g/l)	5.1 (±0.7)
albumin %	30.0 (±2.0)	Albumin (g/l)	20.46 (±0.79)	albumin (g/l)	9.5 (±0.8)
Notes: two zoo birds < 1 year old, Spain		Notes: wild birds from Iran, 9 female, 12 male		Notes: five adults Benidorm zoo	

Recommendation 2

Given the paucity of data for all of the haematological parameters in golden eagles and, in particular, little understanding of how these parameters may be affected by various environmental influences, it seems unwise to rely on these measures as a judge of bird quality. As Fair *et al* (2007) conclude "*although haematocrit can reflect some changes observed in the condition of birds, it may only be truly accurate when there is an extreme deviation from normal condition that might also be evident by simple visual examination".* Nonetheless, it is recommended that haematological data are collected so that the results can be added to the existing sparse data and be used to aid post hoc interpretations of the short and long term fates of released birds.

3. Constraints on chick collection

Since the issue of the initial donor licence further geographical restrictions were placed on the collection of young birds following the publication of the golden eagle conservation framework (Whitfield *et al* 2006). Young birds cannot be collected from any Natural Heritage Zone (NHZ) which is in an unfavourable conservation status. These NHZs fall into two categories. The first contains NHZs, such as Lochaber and the Western Highlands, in which a shortage of prey depresses the eagle productivity to such an extent that they are unable to be self-sustaining. Even before the new restriction was applied it was very unlikely that these NHZs would provide donor stock because the incidence of twins is historically very low. For example, 14 ranges from the west of the mainland fledged only three twins from 225 pair-years over the period 1982-1999 (pair-years is the product of the number of years and the number of ranges for which we have annual data). The second category contains NHZs, such as the Cairngorm Massif and the North East Glens, in which productivity and the proportion of fledged twins is relatively high but the local population is either declining or failing to expand. This failure to translate high productivity into population expansion is thought to be the result of illegal persecution which reduces sub-adult and adult survival to such low values that the populations are not self-sustaining (Whitfield et al 2003, 2004a, 2004b).

The potential donor resource is, therefore, restricted to pairs fledging twins outside of an SPA or pSPA and not in one of the NHZ which is in an unfavourable conservation condition. Eaton *et al* (2007) identified 442 pairs during the last national census. Although the numbers may have changed a little since 2003 it is thought that any change is currently quite small, possibly ±20. 314 of these 442 pairs are outside of an SPA or pSPA. However, only 124 of these are in an NHZ which is in a favourable conservation condition. Examining the productivity history of these ranges over the three national censuses (1982, 1992 and 2003) reveals that six pairs fledged twins in 1982, one pair in 1992 and eight pairs in 2003. It is immediately apparent that even if all of these pairs with twins could be donors there would be insufficient young to meet the release criteria.

We have quite detailed productivity data for 69 of the 124 potential donor pairs covering the period 1981-2008 (these are three areas including mainly the inner Hebrides plus some of mainland Argyll: Area A 22 ranges 1982-2000, Area B 19 ranges 1981-2000 and Area C 28 ranges 1982-2008). Area A fledged 28 sets of twins (24 from just four of the 22 ranges) from 109 successful breeding attempts covering 262 pair-years while area B fledged five sets of twins from 76 successful breeding attempts covering 255 pair-years. Area C fledged 61 sets of twins (33 from just five of the 28 ranges) from 276 successful breeding attempts covering 588 pair-years. Therefore, in total these 69 ranges fledged 94 sets of twins (57 from just nine of the 69 ranges) from 461 successful breeding attempts covering 1,205 pair-years.

Superficially, a 20% twin proportion (94 of 461 successful breeding attempts) looks very positive for donor supply. Unfortunately these data cover a period when twin production was much greater than present. Indeed, the historic rate, combined with fewer geographical restrictions, probably explains the initial optimism about the availability of twins as donors. Given the importance of twin production for the availability of donor stock it is of some concern that there is evidence from the available national data (annual reports from Raptor Study Groups) that the proportion of pairs fledging twins has declined by about 25% over the period 1988 – 2006 (Figure 1).

Understanding this decline in twins is important not only for the Irish reintroduction programme but also for the future of the Scottish population. Changes in golden eagle productivity are a function of two processes that may operate in tandem or independently. Increased productivity is inevitable if more pairs are successful, either by more pairs laying or more pairs converting eggs into fledged young. However, an increase in productivity is also possible when the number of successful pairs is constant but the number raising twins increases. Watson *et al* (2003) found that between-years differences in productivity appeared to be a function of the proportion of ranges fledging young (all regions), although on Skye it was also strongly linked to changes in twin frequency. Steenhof *et al.* (1997) also noted that the overall breeding success of a golden eagle population was related to the proportion of pairs that bred.

Evidence of fledging rate synchrony, with obvious good and bad years for twins across large regions, is suggestive of widespread rather than local influences on productivity. One obvious candidate for a wide scale effect is weather. The effects of weather on golden eagle reproduction have been documented in the USA (Steenhof *et al* 1997) and western Scotland (Watson *et al* 2003). Whitfield *et al* (2007) and Fielding (unpublished) suggested that climate change is most likely to affect Scottish eagles in the oceanic-influenced western Highlands and Islands. Haworth *et al* (2009) expanded the earlier study by Watson *et al* (2003) which suggested that although there were relationships between productivity and weather they were inconsistent between regions. They also presented data which showed that, in some regions, low productivity is at least partially associated with an inability to convert eggs and young birds into fledged young. Almost certainly this is related to problems delivering prey to the nest or the incubating parent. These problems may result from a shortage of prey or increased difficulties catching prey. Haworth *et al* (2009) concentrated on how weather could impact on the delivery of prey to the nest at critical periods.

Figure 1 Proportion of pairs fledging twins (1988-2006). These are national data extracted from RSG annual reports. Twin proportion = 6.71 – 0.0033 Year, adjusted R^2 = 20.4%, p = 0.03 (from Haworth et al (2009))

There are at least four periods in golden eagle reproductive phenology that could be influenced by the weather. First, there is the period before eggs are laid when females

must accumulate sufficient resources to maintain body condition. The second period begins once eggs have been laid. Watson (1997) suggested that two thirds of Scottish birds lay eggs between the 16th March and April 4th. The laying date appears to have some plasticity and may be influenced by the February weather (Watson, 1997). Once eggs have been laid they must be protected from weather extremes and the male must usually obtain sufficient food for both parents (Collopy, 1984). Chicks seem to be particularly susceptible to weather events during the first 20 days (early to late May). For example, the female spends more time brooding young chicks when wind-chill is greater (Ellis, 1979). The potential effects of weather on the chicks should be expected to decline as the chicks grow, with fledging occurring from mid-July.

Therefore, given the potential importance of the weather in May, Haworth *et al* (2009) investigated what relationship, if any, can be identified between productivity (number fledged per pair) and the May weather. They used eagle productivity data for a large area of Western Scotland (Skye, Mull, Lochaber and Argyll), which in combination represented about 25% of the national population. Monthly weather data (1982-2008) were obtained from http://www.metoffice.gov.uk/climate/uk/stationdata/index.html for Paisley, Tiree and Stornoway. The majority of analyses used mean estimates of productivity (number fledged per occupied range) and weather means derived from the three stations.

Haworth *et al* (2009) showed that productivity was significantly correlated across all four regions, suggesting that at least some of the factors impacting on breeding success are large scale rather than range-specific. Weather is an obvious candidate for such a wide-acting factor. The correlations in regional productivity, all of which are significant at $p = 0.005$ or less, were (in descending order): Lochaber and Skye (0.736); Lochaber and Mull ($r = 0.709$), Lochaber and Argyll ($r=0.708$), Argyll and Mull (0.698), Argyll and Skye (0.575) and Mull and Skye (0.519).

Across all four regions the mean golden eagle productivity was not significantly correlated with the mean monthly temperatures for the early part of the year: February ($r = 0.18$, $p = 0.37$); March ($r = -0.07$, $p = 0.73$); April ($r = -0.26$, $p = 0.20$) and May ($r = 0.00$, $p = 0.99$). However, mean productivity was significantly correlated with the mean May rainfall total, although the strength of the correlation varied: Mull ($r = -0.51$, $p=0.007$); Skye ($r = -0.50$, $p = 0.008$); Argyll ($r = -0.44$, $p = 0.022$) and Lochaber ($r = -0.41$, $p = 0.036$). The overall productivity was significantly correlated with the mean May rainfall total ($r = -0.528$) and a regression of productivity on rainfall explained 27.9% of the variation in golden eagle productivity (Figure 2). It is unlikely that May rainfall has an impact on prey abundance, instead its effects are probably related to a reduction in hunting success and possibly some direct effects on young birds in the nest.

On Skye, where there was good data, there was a clear negative relationship between the proportion on pairs fledging twins and the May rainfall total (Figure 3). This is additional evidence that May rainfall may be acting to reduce parental hunting efficiency and thereby impacting on total productivity. There is some evidence for a

similar mechanism in the American kestrel *Fulco sparverius*. Dawson and Bortolotti (2000) showed that their provisioning behaviour was not constrained by the abundance of food rather the availability of food since weather conditions appeared to significantly influence parental provisioning behaviour. In particular, during periods experiencing rain the parental prey delivery rates declined significantly as the duration of the period of rain increased.

Figure 2. Regression of the mean number of golden eagles fledged per occupied range across four regions and the mean May rainfall total. Mean Productivity = 0.60 - 0.002 Mean May Rainfall, adjusted R^2 = 27.9%. (from Haworth et al *(2009)).*

Figure 3 Proportion of pairs fledging twins on Skye in relation to the mean May rainfall total (p= 0.002) Twin proportion = 0.225 – 0.001 May Rainfall, adjusted R^2 = 39.1%. (from Haworth et al *(2009)).*

As part of this study we have completed some additional analyses which show that there is also a significant positive trend (p=0.03) to increasing May rainfall across Scotland during the period 1988-2006 (based on a mean from the Braemar, Paisley, Tiree and Stornoway weather stations) and that this increase is correlated with a decline in the proportion of pairs fledging twins nationally (Twin proportion = 0.2223 - 0.001 Mean May Rainfall, adjusted R^2 = 32.5%, p = 0.006).

It is clear from the above analyses that, even without geographical restrictions, it will be very difficult to obtain significant numbers of donor birds from nests with twins. The imposition of geographical constraints makes this even more difficult. It appears that there has been a long term decline, across the country, in the proportion of pairs fledging twins. This represents a significant change from the situation applying during the development of this reintroduction programme.

Recommendation 3

The current licence conditions which restrict access to potential donor birds make it very difficult to obtain sufficient birds. The continuing decline in the proportion of twins, which may be related to spring weather, suggests that this situation will not improve. Consequently, it is important that other strategies, or licence amendments, are adopted to increase the potential supply of donor stock.

4. Review of supplementary feeding

4.1 Background

Many birds of prey experience brood reduction, i.e. the number of young fledged is smaller than the number hatched. The processes behind brood reduction have been the subject of much speculation and include evolutionary theory. It appears that it is relatively common for one chick to kill a smaller, younger, sibling. This is described by a variety of terms including fratricide, siblicide and cainism (a biblical reference to Cain and Abel). McGrady (1997) in his review of golden eagles says that it is common in golden eagles and may occur as late as the fourth week. Edwards and Collopy (1983) and Meyburg (2002) discuss the differences between obligate and facultative cainism. The golden eagle is a species which demonstrates facultative cainism and this adaptive behaviour is often attributed to a shortage of food (see below for examples). For example, Lack (1966) said that "*a well fed chick does not attack its nest-mate*". Edwards and Collopy (1983) also raise the importance of relative size and age gap in the chicks. This may be a particular problem when the female has experienced some food shortages over the winter. Edwards and Collopy (1983) suggest that a nutritionally stressed female is likely to produce eggs that have a larger hatching interval and a smaller second egg. There is some evidence for this in other raptors, for example Aparicio (1999) demonstrated, using supplementary feeding, that the variation in clutch egg sizes in kestrels *Falco tinnunculs* was influenced by feeding conditions before and during egg formation. This is important in the context of any supplementary feeding experiment. If feeding only takes place following laying the earlier consequences of female malnutrition may mask the benefits arising from the extra food for nestlings. Edwards and Collopy (1983) suggest that differences in egg size and the laying interval create the proximate mechanisms (a large size difference in chicks) that establish conditions in which siblicide is more likely. If siblicide arises because of the size difference, rather than a food shortage, this suggests that supplementary feeding may not be an effective tool.

This section has three elements. First, the current Scottish golden eagle prey base is assessed to demonstrate the potential for food shortages. This is followed by a review of the effectiveness of supplementary feeding programmes for eagles and other birds of prey. Finally, the problems associated with demonstrating the effect of a supplementary feeding experiment for golden eagles are described.

4.2 The current prey context in Scotland

Haworth *et al* (2009) and Whitfield *et al* (2009) were able to demonstrate that, contrary to common perceptions, golden eagle productivity was not linked to diet specialisation. Instead it appears that it is prey abundance that is important and diet specialisation is an inevitable outcome when a small number of prey items are super-abundant.

The Haworth *et al* (2009) and Whitfield *et al* (2009) studies concentrated on pairs in the Inner and Outer Hebrides and they found that the failure of breeding attempts occurs most frequently during incubation or with small young. A small number fail with young at more than 6 weeks old or shortly after fledging. Late failure has been a feature of

golden eagles breeding on the Uists in recent years and may be more widespread than previously thought. If late failure is more common then some of the estimates of golden eagle productivity may be optimistic since older chicks are usually assumed to have fledged.

There is relatively little information on the timing of nest failures. Payne and Watson (1983) recorded that 21 of 25 pairs (84%) in NE Scotland laid eggs in 1982, of these three nests failed to hatch young (85.7% of eggs hatched) and 15 nests fledged young (71.4% of eggs converted to fledged young). Lockie (1964) describes the death of two young eagles at six weeks which he ascribes to a shortage of food. Fernández (1993) examined the impact that rabbit viral haemorrhagic disease had on golden eagle productivity. The main impacts were on the proportion of pairs laying eggs, reduced from 84% to 67%, and also on the proportion of successful pairs, reduced from 59% to 31% largely because of an increase in failures during incubation. Corkhill's (1980) interpretation of the causes of breeding failure on Rhum also raises the need for caution when interpreting data from the 1950s and 1970s. He shows that five of 28 breeding failures (18%), between 1957 and 1978, were because eggs were not laid. A further nine (32%) were due to broken eggs and twelve (41%) resulted from addled eggs. Only two (7%) were a result of chick death. Corkhill (1980) provides evidence to suggest that these failures were not the result of a shortage of food. Rather, they arose as a result of contamination by toxic residues that derived from their seabird prey. Similarly, and more worryingly, Nygård and Gjershaug (2001) found relatively strong negative correlations between reproductive output and shell thickness and DDE concentration in eggs from ranges in western Norway (1973-1999). They suggest that their data indicates that the golden eagle may be a particularly sensitive species to DDE and that the higher organochlorine content found in the eggs of coastal birds was caused by a diet that includes marine birds. Both of these studies build on the pioneering work of Ratcliffe (1960) who had noted that eggs of golden eagles were sometimes broken in the nest by incubating females during the 1950s and Lockie and Ratcliffe (1964) who demonstrated that reduced reproductive success in golden eagles, in the Scottish Highlands in the 1960s, was due to organochlorine compounds arising from the use of dieldrin in sheep dip.

Marquiss *et al* (1985) examined the factors associated with a reduction in breeding in SW Scotland. Although they thought that afforestation was the principal cause they suggested that good breeding performance was associated with spring (prebreeding) diet with the most productive pairs consuming more live prey (large birds) and less carrion. Although it was only based on a small sample, Pout (1998) suggested that adult golden eagles may have a diet that contains a significant proportion of carrion at the same time that they are feeding the young bird with live prey. However, he also thought that adult eagles favoured live prey over carrion during the prebreeding period. Tjernberg (1981) suggested that, whether breeding occurs or not, is probably determined by prey abundance early in spring just before eggs are laid. Steenhof *et al*

(1997) also found that the percentage of pairs laying was related positively to jackrabbit abundance and inversely related to winter severity.

In the more northern regions, e.g. Alaska and Scandinavia, there is evidence that breeding success is closely linked with the availability of live prey, primarily because major prey species often have marked abundance cycles that are much less clear in, or absent from, Scottish prey species. For example, Tjernberg (1981), working in northern Sweden (1975–1980) found that the proportion of golden eagle pairs with successful breeding (21%–85%) and the number of young produced per occupied territory (0.27–1.24) varied greatly between years. Productivity in the northern pairs was significantly correlated with the total hunting bag of small game species. However, this was not the case in more southerly pairs. The lack of a correlation was thought to be due to a good reproductive year (1977) when small game species were scarce. Tjernberg (1981) thinks that this may be explained by favourable weather conditions during the spring of 1977. Nystrom *et al* (2006), also working in northern Sweden, examined the relationship between prey density fluctuations and golden eagle productivity. Even though the available prey diversity was low the pairs that they studied maintained a relatively broad food niche. Most of the main prey species (Microtine rodents, hare and Ptarmigan) had similar population fluctuations and the golden eagle breeding success was correlated with the annual density index of the most important prey category, the *Ptarmigan* species.

McIntyre (2002) showed that, in the Denali National Park in Alaska, occupancy rates were independent of prey cycles but laying rates were lowest when spring prey populations were at their lowest. However, the success of pairs that laid was not influenced by spring prey abundance.

Lockie (1964) thought that in the relatively poor regions of Wester Ross, there was annual variation in the amount of live prey and carrion and that in “good years” the combination of live prey and carrion would be sufficient to allow reproductive success for the golden eagle. Brown (1969) comes to a similar conclusion in that he suggests that the supply of food “appears rather scare in Sutherland compared with the Eastern Highlands” but that the difference changed between years. He identified 1967 as a year in which there seemed to be very little live prey with a possible ten fold reduction compared with the period 1958-1960. However, he thought that it was unlikely that there was less than 5,000 kg of carrion per territory, a figure that would allow birds to continue their occupation despite the scarcity of live prey.

The parish sheep statistics data gathered by Haworth *et al* (2009) showed that a substantial decline in numbers is well now under way, at least in many parts of the Hebrides and probably elsewhere in the west of Scotland. Although there are no obvious effects of this change perhaps none should be expected over such a short timescale. It is also worth bearing in mind that sheep numbers are only now declining below the stocking levels of the early 1980s. Hewson (1984) suggested that golden eagles (and foxes) killed lambs when they were 1-5 days old, with golden eagles taking

lambs up to 6 kg. At that time the main threat to lambs was during the first ten days of May. Watson (1997) gives a median laying date of the 25th March and an incubation period of approximately seven weeks. This means that young eagles would not hatch until about May 13th, which is after the period that Hewson quotes as the most likely period for predation on lambs. It is difficult to reconcile these dates since there is clear evidence that lambs are present in nests with young eagles.

Lockie and Stephen (1959) suggested that eagles began to increase on Lewis in about 1946. This coincided with the period when mountain hares, grouse and some rabbits (on the hills) began to decline. They quote a keeper on the Morsgail Estate who suggests that hares began to disappear in 1946-47 from areas where they had once been common. Although the reasons for these declines are unknown they suggest that it may have been associated with an increase in the number of sheep. If their suggestion is true an increase in these prey species may be expected as the number of sheep decline. However, their observation also suggests that a decline in the golden eagle population is also possible. Watson (1997) thought that a reduction in sheep numbers, such as that now underway, should lead to a reduction in eagle density in the west but this could be compensated for by a long term increase in productivity.

Lockie writing in 1964 said that it was clear "from the writings of sportsmen " that wildlife, in NW Scotland, was much more abundant in the early 19th century. However, Lockie (1964) also notes that, despite the decrease in live prey, there were more foxes and golden eagles than previously. Lockie quotes Darling (1955) to suggest that the reduction in live prey arose as a consequence of increasing sheep density combined with excessive burning that has destroyed much of the cover needed by many of the prey species. Lockie (1964) thought that eagles would be more likely to take larger lambs, outside of their preferred prey size-range, when live prey and carrion were scare. Watson (1997, p 141) suggests that the tendency for golden eagles in the United States to lay larger clutches is due to the better food supply and that there is evidence that clutch sizes have declined in Scotland since the middle of the nineteenth century. Such a decline is consistent with the types of habitat degradation described by Lockie (1964) and others.

There has been discussion and speculation previously as to how much prey is required for a eagle range to be productive. McGahan (1967) working in south-central Montana, recorded that one pair of eagles brought an estimated 490 g of edible food mass per eagle per day to a nest during a 39-day period. Over a 100-day period this means that each eagle took an estimated 40-49 prey individuals to the nest, with lagomorphs being the most important species (white-tailed jackrabbits *Lepus townsendii* and cottontails *Sylvilagus audubonii* and *S. nuttallii*). Brown and Watson (1964) estimated that a pair of eagles needed 174 kg of live prey and carrion per year. Brown (1969) expanded on this by suggesting that another 54 kg was required if an average of 0.8 young per year were reared plus an additional 43 kg for sub-adult birds using the territory intermittently. Takeuchi *et al* (2006) had a larger figure for the young bird. Using video recordings at

nests they showed that there was temporal change in prey selection during nestling periods, but with similarities in later deliveries of snakes and in total prey weights (83.7–89.9 kg) delivered to successfully fledged broods. This is closer to the figure that can be extrapolated from Collopy (1984) who gives a mean delivery of 1.42 kg per day (approximately 100 kg). However, these are delivery and not consumption figures so a lower figure is presumably adequate. Indeed, Collopy (1984) quotes a much lower figure of 0.885 kg per day given by Lockhart. Even after making allowances for the assumed 0.8 fledging, the adjusted figure for Brown and Watson (1964) remains lower at 67.5 kg. Similarly, Fevold and Craighead (1958) arrived at a larger figure for adult birds. They fed captive golden eagles mainly venison during autumn and winter. Extrapolating from their figures gives annual requirements of 112 kg (female) and 96 kg (male) or 208 kg for a pair. If the average range areas per pair quoted by Brown and Watson (1964) are used (4613 ha – 7273 ha) their food requirement estimates equate to only 0.06 and 0.04 kg prey ha^{-1} $year^{-1}$. Even if Brown and Watson had made a large underestimate it seems unlikely that such small quantities are not reached, even in the most degraded habitats. Indeed, using more conservative estimates the requirement is still less that 8 kg per km^2 per year. Brown and Watson (1964) recognized this and noted that the average food potential in all areas is greatly in excess of the requirements. However, they also recognize that live prey may be relatively scarce in some western areas and that this is offset by the amounts of carrion. Their statement that "*large differences in food potential between areas do not correspond with differences in eagle density*" was later refined by Watson *et al* (1992) who showed a correlation between eagle density and carrion abundance.

There is limited evidence from Mull that, at least for some ranges, the removal of sheep has had little measurable impact on golden eagle productivity. At one range sheep and deer were removed in 1995 to facilitate large scale landscape regeneration. This pair has continued to breed successfully averaging more than 1 chick per year from 1997 onwards. In the past three years sheep have been reduced to very low numbers across three other ranges in central Mull and in 2008 these three produced five young. At another range in north Mull extensive afforestation by broadleaf native woodland of a large part of the range three years ago coincided with the pair laying eggs for only the second time in almost thirty years and then breeding successfully in both 2007 and 2008. However, it is essential that monitoring of such ranges continues over a much longer period to determine if such improvements are transient and more general.

The relationship between breeding productivity and land management is complex. In general however deer are most likely to exert an indirect influence on prey abundance and availability through grazing pressure either on their own or most frequently in combination with sheep and burning. Unfortunately neither sheep statistics nor deer counts correspond to golden eagle range boundaries making it difficult to assess accurately the impacts of varying levels of grazing upon breeding productivity. Differing levels of grazing intensity are likely to impact differentially on the various key groups of

potential prey, particularly hares and rabbits, and this in itself will vary from region to region.

Weather is likely to have an influence on golden eagle breeding productivity. Various weather related parameters have been explored in conjunction with productivity data. In this study we showed that May weather, particularly low rainfall, was found to be strongly correlated with good breeding success in golden eagles in the west of Scotland. Tjernberg (1981) has suggested that in Sweden the good reproductive output in 1977 may be explained by favourable weather conditions that spring. Green (1996) suggested that the large reduction in productivity between the 1982 and 1992 national censuses, from 0.52 to 0.32 fledged per pair, was at least partly due to direct and indirect effects of the weather. It is worth pointing out that the order of magnitude in variation in productivity due to weather between 1982 and 1992 and between 2007 and 2008 appears to be as great as the productivity variation brought about by the variability in the differences in prey. Steenhof *et al* (1997) found that rabbit abundance (the main prey) and the number of extremely hot days during brood-rearing were the variables most useful in predicting percentage of laying pairs that were successful. They also found that golden eagle reproduction was limited by rabbit abundance during approximately two-thirds of the years studied and that weather influenced how severely eagle reproduction declined in those years.

It is reasonable to state that reduced sheep grazing within the Hebrides has not, as yet, had any discernible effect on golden eagle numbers, distribution or productivity. Overall it would appear that a period of large scale landscape change is now well underway in the west of Scotland. Reduced sheep stocking and associated burning are likely to be beneficial to biodiversity in general, especially over the medium term (25 years). Additionally widespread forest restructuring is now taking place together with the establishment of small scale native woodlands either by planting or natural regeneration. To this must be added the unknown effects of climate change which are likely, in a Scottish context, to be most pronounced in the oceanic west and north.

As early as 1969 Brown identified the need for far more detailed studies of golden eagle prey, diet and productivity, which needed to be carried out for a number of years. In this way it would be possible to relate the amount of prey in a territory to its breeding success. Brown (1969) makes the rather surprising observation that his work in Sutherland, during 1967, did not indicate any marked differences in food supply between successful and unsuccessful territories. Indeed, during the data collection in June and July, it was the unsuccessful territories that appeared to be better supplied with prey.

In the immediate future Haworth *et al* (2009) suggested that some experimental work involving supplementary feeding and the creation of additional food resources, for example rabbit warrens, is warranted in selected areas. In the west of Scotland rabbits can be a particularly important food resource for eagles and although sometimes

considered an alien and/or pest species conserving and enhancing rabbit populations may be crucial (Lees and Bell, 2008).

4.3 Supplementary feeding in raptors

In the short term supplementary feeding at the nest might appear to be an attractive option to some of the problems described in the previous section. Robb *et al* (2008) is the most recent review on the effects of supplementary feeding on bird populations. However, reflecting the number of papers in different groups, relatively few of the examples are birds of prey. The results from the various studies can, at best, be declared to be equivocal, not the least because there can be quite subtle effects that require long term studies and the effects of additional feeding on siblicide are uncertain. There are many studies which show that the effects of supplementary feeding depend on the amount of natural prey. It is unclear where the balance is between insufficient natural prey to make supplementary feeding beneficial and sufficient natural prey so that supplementary feeding is not cost effective. Consequently, it is very difficult to see how, *a priori*, judgements can be made about the need for such actions.

Both Wiehn and Korpimäki (1997) and Dawson and Bortolotti (2002) showed experimentally that when American and Eurasion kestrels, respectively, were provided with additional food at the nest this did not translate into heavier offspring. Instead, in both cases, female parents reduced their foraging activities so that control and experimental offspring received the same amount of food. However, female parents were heavier in the experimental nests and spent longer at the nest leading, in the work of Wiehn and Korpimäki (1997), to more offspring. Similarly, Brommer *et al* (2004) found the same effect (heavier female parent and no effect on the offspring) of supplementary feeding of Ural owls *Strix* uralensis. In this example, the better female condition resulted in pairs breeding one week earlier in the next year. These experiments, and the earlier work of Dawson and Bortolotti (2000), point to the more significant effects of weather on offspring condition and survival. Poole (1982) found that protracted periods of bad weather reduced the parental feeding rates in osprey leading to an increase in mortality of the smaller chick. It seems that extra food may not reduce sibling aggression but it can lead to greater survival rates (Mock *et al* 1987). Hörnfeldt *et al* (2000) examined brood size reduction in experimentally fed and control Tengmalm' s owl *Aegolius funereus* nest boxes. They did not find any significant effect, in fact mean brood sizes were smaller in the experimentally fed nest boxes. There are several elements of this experiment that highlight some of the design and interpretation problems for supplementary feeding experiments. First, the sample sizes were only sixteen suggesting very low statistical power. Secondly, three control and three experimental parents abandoned their broods while a further two (experimental) and four (control) broods hatched only one egg. Finally, and highlighting again the importance of natural conditions, the position of the vole cycle suggested that there may have been a surplus of natural prey which may have prevented the identification of a feeding effect.

One of the problems with many of the studies is they lack any statistical power. For example, Estes *et al* (1999) used the results from just seven northern goshawk *Accipiter gentilis* supplementary fed nests. Their observation of one proven siblicide in a control nest is taken to be proof of a relationship between food resources and brood reduction. Although Hansen (1987) documents greater offspring survival in bald eagles *Haliaeetus leucocephalus* that had supplementary feeding he also describes examples in which the parents refused to take the food (salmon carrion) that was placed in view of the nest. The inability to guarantee adult behaviour and the survival of experimental nestlings means that it may be difficult to design conclusive studies. Gende and Willson (1997) also worked on bald eagles and suggested that the supply of supplemental food had little effect on chick survival, largely because very few control or experimental nests failed post-hatching. Again, this highlights the confounding effect of natural prey levels on such experiments.

There are other indirect effects of supplementary feeding. For example, Oro *et al* (2008) found that additional feeding sites for the endangered bearded vulture *Gypaetus barbatus* resulted in greater survival of sub-adults but had no impact on adult survival. Indeed, over the period studied adult survival declined. Ward and Kennedy (1996), in supplementary feeding experiments with northern goshawks, concluded that the food limitation varies between years and that excess food did not have a direct effect on nestling starvation rates. Instead, the excess food altered the female parent' s behaviour so that her longer presence at the nest may have deterred predators. Later work by Dewey and Kennedy (2001) on the same species came to similar conclusions. Adult females from experimental nests were heavier and remained closer to the nest. They found a significant difference in nestling survival in one year but not the previous year and this was explained by differences in the amount of natural prey.

The best evidence for positive benefits of supplementary feeding on an eagle comes from Spain and the work of Gonzáles, Margalida, Sanchez, Oria and others (for example Gonzáles *et al* 2006 and Margalida *et al* 2007). Margalida *et al* (2007) concluded that sibling competition and aggression was the main cause of nestling mortality and that supplementary feeding resulted in an increase in the fledging rates. Gonzáles *et al* (2006) document the magnitude of this effect with an increase in the fledging rates for adult pairs from 0.72 to 1.56 and a similar increase (0.53 to 1.57) for sub-adult pairs. They say that sibling aggression stopped completely in supplementary fed nests and that this made the removal of chicks, for fostering, both unnecessary and unethical. However, Ferrer and Penteriani (2007) are quite critical of these papers and the conclusions. They point out that the original purpose of the supplementary feeding was to replace prey that was lost following a cull of waterfowl (to avoid a botulism outbreak) and they question the level of sibling aggression quoted in the previous papers. Ferrer and Penteriani (2007) used classical population dynamics theory to show that despite the earlier claims, and even under the most sympathetic of assumptions, supplementary feeding had relatively little impact at the population level and was largely irrelevant to the population recovery now taking place. Instead it was conservation measures, such

as changes to power lines, that increased survival of floaters and adults which had the greatest effect. It is important not to lose track of this important observation in Scotland. The original population models developed for the Irish reintroduction (O'Toole *et al* 2002) came to the same conclusions about the relative importance of productivity and survival.

4.4 Experimental Design and Statistical power

It is clear from many of the studies described above that natural prey can have a very significant effect on the interpretation of results. It is difficult to see how these problems could be addressed *a* priori and it probably means that any experiment would have to run for more than one year.

It is also clear that many of the published studies have lacked statistical power or have identified indirect effects from supplementary feeding. Even in the most well known example, the Spanish imperial eagle, is unclear if the effects have been as positive as some of the claims suggest.

If it assumed that 14% of successful nests fledge twins and, as suggested by Eaton *et al* (2007), that 50% of two chick broods are successful a conversion of all of these second chick deaths would increase the percentage with twins to 21%. It is possible to estimate what sample size is needed to detect this change with the normally accepted minimum of 80% power. An experiment that is capable of reliably detecting a significant change from a proportion of 0.14 to 0.21 requires a sample size of 214. Unfortunately this is larger than the number of successful pairs each year and it is unacceptable to use pseudo-replication such that the same nests are included across different years. If a more manageable sample size of 30 was used the power drops to 24% meaning that there is only a one in four chance of detecting the improvement when it occurs. It can also be argued that the avoidance of all second chick mortality is unlikely, no matter how much supplementary feeding is applied. If a more biologically realistic change from 14% to 18% of successful twins is assumed the sample required for 80% power becomes an even more unrealistic 630 while the sample size of 30 now only has 12% power, i.e. there is a seven in eight chance that a real improvement will go undetected. Given the difficulty of achieving a scientifically acceptable level of statistical power it may be unwise, and possibly unethical, to proceed with such an experiment.

Recommendation 4

The mechanisms bringing about brood reduction in golden eagles are not well defined. There is strong evidence that productivity shows considerable annual variation and that weather, during the nestling stage, can play an important role in determining the productivity of the Scottish golden eagle population, possibly by influencing the severity of brood reductions. Consequently, careful thought needs to be given to the design of any experiment which aims to improve productivity. It is clear that natural conditions can confound any such study and it is difficult to achieve an appropriate level of statistical power. The rationale and practical details of any supplementary feeding experiment for golden eagles in Scotland needs to be carefully thought out in advance

of its initiation. It is important to distinguish between an experiment which aims to demonstrate that prey is limiting productivity in some ranges which could be corrected by long term habitat management or prey enhancement and a treatment which aims to provide short term increases in productivity. Since it appears that one golden eagle supplementary feeding experiment is currently underway it may be wise to wait for any outcomes from this and then reassess the need for, and design of, such a study. Finally, and importantly, if the aim of supplementary feeding is to improve the conservation status of the Scottish golden eagle population any improvements arising from supplementary feeding are likely to have little effect given the apparently high levels of adult and sub-adult mortality in some regions.

5. Removal of very young birds

It has been suggested that nesting management may be an effective alternative to supplementary feeding at or near the nest. This approach involves removing very young chicks from two chick broods and either fostering them or raising them in captivity. Meyburg (1987) and Meyburg *et al* (2008) describe several examples of nesting management in the Spanish imperial eagle *Aquila adalberti* and, particularly, the lesser spotted eagle *Aquila pomarina*. In the Spanish Imperial example he describes removing a third egg from a clutch of three and hatching this in an incubator. The chick was then placed in a nest containing infertile eggs and was subsequently reared successfully by the foster parents. The lesser spotted eagle example is a much larger experiment beginning with a 'proof of concept' between 1968 and 1974 in Slovakia. The lesser spotted eagle exhibits obligate cainism so it is very rare that a nest fledges more than one chick. Second chicks were removed from nests and either hand-reared in captivity or reared by black kites *Milvus migrans* before being returned to the natal nest prior to successful fledging. Because of its threatened status the state of Bavaria implemented an extended nestling management programme in 2004. Second chicks, or Abels, are removed from nests at a very young age and hand reared in captivity. Subsequent monitoring has demonstrated that such birds have been able to complete a migration cycle to Africa.

The advantages of removing young birds are:

a larger pool of potential donors;
reduced impact on the Scottish population since donor birds are less likely to have fledged successfully in the nest;
a chance to improve bird quality prior to release by providing an optimum diet which should help to prevent the effects of early malnutrition, thereby increasing the lifetime fitness of the released birds.

There are fewer disadvantages and they relate, generally, to logistics rather than biology. There are potentially some ethical issues but the failure to convert many second chicks into fledged young means that, on balance, the benefits outweigh the costs. It is, however, worth noting the comments of Ferrer and Penteriani (2007) who observed an increase in the hatching rate of the Spanish imperial eagle after deciding not to use translocation as a means of reducing siblicide. They said nest management

took an average of 7.7 nest visits and, when trying to protect the 4.8% of chicks killed by siblings, they were killing 15% of the eggs (Ferrer and Hiraldo 1991).

Due to time constraints it has not been possible to follow-up what look to be some very relevant papers in the 1984 International Zoo Year Book (Volume 23(1)).

Recommendation 5

It would be worthwhile testing this approach on a limited number (<5) of birds. Ideally, these would be obtained from nests with two chicks that have never fledged twins. Adopting this precautionary approach should help to ensure that there is no, or at worse a very small, impact on the Scottish population. It would also provide useful lessons for the future.

6. Review of population modelling and relaxation of geographical restrictions

The original population modelling (O'Toole *et al* 2002) suggested that the removal of 15 **fledged** young from the Scottish population would have no impact on the donor population's future trajectory. It is important to clarify the difference between fledged birds, included in the model, and young chicks removed from nests with twins as donor birds. As Eaton *et al* (2007) noted, in their summary of the 2003 national census data, "*12 chicks were taken from nests for translocation to Ireland. Given that of 22 eagle pairs that were known to have hatched two eggs without subsequent chick collection, 11 (50%) reared both chicks, it is possible to postulate that approximately half the birds removed would have survived to fledging; six more birds might have fledged in Scotland*". Therefore, the removal of 15 fledged young, as modelled for the original impact assessment, is equivalent to the removal of up to 30 young birds. Since it is difficult to imagine a scenario under which even half this number could be obtained as donors it is clear that modifications to the licence conditions, that would increase the supply of donor birds, would not result in a significant impact on the Scottish population.

The initial population modelling was undertaken at a national level, there was no regional component to it and, prior to the release of the Whitfield *et al* (2006) golden eagle conservation framework analyses, permission was granted to remove young birds from all regions including, for example, the Central Highlands Natural Heritage Zone (NHZ). In 2003 one chick was removed from range D/SP12. However, because this NHZ failed Whitfield *et al's* (2006) level 1 and 3 tests, SNH refused permission for further rem ovals from this and similar NHZs. The level 1 test examined range occupancy *"if <66% of known territories were occupied in 2003, the NHZ was in an unfavourable conservation status for this species irrespective of other criteria"*. There was a 39% shortfall in this NHZ so the test was failed (just). The level 3 tests examines the difference between actual and predicted population trajectories "*As a Level 3 test, we examined the predicted population projections from the GEPM against the observed trends in the number of occupied territories from the three national censuses. If the GEPM predicted stability or increase for the given fledging rates under the Level 2 tests but the observed population trend failed to match predictions then the survival limits employed in the*

Level 2 test were probably not being met. Hence, for example, if stability or increase was predicted but decline was observed, then a NHZ was deemed to have failed the Level 3 test."

The level 1 and 3 tests are inextricably linked since an excess of vacant territories (level 1 test), under conditions that should favour an expansion (level 2 test), can only occur if there is some external factor preventing population expansion (level 3 test). For example, the Central Highlands NHZ population declined over the period 1982-2003 with over 50% of its known territories vacant in 2003. Given the productivity of the occupied territories it is expected that, in the absence of external influences (i.e. increased juvenile and adult mortality), the NHZ population should have expanded. This is the reason why this NHZ failed the level 3 test. It is likely that very few of the birds fledged by these territories contribute to the Scottish population so their removal to Ireland would have no, or minimal, impacts in Scotland. If the reasons preventing the growth of this, and similar, regional populations were corrected then it is likely that these young birds would contribute to an expanding Scottish population. Therefore, the removal of two or three young from these eastern NHZs, in the short term, is unlikely to prejudice the future of the regional or national golden eagle populations.

The NHZ boundaries used in the Whitfield *et al* (2006) analyses cannot, and should not, be used to indicate limits for golden eagle population recruitment. They were used in the golden eagle framework analyses to provide an objective geographical sub-division of Scotland that produced well defined regions that were consistent with other SNH work. These regions were then used to identify local constraints on the golden eagles and were never intended to partition the golden eagle population into self-contained populations. Other spatial divisions could have been used.

In response to a previous "Call-off" contract Haworth and Fielding (2008) created an alternative 'region' by drawing a circle with a radius of 30 km, centred on range D/SP12. D/SP12 was chosen because it has previously provided chicks for the reintroduction and it is in the Central Highlands NHZ, which is currently in an unfavourable condition. The 30 km radius was chosen to create a region with an area that is approximately equal to that of the Central Highlands NHZ. This new region had 23 territories in 1982 compared with 26 known territories for the NHZ. As in the Central Highlands there have been territory loses leading to 17 territories by 1992 and 15 in 2003. Therefore, the proportion of territories occupied in 2003 was 65.2% (15/23). This just fails the level 1 test which requires 66% occupancy. Productivity in these territories was good: 0.52 in 1982 (12 fledged from 23 territories), 0.47 in 1992 (8 fledged from 17 territories) and 0.73 in 2003 (11 fledged from 15 territories). The mean productivity was 0.56 (31 fledged from 55 territories) and the new region passed the level 2 test. The region failed the level 3 test because this level of productivity should result in population expansion in the absence of external influences. Given the very marginal failure of the level 1 test it is reasonable to conclude that the main cause for the failure of this region to pass the tests for favourable conservation status is its failure to expand. As in the NHZ analyses it seems unlikely that the removal of young birds from this region would impede the

population's recovery since there is evidence that many of the young fledged do not survive long enough to occupy a vacant territory.

Recommendation 6

We can find no strong ecological reasons that should prevent the removal of young birds from eastern NHZs which are currently assigned an unfavourable status. The logic for this statement is that (a) the NHZ boundaries do not represent boundaries for golden eagle populations and (b) very few young appear to survive long enough in these NHZs to enter the breeding population so their lawful removal should have no impact on the national, or even, regional population.

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Annex 3. Letter provided by The National Parks and Wildlife Service, DEHLG, Ireland regarding the suitability of the release environment in Ireland for golden eagles.

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

National Parks and Wildlife Service
7 Ely Place
Dublin 2

22/5/09

Professor Des Thompson
Scottish Natural Heritage
Silvan House
3rd Floor East
231 Corstorphine Road
EDINBURGH
EH12 7AT

Re: Review of licensing of removal of Scottish Golden Eagle chicks for re-introduction programme in Donegal, Ireland.

Dear Des

At the meeting on 19 May, we agreed to provide information under four headings: legislation regarding use of poison, food supply, monitoring of the introduced birds and how wildlife crime is tackled in Ireland. I understand that Lorcan O'Toole will deal with the issues of food supply and monitoring, so my reply deals with the first and fourth items listed above.

In the first instance, however, I would like to thank you and the Scottish authorities for all of your efforts in support of the project to date. As you know, the project has been very successful in raising the profile of biodiversity restoration and protection among the public and the farming community and paved the way for two further programmes in other parts of Ireland. All three projects have had strong support at Ministerial and general political level.

However the fall-off of availability of birds means that the project is already running significantly behind schedule of releases of birds and I am very anxious to ensure everything necessary be done to reach the target of releases in as short a time frame as possible. It is in the nature of this work that delays crop up; but given the need to maximise use of scarce resources and minimize the risk of failure, it is critical to us that the project is completed soon.

I also want to stress in these preliminary remarks that the poison issue in regard to the Golden Eagle project is inevitably blown out of proportion by some incidents at the far end of the country from the Golden Eagle project, and by our policy of giving full publicity to any incident of poisoning. As you know the tremendous expansion of the buzzard population and the consistent strength of the raven population in Donegal, and indeed right across Ireland, is proof of the low level of threat posed by poisons.

Let me come now to the issues mentioned above.

Current and proposed legislation concerning the use of poisoned baits

Under current Irish law, it is permissible to put out certain poisonous or anaesthetic substances to kill birds, foxes or other species harmful to livestock but only under the following circumstances:

- Neither dead livestock nor farm produced meat products may be left on land
- The use of poison must be notified in advance to the Garda Siochana and baits must be secured to the ground so that they cannot be moved
- Signs must be erected warning of poison use

All known incidents in which raptors have been poisoned have therefore been illegal.

Following some recent incidents, the Minister for the Environment, John Gormley, announced that he would rapidly strengthen the law in relation to use of poisons. On 21st May, officials of the National Parks and Wildlife Service met with counterparts from policy and legal sections of the Department of Agriculture, Food and Fisheries (DAFF), outlining a 2-phase approach to further tightening of the law relating to poison use on lands. The obligations of Ireland under the EU Birds Directive were discussed.

The first phase will be rolled out in the next few weeks, and will ban the use, except under licence, and only in exceptional circumstances, of poison/anaesthetic baits based on meat, fish or eggs or products thereof.

The second phase will be to develop further regulations to create an effective means of prosecution of people using poison in a manner liable to harm birds of prey, perhaps involving a ban on certain substances such as Alphachloralose; and at the same time to look at effective means of minimising risk of secondary poisoning of birds of prey including owls.

The need for further work in the raising of awareness and changing of mindsets was discussed and agreed.

The Department of Agriculture officials were very supportive of the raptor re-introduction projects and agreed the need to achieve full conformity with the Birds Directive and the need to reduce any risk to birds of prey.

Dealing with Wildlife Crime in Ireland

Most of the work of detecting and prosecuting infringements of wildlife legislation is carried out by the conservation ranger staff of the National Parks and Wildlife Service. The police force, the Garda Siochána, may also investigate and prosecute

such infringements. There is a good working relationship between NPWS and the Garda. There is also a good level of public support for the work and many cases stem from information supplied by concerned members of the public. We also invest significantly in training ranger and management staff in the investigation and prosecution of offences.

In general, the level of wildlife crime is very low in Ireland, with little tradition of illegal exploitation compared with other countries. Most of our ranger work in fact concerns the illegal damaging of habitats. It is fair to say of course that, as in any country, detection of illegal actions concerning species can be difficult, and in particular providing evidence strong enough to secure conviction is not easy. However, for example, we recently had a successful prosecution of a farmer poisoning rooks in a tillage area.

We look forward to the outcome of the review. We hope that the very clear advice by Dr Fielding, which supports the continuation of the licensing will allow you to decide on a licence providing sufficient birds this year to work in a time- and cost-effective manner and to allow us quickly reach the target of 75 releases.

With warm regards

Ciaran

Ciaran O'Keeffe
Director,
Science and Biodiversity

Annex 4. A report from The National Parks and Wildlife Service, DEHLG, Ireland regarding the suitability of the release environment in Ireland for golden eagles. This brief has been produced to respond to a range of questions posed regarding the work.

In the first instance, the National Parks and Wildlife Service would like to thank the Scottish authorities for all of the support of the project to date. It has been very successful in raising the profile of biodiversity restoration and protection among the public and the farming community and paved the way for two further programmes in other parts of Ireland. All three projects have had strong support at Ministerial and general political level.

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Current and proposed legislative provisions for combating the use of poisoned baits, notably in relation to the release areas

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The efforts being taken to combat wildlife crime as it might affect golden eagles

The Golden Eagle poisoning incident

The Golden Eagle found poisoned on the 19th February 2009, near Dunlewey, County Donegal was poisoned illegally. This incident was illegal under current Irish Legislation because; a banned substance, Paraquat, was used, no poisoning signage was erected on any of the approach roads or track on to the site, none of the local Garda Station in West Donegal were informed in writing that poison was to be used.

The subsequent search of the area by 6 National Parks and Wildlife Service personnel and the Project Manager did not find any bait *in situ*. A search of the upland area in the vicinity of the dead eagle by an Irish Air Corps helicopter, drafted in from Baldonnel Airport near Dublin, co-ordinated by a member of NPWS management also failed to find the poisoned bait.

Inspector Henry, Garda Siochána, Glenties, was in charge of the investigation and his staff visited and examined all poison registers in all licensed poison retailers in West Donegal and beyond but were unable to identify any potential suspect that would have bought Paraquat, prior to it being banned in late 2007.

The Garda interviewed the prime suspect at length in a detailed interview but no evidential proof or comments given under caution could link the prime suspect in the case with the poisoning incident itself. Numerous circumstantial evidence from farming neighbours, Dept Agriculture farm inspectors and an anonymous letter were deemed to be inadmissible.

This is the first confirmed poisoning of any released bird. The bird was recovered due to locational data provided by the North star GIS satellite tag it was carrying. Two other satellite tagged birds, fitted with satellite tags in 2005, were followed over an eighteen month period, whilst their batteries lasted, and they were not persecuted.

Like many parts of Europe, poisoning continues to be a key threat in the distribution of scavenging raptors in Ireland. The International Congress on the Illegal use of Poison in the Natural Environment (Mallorca, 2nd-5th March 2000) brought together a variety of experts from across Europe to discuss the matter. The Royal Society for the Protection of Birds highlighted the campaign that tackles illegal poisoning in the United Kingdom. The campaign has a two pronged approach; (i) the encouragement of public awareness of illegal (and

legal) activities, and (ii) a scheme to investigate poisoning incidents. The SNH Report, *A Conservation Framework for Golden Eagles* clearly outlines the recorded levels of illegal poisoning incidents in the Scottish uplands over the period 1982-2003. Over this 21 year period, there were over 200 persecution incidents (over 10 a year), and detailed statistical analysis of the Golden Eagle population in Muirburn areas clearly suggests that numerous other incidents probably go undetected every year.

Scale of the Problem

Fifty three Golden Eagles have been released in Ireland, between 2001 and 2008. 5 of these birds have been recovered dead in that period, including one poisoned bird. The other birds were believed to have died from natural causes (two corpses had negative toxicology results and circumstances suggest the two other decomposed bodies had not suffered from poisoning). We believe that an absolute minimum of 15-20 birds are still alive.

Until recently, there were insufficient scavenging birds of Prey in Ireland to give an indication of the level of poisoning in Ireland. (See Appendix I for an overview of the poisoning situation in Ireland, contained in the original SNH Golden Eagle Licence Application). Therefore it is important to put the scale of the emerging Irish problem in some form of context, such as the scale of the problem facing the nearest, and viable, Golden Eagle population in Scotland (see Tables 1 and 2).

Table 1. Birds of Prey confirmed poisonings in Scotland in 2004-2008

	Red Kite	Buzzard	Goshawk	Peregrine falcon	Golden Eagle	Tawny Owl	Sea Eagle	Total
2004	**3**	**31**	**1**	**3**	**0**	**0**	**0**	38
2005	**2**	**14**	**0**	**0**	**1**	**0**	**0**	17
2006	**5**	**25**	**0**	**1**	**2**	**1**	**0**	34
2007	**10**	**12**	**0**	**4**	**1**	**0**	**0**	27
2008	**2**	**13**	**0**	**0**	**0**	**0**	**1**	16
Totals	22	95	1	8	4	1	1	132

Table 2. Birds of Prey confirmed poisonings in Ireland in 2004-2009

	Red Kite	Buzzard	Goshawk	Peregrine falcon	Golden Eagle	Tawny Owl	Sea Eagle	Total
2004	**0**	**0**	**0**	**0**	**0**	**NA**	**NA**	**0**
2005	**0**	**0**	**0**	**0**	**0**	**NA**	**NA**	**0**
2006	**0**	**0**	**0**	**0**	**0**	**NA**	**NA**	**0**
2007	**1**	**0**	**0**	**0**	**0**	**NA**	**1**	**2**

2008	**0**	**0**	**0**	**0**	**0**	**NA**	**3**	**3**
2009	**1**	**0**	**0**	**0**	**1**	**NA**	**1**	**3**
Totals	2	0	**O**	0	1	NA	5	8

There are clearly marked differences in the level of wildlife crime investigations undertaken and the size of respective raptor populations in both countries. We firmly believe that several Buzzards are poisoned in Ireland each year, but such incidents are either not recorded or not sufficiently investigated. But we also suggest that for the level of persecution of Golden Eagles to have such a negative impact on population in Eastern Scotland, as outlined in *A Conservation Framework for Golden Eagles,* the confirmed Scottish poisonings of Golden Eagles, outlined above, would need to be multiplied by a very large number indeed.

Public Awareness

Just like the UK Statutory Authorities and the RSPB's response to poisoning in the UK, the NPWS and the Golden Eagle Trust have very quickly raised Irish public awareness of the threat of illegal poisoning of Irish Eagles. Over the last eighteen months, since the first reintroduced raptor was poisoned in Ireland, the level of public awareness to the poisoning issue in Ireland has increased steadily. Several prime time TV News features, national print media reports and an editorial in the Irish Times (2/5/09) and local and national radio pieces (including a 30 minute interview with Minister John Gormley on RTE Radio 1 15/5/09 primarily on the poisoning issue) all demonstrate that the media and public concern over the misuse of poison, is approaching the level of awareness among the British public.

Table 3. Publicity generated nationally and internationally regarding poisonings.
As a crude measure, one could enter the phrases below and carry out a Google search in an effort to examine the level of awareness in each country, apparently reflecting more publicity about the Irish incidents compared to Scottish incidents.

World Wide Web Google Search Phrase	No of Hits
Eagle poisoned in Ireland	484,000
Eagle poisoned in Scotland	380,000
Eagles poisoned in Ireland	340,000
Eagles poisoned in Scotland	256,000

Considering the relative size of the Irish and British populations, the respective sizes of the British and Irish media and the PR machine of the RSPB (with

approx 600 staff and 1 million members) and the GET (3 staff and no members), this is a clear demonstration of the level of seriousness this issue warrants in Ireland. After just 18 months of campaigning, around confirmed incidents, compared to the 18 year old campaign started in the UK in 1991, The Project team feels that the level of public engagement is extremely high. The current Minister for the Environment, Heritage and Local Government, John Gormley T.D., is the leader of the Green Party and is totally committed to eradicating the persecution of Irish Eagles through poison and has expressed his personal disgust on the matter repeatedly and publicly.

The Project team notes with dismay that there have been several inaccurate pieces of media coverage, prompted by the SGA, in the Scotsman, Argyll News, the Strathspey Herald, Shooting Times and elsewhere commenting that several Scottish Golden Eagles had been found poisoned in Ireland and several have died in captivity, and post mortems were not carried out on recovered corpses. As the Review Group has been informed, these reports are misleading and downright inaccurate.

Liaison with Key Stakeholders

The Project Manager initiated a widespread consultation with all key stakeholders prior to the project and this level of liaison continues at present. The project was initially funded as part of the Republic of Ireland's National Millennium Committee programme, which gave it a unique national profile and fostered a very real sense of public ownership of the project. The Irish Farmers Association has played a key role in the Project Steering Group during the early stages of the project and is kept abreast of the project continuously. The Project Manager has also addressed the IFA in Mayo, Connemara and Leitrim. The Donegal IFA publicly condemned the poisoning of the Golden Eagle publicly in the Irish Times (5/3/09) and on the main evening current affairs programme, Drivetime, RTE Radio 1, (3/3/09) alongside Duncan Orr-Ewing (RSPB), who gave the Irish public a clear overview of ongoing Eagle persecution in Scotland as a context to the Donegal incident.

The Project Manager has also developed an excellent working relationship with the National Association of Regional Gun Clubs, giving presentations at their Donegal and Mayo county Executive meetings for example. Indeed, Lorcan O Toole has been invited to give a key note address to the national AGM of NARGC in Donegal in October 2009, as the Donegal county executive celebrate its 50th anniversary. Again, contrary to unfounded comments by the SGA, the Golden Eagle Project enjoys widespread support among the farming and shooting communities in Donegal and beyond.

The potential adequacy of the food base for released golden eagles

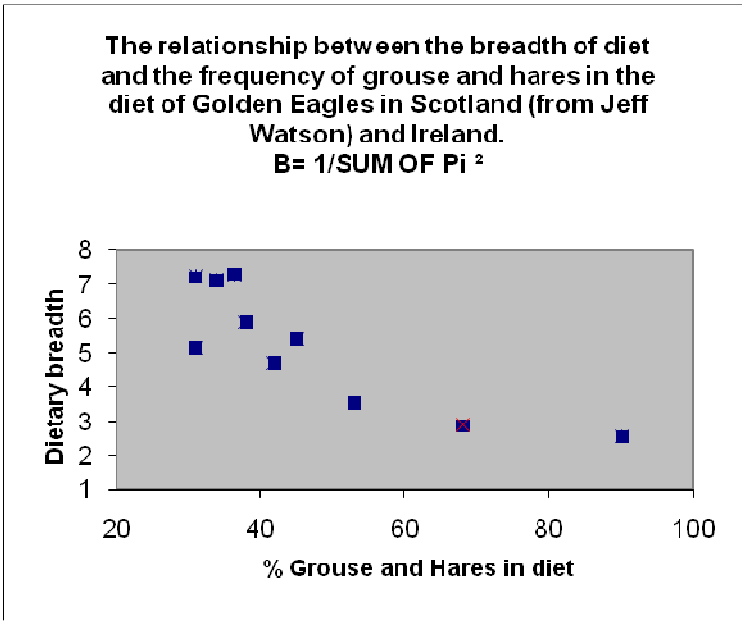
At the outset of the reintroduction programme, concerns were raised by several prominent Ornithologists on the east coast of the island of Ireland, that there was insufficient live prey in Donegal to sustain a viable and productive Golden Eagle population in Donegal. Indeed at the time serious concerns were raised that Irish Hares (weighing $\leq$ 4.5 kg) were heavier than Scottish Hares and were too heavy for eagles to lift. However the project team pointed out that introduced Irish Hares on the Isle of Mull were routinely taken by Golden Eagles there. The matter had been explored by Ciaran O'Keeffe and his NPWS colleagues in 1990 and 1991 using live prey transects based on similar work carried out by the late Dr Jeff Watson in Scotland. Dr Duncan Halley in Norway carried out an independent outside review of the Irish Golden Eagle Reintroduction proposal, on behalf of the Heritage Council in Ireland and concluded that the work carried out by Dr O Keeffe had a sound methodology and was comparable to the Scottish figures. Table 4 below outlines these findings. The Donegal adjusted figure was added in by the GET and only uses data from potential Golden Eagle territories in Donegal. The data below suggests that of the 10 areas surveyed, Donegal comes out in third or fourth position, suggesting that there is sufficient food to accommodate productive Home Ranges in Donegal. Lorcan O Toole spent six months surveying Golden Eagles in Lochaber in 1992 and never once saw a Red Grouse (only Red Grouse droppings) or Hare and only saw one Rabbit on the Fort William Roundabout. The live prey availability in Donegal is variable across the Home Ranges. In Glenveagh, the 2007 food remains at and near the nest site were carefully monitored and examined with the assistance of Robin Reid (a well known Scottish Golden Eagle fieldworker) and the following prey items were detected:

Irish Hare	9	(incl 1 leveret)
Red Grouse	2	
Badger Cub	2	
Fox Cub	1	
Corvid	1	
Passerine	1	

Table 4. Live Prey Availability from Watson and O Keeffe

	Grouse	Hare	Rabbit	Live Prey Total
Sutherland	9.8	0.5	4.1	16.1
NW Ross-shire	10.4	0.8	0	12.5
Central Ross-shire	20	2.3	0.5	29.1
East Highlands	81.7	12.8	0	102.7
Lochaber	4.9	0	2.5	8.7
Argyll	8.6	1	11.5	21.1
Skye & Lochalsh	2	0	97.5	100.3
Mull	2.1	18	8	28.1
Perth & Kinross	35.3	7.7	0	51.9
Donegal	3.5	26.6	5.6	35.7
Donegal Adjusted	3.1	34.6	8.4	46.1

Table 5. The dietary breadth of the Glenveagh pair, using the only available single sample set, compared with similar more robust Scottish dietary breadth data.



Dietary Breadth B=1/SUM OF % OF DIET SQAURED FOR EACH TAXON
Glenveagh/Ireland
2007

Hare 56%	0.3136
Grouse 12%	0.0144

Badger Cubs 12%	0.0144
Fox cub 6%	0.0036
Passerine 6%	0.0036
Curved 6%	0.0036
Total 0.3532	
Dietary Breadth =	
2.83	1/0.3532 =DB

In 2009 the Glenveagh nest food intake has been monitored on three separate nest visits to date and has found that the adults have brought in at least 5 Hares (including a leveret), 1 badger cub and 1 Fox cub. This again suggests a difference among Irish and Scottish Golden Eagle diets. In 1994, Dr Jeff Watson wrote a letter to Ireland's leading mammalologists, Dr Paddy Sleaman, and said his records, presumably among several hundred of prey items, only had 2 records of Badgers among Golden Eagle dietary items. The Irish Badger population is much more widespread than British Badgers and they can be found from sandy coastal islands to up to 400m ASL and it is estimated that the Badgers population is around 250,000 in Ireland. We believe the presence of at least of 3 badger cubs, during two nesting attempts in Glenveagh is significant.

The availability of Irish Hares would appear to be crucial to the successful breeding of Irish Eagles. Irish Hares can weigh up to 4.5kg and a single adult is likely to provide sufficient food for a single chick, not adults, for 3-4 days. Recent Hare Survey work by NPWS (Irish Wildlife Manual 30, 2007) and Quercus staff suggest the Irish Hare population found on Bog, Moor, Heath and Marsh alone had a spring density of 5.11 hares/km^2 in 2006 and 2.89 hares/km^2 in 2007, showing a clear cyclical nature of the Irish Hare population in this and other suitable habitat types.

Results of recent Red Grouse Survey work by Birdwatch Ireland and NPWS has yet to be published, but preliminary reports (UCC Fifth Irish Ornithological Conference 2008) would suggest that the Northwest of Ireland has some of the strongest remaining Grouse populations in Ireland, with 1-9 pairs/km^2 noted in Donegal. The Grouse densities will never reach the levels of Grouse found in eastern Scotland and managed through Muirburn.

Both Hare and Grouse densities in Donegal will be largely dependent on the surrounding sheep grazing regime. As noted by the Central Statistics Office, the number of Sheep in Donegal, as elsewhere in Ireland, has begun to decrease in response to the change from headage to area based farming subsidies. This may lead to a decrease in the amount of available sheep carrion on Irish uplands

but should, after an unknown time lag, lead to improving habitat and possibly a decrease in upland Fox densities and their constraining influence on Hare numbers.

The adequacy of the survey and monitoring effort devoted to looking for released birds.

The monitoring and survey of widely dispersing immature raptors is one of the greatest challenges facing raptor conservation and science worldwide. There will always be gaps in the knowledge concerning the status of dispersed immature birds. It has been widely documented that the monitoring of reintroduced White-tailed Eagle and Red Kite beyond the core release was and is a real problem among Scottish release projects to date. Indeed the difficulty of monitoring immature Golden Eagles in Scotland is widely recognised among Scottish raptor specialists as exceptionally difficult due to their sporadic dispersal pattern and the difficulty in getting into suitable vantage points in difficult terrain.

This issue was discussed at length at the last Golden Eagle Steering Group meeting in Monaghan in 2008. The Steering Group includes NPWS, GET, Birdwatch Ireland, Northern Ireland Environment Agency and RSPB Northern Ireland. Scottish Natural Heritage (Dr Andrew Douse and Dr Phil Whitfield) were invited to all the bi-annual Steering Group meetings for the initial four years, and would be welcome to attend future steering group meetings, but only managed to attend one meeting during that period. Advice from any informed source on this matter, and other matters, continues to be very welcome throughout the course of the project.

The Project Manager spent 6 years managing the SNH/RSPB Red Kite reintroduction programmes in Northern and Central Scotland and incorporated the approved Scottish monitoring and surveying techniques in the Irish project. All released birds have been fitted with wing tags in Ireland. Up to 2007 all released birds were fitted with Bio track TW 3 radio back packs. The released birds were routinely monitored especially in the Derryveagh and Bluestack Mountains. Since 2006, as the number of emerging Home Ranges became established in these two keying immature haunts, newly released birds have tended to wander further afield. The logistical effort in monitoring single birds in far flung temporary haunts was not considered productive on any intensive scale. The monitoring of reintroduced birds in Scotland has set the precedent of following released birds intensely within the core range, either all year round (Red Kite projects) or by utilising a seasonal fieldworker (Feb – October for the Wester Ross White-tailed Eagle programme). Extra effort and field staff were utilised in monitoring widespread White-tailed Eagle breeding attempts during the 1980's and 1990's.

In Ireland, a full time project manager has monitored released birds by radio tracking and or visual observations throughout the course of the project. Extra radio equipment was bought for NPWS staff in Mayo National Park, Connemara National Park and volunteers (Joe Kavanagh in Leitrim and John Cromie in Ballybofey) in 2006. Unfortunately the number of imported and released birds tailed off considerably after these additional resources were spent, due to licensing restrictions imposed in 2006 due to the emerging concern over the level of persecution in four eastern Natural Heritage Zones, where the project had collected up to 40% of our donor stock previously.

Satellite tracking has been used to monitor released Golden Eagles since 2005, utilising the best available technologies. 3 of the 18 (17%) birds released birds between 2005-2008 have been satellite tagged. Another two Microwave satellite tags have been ordered for this year in an effort to increase our knowledge of dispersing birds, as agreed at the last Irish project Steering Group. Satellite tracking, rather than increasing field staff covering several neighbouring counties in search of a small number of nomadic 1st, 2nd and 3rd year birds would seem to be the most effective way of monitoring released Golden Eagles, and would appear to be one of the key tools that may be used to assess the status of so many missing immature Golden Eagles in eastern Scotland also.

Due to a widespread awareness campaign, especially among the hill walking sector, the project receives regular Golden Eagle sightings from across Ireland either by phone or through the sightings database on our popular project web site. Unfortunately, as would be expected only a small number of observers manage to identify the individual wing tag markings of the Golden Eagle. There are several unconfirmed reports of an unidentified Golden Eagle with wing tags on the Isle of Mull, which demonstrates the real obstacles this species hold for indentifying individual immature birds away from nest sites.

The level of monitoring of all breeding attempts has also been thorough. Detailed nest records are kept and we have a good dataset of core territory areas, and all key breeding parameters. Again the project manager has adopted proven breeding monitoring requirements approved for the Scottish Red Kite project and the 1992 Scottish Golden Eagle breeding Survey.

It would be fair to say that the reintroduction project has not monitored home ranges to the same extent as commercially funded and specific wind farm environmental impact studies, due to the lucrative potential dividends for such resource rich developers.

The Irish project team have adopted an overall management plan more suited to the priorities of an emerging population, within a country previously devoid of large raptors and with significant challenges in public awareness and policy issues. In order to improve the overall national outlook for Irish raptors going forward, there was a deliberate decision to invest significant time in also

preparing and expanding the Irish raptor release programme into other parts of the country, namely Kerry and Wicklow, in the belief that these sister projects would have a real significant impact on the positive outlook for Donegal's Golden Eagles. And whilst it would be fair to suggest that the conservation of Golden Eagles has taken precedence over the scientific evaluation of all aspects of Golden Eagles ecology, we nonetheless have maintained a rigorous dataset of Golden Eagle records. The project has worked very closely with two recognised golden eagle experts, Dr Paul Haworth and Dr Alan Fielding, who co-authored the golden eagle conservation framework and have published extensively in the recent scientific literature.

Conclusion

The Irish Project partners look forward to the outcome of the review. They hope that the very clear advice by Dr Fielding which supports the continuation of the licensing will allow SNH to decide on a licence providing sufficient birds this year to work in a timely and cost-effective manner and to allow the project quickly reach the target of 75 releases.