

# **NRW General Licence Review Report**

**Assessment of the evidence base and  
recommendations for inclusion of wild birds listed  
on General licences (001, 002, 003 & 004) in Wales  
and whether there are other non-lethal satisfactory  
solutions available**

**September 2019**

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## Executive summary

### Background

1. General licences provide a statutory basis to allow any authorised person to lawfully control certain species of wild bird, by shooting or trapping. Four of them, namely GL001, GL002, GL003 and GL004 have been used in Wales to, respectively: prevent serious damage to agriculture, forestry and fisheries and to prevent the spread of disease; protect public health and safety; preserve air safety; and for the conservation of other avian and non-avian species. Since 2013 Natural Resources Wales (NRW) has been the appropriate authority in Wales for all wild bird licences.
2. Following a legal challenge by way of judicial review by Wild Justice, Natural England revoked three of their General Licences to kill or take certain species of wild birds on the basis that they had been granted unlawfully. The challenge was that Natural England had failed to make its own assessment as to whether there were no other satisfactory solutions, as required by the EU Wild Birds Directive and section 16 of the Wildlife & Countryside Act 1981 (as amended).
3. Whilst NRW has not received a legal challenge, we sought our own legal advice in a Welsh context. Advice from our legal counsel was that NRW, like Natural England, was not legally compliant in the way in which we had issued the four NRW General Licences (GL001-004).
4. Based on the risk that NRW as the appropriate licensing authority was not legally compliant, NRW carried out i) a review of the evidence-base to support the inclusion the species listed on GL001-004 and ii) a scientific literature review of control measures to assess whether there are other non-lethal satisfactory solutions available. That work included extensive consultation with user stakeholders. The main findings of this work and the recommendations arising from it are presented.

### Main findings:

- i) In Wales, rook has significantly declined in abundance, by 60% between 1994-2017 and by 50% between 2007-2017. Due to the significance of this decline, rook is recommended to be removed from GLs 001-004.
- ii) There are 27 species-purpose combinations that are recommended to be removed from the General Licences. These are: **rook** (from GL001, GL002, GL003 and GL004) **jay** (from GL001 & GL002), **collared dove** (from GL001, GL002 & GL003), **feral pigeon** (from GL003 & GL004), **carrion crow** (from GL002 & GL003), **magpie** (from GL002 & GL003), **jackdaw** (from GL002 & GL003), **Canada goose** (from GL003 & GL004), **wood pigeon** (from GL002 & GL003) and **great black-backed gull, lesser black-backed gull, herring gull, black-headed gull, common gull and lapwing** (all from GL003).
- iii) There are 11 species-purpose combinations that are recommended to be retained on the General Licences. These are: **carrion crow** (on GL001 & GL004), **magpie** (on GL001 & GL004), **jackdaw** (on GL001 & GL004), **feral pigeon** (on GL001 & GL002), **wood pigeon** (on GL001), **Canada goose** (on GL001) and **Jay** (on GL004).
- iv) **GL001** – ‘Licence to kill or take certain wild birds to prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease is recommended to be renamed **Licence to kill or take certain wild birds to prevent serious damage**

to livestock, foodstuffs for livestock, crops, vegetables or fruit or to prevent the spread of disease to livestock, foodstuffs for livestock, crops, vegetables or fruit and to include **carrion crow, magpie, jackdaw, feral pigeon, wood pigeon and Canada goose**. There is no published scientific evidence that **carrion crow, magpie** or **jackdaw** cause serious damage/harm to livestock or crops, though the possibility cannot be excluded that this represents an evidence gap, rather than providing evidence of no impact. Therefore, it is recommended that there is a need for further collation and assessment of anecdotal evidence specific to Wales. Furthermore, there is no well-established scientific or anecdotal evidence that for **feral pigeon** and **wood pigeon** there are non-lethal satisfactory solutions available that demonstrate they are effective, practical and proportionate, however, an economic appraisal of deterrent methods is recommended.

- v) **GL002** – ‘Licence to kill or take certain wild birds for the purpose of preserving public health and public safety’ is recommended to be renamed to ‘**GL002 - Licence to kill or take certain wild birds for the purpose of preserving public health and preventing the spread of disease to humans**’ and to only include **feral pigeon**. Though there is well established evidence that **carrion crow, magpie** and **jackdaw** are vectors of human enteropathogens (eg *Cryptosporidium parvum*, *Giardia lamblia*) there is almost no published scientific literature to demonstrate transmission of enteropathogens to humans. **Woodpigeons** and **collared doves** are potential reservoirs and vectors of microorganisms (eg *Chlamydia psittaci*), which could cause infections and allergic disease in humans and poultry. There are very few data on the prevalence of disease in **woodpigeons**, with the grey literature often referring to **feral pigeon**. On the basis of this assessment all these species, with the exception of **feral pigeon**, are recommended to be removed from a revised General Licence 002.
- vi) Due to the relatively small number of aerodromes and airfields in Wales, and the low volume of potential individual licence applications, it is recommended that General Licence 003 – preserving of air safety - is revoked and instead subject to the individual licensing process, where the species for which control is sought will be carefully assessed against the applicant’s evidence base and proven implementation of non-lethal satisfactory solutions.
- vii) **GL004** – ‘Licence to kill or take certain wild birds for the purpose of conserving flora and fauna, including wild birds’ is recommended to be renamed to ‘**GL004 - Licence to kill or take certain wild birds for the purpose of conserving wild birds**’ and to include **carrion crow, magpie, jackdaw** and **jay**. There is some established scientific evidence that **magpie, jackdaw** and **jay** can feed on the eggs and young of wild birds and collectively may limit the populations of their prey species, but the majority of published scientific studies do not identify the scale of effect of individual corvid species on other wild bird populations. Analyses of published studies of large-scale and extensive national monitoring datasets provides little evidence that **carrion crow, magpie, jackdaw** and **jay** have driven UK and/or Wales scale declines in songbird populations (particularly those species of farmland and woodland habitats). However, it is not possible to exclude the possibility that impacts can be significant at a local scale. Therefore, it is recommended that further engagement with General Licence user and non-user stakeholders is required in the form of additional data gathering and establishment of an NRW General Licence Working Group.
- viii) A literature review was carried out to address whether there are non-lethal deterrents that could be applied to meet the legal test of ‘no other satisfactory solution’ for GLs 001, 002 and 004. The findings confirmed that the number of published studies available was too small to assess against each of the 28 identified deterrent methods, with the exception of lethal control, and did not provide any quantitative and robust

evidence of other satisfactory solutions that were effective and proportionate to the risk.

- ix) Many authors of published studies often reiterated that non-lethal measures to protect vulnerable resources and preserve human safety often involved combining and interchanging a suite of different bird scaring techniques that had to be constantly moved or interchanged both spatially and temporally. Even when this was undertaken, avian pests appeared to habituate to these non-lethal techniques very quickly.
- x) A recurring theme in the literature in relation to the management of wild birds listed in GL's 001-004, was the necessity for lethal means to reinforce non-lethal measures.

## 1. Introduction

1.1 This report summarises the evidence underpinning the recommendations made to the Board of Natural Resources Wales (NRW) to revoke the four General Licences (GL001, GL002, GL003 and GL004) issued in January 2019 to control certain wild bird species in Wales, and to reissue revised GLs 001, 002 and 004. It describes the range of evidence gathered and analysed and sets out the conclusions reached.

## 2. Background

2.1 General Licences provide a statutory basis for people to lawfully carry out a range of activities that would otherwise be illegal without the need to individually apply for a licence. NRW makes available licences for certain activities relating to wild birds<sup>1</sup>. In Wales, General Licences 001 to 004<sup>2</sup> give permission to authorised persons<sup>3</sup> to take or kill certain wild birds, or damage, take or destroy their nests, or destroy their eggs for certain purposes for example to protect public health and safety, to protect crops and livestock or for the conservation of other species. These licences are issued on an annual basis under Section 16(1) of the Wildlife and Countryside Act 1981 (as amended) and apply to 15 bird species.<sup>4</sup> They allow lethal action and capture to be carried out, which would otherwise be illegal, without the need to apply for a bespoke licence.

2.2 The Birds Directive (2009/147/EC; formerly 79/409/EEC) requires EU member states to prohibit the deliberate killing of wild birds. Article 9 of the Birds Directive allows member states to derogate, for one or more of the purposes listed in Article 9(1) of the Directive, “where there is no other satisfactory solution” to such a derogation. The requirements of the Birds Directive are transposed into domestic law by the Wildlife and Countryside Act 1981 (the Act). Section 16(1) of the Act allows a licence to kill or take wild birds to be granted for the purposes outlined in paragraph 2.1 above (amongst others). Section 16(1A)(a) of the Act provides that the appropriate authority “shall not grant a licence for any purpose mentioned in [section 16(1)] unless it is satisfied that, as regards that purpose, there is no other satisfactory solution”.

2.3 On 25 April 2019, following a legal challenge by Wild Justice, Natural England revoked three General Licences in England to kill or take certain species of wild birds to: prevent serious damage or disease (licence GL04); preserve public health or public safety (licence GL05); and conserve wild birds, and flora and fauna (licence GL06). In the course of the following two weeks, NE issued three new general licences to kill or take: **carrion crows** *Corvus corone* to prevent serious damage to certain types of livestock (licence GL26); **Canada geese** *Branta canadensis* to preserve public health and safety (licence GL28);

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<sup>1</sup> The Wildlife and Countryside Act, 1981 (as amended), S27 defines a wild bird as any bird of a [F16species] which is ordinarily resident in or is a visitor to [F17the European territory if any member State] in a wild state but does not include poultry or, except in sections 5 and 16, any game bird;

<sup>2</sup> NRW General licence 001 - 2019 Licence to kill or take certain wild birds to prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease, 002 - 2019 Licence to kill or take certain wild birds for the purpose of preserving public health and public safety, 003 - 2019 Licence to kill or take certain wild birds for the purpose of preserving air safety, 004 - 2019 Licence to kill or take certain wild birds for the purpose of conserving flora and fauna, including wild birds.

<sup>3</sup> ‘Authorised person’ means an owner or occupier of the land where the operation will place, or any person authorised by an owner or occupier, or authorised in writing by a local authority, the Welsh Ministers or certain other public bodies.

<sup>4</sup> Carrion crow, jackdaw, jay, magpie, rook, lesser black-backed gull, herring gull, great black-backed gull, common gull, black-headed gull, lapwing, wood pigeon, collared dove, feral pigeon, Canada goose.

and **woodpigeons** *Columba palumbus* to prevent serious damage to crops including fruit and vegetables (licence GL31).

**2.4** On 4 May 2019, Defra launched a ‘call for evidence’, seeking views from all concerned parties on: i) the effectiveness and practicability of alternatives to killing or taking wild birds, ii) the benefits and problems with the revoked general licences, and iii) the impact which the revocation of the licences had had on the ground. In particular, Defra stated that the Secretary of State wanted to gain a clear understanding of the implications of the revocations of these General Licences for the protection of wild birds, and the impacts on crops, livestock, wildlife, disease, human health and safety and wider nature conservation efforts.

**2.5** Following Defra’s evidence-gathering exercise the three revoked General Licences for the killing or taking of wild birds in England were reissued on 14 June 2019 and a report published on 12 July 2019 which presented their findings from the call for evidence.

**2.6** While NRW has not to date received a legal challenge, legal advice indicated that NRW, like Natural England, was not legally compliant in the way in which the four General Licences 001,002,003 and 004 had been issued in Wales. As the licensing authority, NRW has to be satisfied that there is no other satisfactory solution other than lethal control or capture. However, to date NRW had delegated the decision on whether there is no other satisfactory solution to the licensee, that is the user.

**2.7** In response to the legal challenge by Wild Justice to Natural England, NRW carried out an evidence-led review, specifically to examine two questions:

**Q1** What is the extent and quality of evidence available to support inclusion of each of the 15 species of wild bird listed on General Licences 001-004 in Wales?

**Q2** Does the evidence base support the position underpinning NRW’s legal decision to issue General Licences 001 to 004 in Wales, namely that there is no other non-lethal satisfactory solution available?

**2.8** To address question 1 NRW carried out an extensive literature review to determine:

(i) the evidence on whether each species listed on General Licence 001 causes serious damage to agriculture, forestry or fisheries, or the spread of disease;

(ii) the evidence on whether each species listed on General Licence 002 poses a threat to public health and public safety;

(iii) the evidence on whether each species listed on General Licence 003 poses a threat to air safety;

(iv) the evidence on whether each species on General Licence 4 poses a threat to the conservation of wild birds; and

(v) whether there is evidence that any population of each of the species listed on General Licences 001-004 has shown a long-term marked decline in range and/or abundance in Wales, that is, a decrease of more than 25% between 1994-2017;



(vi) whether any species listed on GL001-004 are listed 'Red' or 'Amber' on 'Birds of Conservation Concern 3 Wales' (Johnstone and Bladwell, 2016)?

2.9 To address question 2, NRW carried out a literature review to determine the scientific quality (defined by the scientific rigour and strength of peer-reviewed scientific studies and/or reviews) of evidence that would either support or undermine the proposition that there are no satisfactory solutions other than lethal measures, for the control of the species concerned for the derogation purposes listed in GL001-004.

### 3. Assessment Method

**(Q1) What is the extent and quality of evidence available to support inclusion of each of the 15 species of wild bird listed on General Licences 001-004 in Wales?**

3.1 In Wales, 15 bird species are currently listed within General Licences 001-004 representing 38 species-purpose combinations (Table 1). To determine whether there is robust evidence for a species inclusion within General Licences 001-004, a prioritised framework using a six-stage process was developed.

**Table 1.** Bird species listed on General Licences 001-004 in Wales.

Species	GL001 - prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease	GL002 - preserving public health and public safety	GL003 - preserving air safety	G004 - conserving flora and fauna
Carrion crow	√	√	√	√
Magpie	√	√	√	√
Jackdaw	√	√	√	√
Jay	√	√	Not listed	√
Rook	√	√	√	√
Collard dove	√	√	√	Not listed
Feral pigeon	√	√	√	√
Wood pigeon	√	√	√	Not listed
Canada goose	√	Not listed	√	√
Great Black-backed gull	Not listed	Not listed	√	Not listed
Lesser Black-backed gull	Not listed	Not listed	√	Not listed
Herring gull	Not listed	Not listed	√	Not listed
Black-headed gull	Not listed	Not listed	√	Not listed
Common gull	Not listed	Not listed	√	Not listed
Lapwing	Not listed	Not listed	√	Not listed

### 3.2 Stage 1. Removal of GL003 – preserve air safety

GL003 has 14 avian species listed of which 5 are Red Listed on Wales' Birds of Conservation (**great black-backed gull** *Larus marinus*, **herring gull** *Larus argentatus*, **black headed gull** *Larus ridibundus*, **common gull** *Larus canus* and **lapwing** *Vanellus vanellus*) and one Amber listed (**lesser black-backed gull** *Larus fuscus*) (Johnstone & Bladwell 2016). There is a relatively small number of aerodromes and civilian and military airfields currently operational in Wales ( $N = 13$ ). **Due to the complexity of the issues involved and the low number of locations it is recommended that this General Licence is revoked.** Anyone wishing to use lethal measures to control any species of wild bird for the purposes of preserving air safety would need to apply for an individual or 'bespoke' licence.

### 3.3 Stage 2. Literature review of evidence to support inclusion of species on the General Licences

The literature review undertaken by Scottish Natural Heritage (SNH) of the evidence base for inclusion of bird species listed on General Licences 1, 2 and 3 in Scotland (Newson *et al* 2019) was examined and its findings assessed and applied in a Welsh context to GL001, GL002 and GL004. Where a species-purpose combination was not assessed by Newson *et al* (2019) it was subject to a separate evidence search and assessment of published scientific studies.

### 3.4 Stage 3. Assessing the strength of the evidence and scientific rigour of literature

Newson *et al.* (2019) categorised the evidence base according to the strength of the evidence of impact for each species-purpose combination across General Licences 1, 2, 3 issued in Scotland to kill or take wild birds. Their values for species listed on General Licences 001, 002 and 004 in Wales were applied at two levels: (i) the strength of evidence as presented by the reviewed literature; and (ii) the quality or scientific rigour of that evidence.

#### i) *The strength of evidence as presented in literature*

**Strong evidence** (score of 2) – Clear effects in at least some situations;

**Some evidence** (score of 1) – Potential effects in at least some situations;

**Little or no evidence** (score of 0) – No demonstrated effect.

#### ii) *Scientific rigour of the evidence as evaluated from literature*

**High degree of scientific rigour in the evidence** (score of 2) – Experimental evidence or a causal relationship between species' and impacts is unequivocally demonstrated;

**Some scientific rigour in the evidence** (score of 1) – Correlative evidence that is not supported by experiment or where causal relationships have not necessarily been demonstrated but where they are possible;

**No scientific rigour in the evidence** (score of 0) – Evidence is restricted to unsubstantiated claims or anecdotes.

### 3.5 To synthesise the results, the maximum score for strength of evidence and scientific rigour for each species-purpose combination were added together. This identified

three levels of evidence: (i) well established scientific evidence of impact (score of 4); (ii) some established scientific evidence of impact (score of 2-3) and little or no evidence base (score of 0-1).

3.6 **Stage 4. Expert opinion and anecdotal evidence of the likelihood of a species causing serious damage/harm, where there is little or no scientific evidence of harm**

For those species where the process described above found there was little or no published scientific evidence of impacts (i.e. a summed score of 1 or 0), the possibility remains that this represents an evidence gap, rather than providing evidence that there is no impact. Therefore, those species–purpose combinations were considered further against: i) NRW expert opinion, ii) anecdotal evidence using stakeholder responses to Defra’s Call for Evidence (eg RSPB, RSPCA, GWCT, BASC etc) and iii) bespoke General Licence questionnaire surveys in Wales (eg BASC 2019, NFU, 2019). The aim of this stage was to categorise each of these species-purpose combinations as follows:

- high expert opinion/well established anecdotal evidence of potential harm (score = 3);
- medium expert opinion/some established anecdotal evidence of potential harm (score = 2);
- low expert opinion/no anecdotal evidence of potential harm (score =1).

These scores were used to determine ‘**Likelihood**’. There is a possibility of a degree of bias in these scores due to the fact that the majority of stakeholders providing anecdotal evidence represent General Licence user groups.

3.7 For each species-purpose combination, where the strength of evidence and the scientific rigour of evidence had a combined score of 0 or 1 (maximum score = 4; Stage 4 assessment) plus an expert opinion and anecdotal evidence score of 1 (the maximum score being 3; Stage 3 assessment), giving an overall score of 1 or 2 (the maximum score being 7) then a species was recommended to be removed from that General Licence without the need to consider stages 5 and 6 below, and without the need to consider the legal test of whether there are no other non-lethal satisfactory solutions available. Each species-purpose combination with an overall score of 3 or higher at the end of stage 4 went on to Stage 5.

3.8 **Stage 5. Changes in distribution or abundance of bird species referenced in GL001, GL002 and GL004.**

Following completion of Stage 4, the conservation status of all remaining species was then considered. A species was recommended for removal from all General Licences if it had experienced a long term marked decline in population abundance. A ‘long term marked decline’ was defined as a 25% or greater reduction in abundance and/or distribution metrics, over a 25-year period across Wales. This follows established criteria to define bird species of conservation priority in ‘Birds of Conservation Concern’ in the UK (Eaton *et al.* 2015) and Wales (Johnstone & Bladwell, 2016). Using this approach accepts the assumption that distributions of birds change and declines, or increases may be localised rather than national, such that ‘marked’ changes may have occurred regionally but not generally across all of Wales.

- 3.9 The British Trust for Ornithology (BTO) was commissioned by NRW to provide evidence of marked changes in the distribution and abundance for the 15 bird species listed in GLs 001-004 in Wales (see Balmer and Noble, 2019). All 15 species were assessed using national and regional bird atlases and avifaunas (Balmer *et al.* 2013, Lovegrove *et al.* 1994), the BTO/JNCC/RSPB Breeding Bird Survey (BBS: Harris *et al.* 2018), the BTO/RSPB/JNCC/WWT Wetland Bird Survey (Frost *et al.* 2018), surveys of breeding seabirds (Mitchell *et al.* 2004) and the Seabird Monitoring Programme (JNCC 2016).
- 3.10.1 Newson *et al.* (2019) recognised a number of limitations in determining marked changes in a given species distribution and abundance, these are:
- i. The changes that can be described are necessarily limited in scale to the sources of data readily available. For example, national *bird atlases* generally summarise the distribution of birds at a 10 by 10 km square resolution (hectad scale), while regional atlases tend to be at finer resolution, typically at tetrad scale (2 by 2 km squares). Although coverage by atlases tends to be near-complete, atlases sample fixed periods only. For example, national atlases have covered the periods 1968-72, 1988-91 and 2007-11. The Breeding Bird Survey has sampled randomly selected 1 km squares annually since 1994. This permits an annual assessment of changes in abundance for many widespread and common breeding species, including a Welsh-specific trend for most of the breeding species considered by this review. Although the number of sampled squares is stable (318 1km squares were surveyed in Wales in 2018), this still remains sufficient for routine assessment of trends within Wales; regional assessments may be only feasible for a limited range of species, but these would require additional and bespoke analyses.
  - ii. The Wetland Bird Survey collates counts of waterbirds at coastal and freshwater bodies. Some sites are counted at monthly intervals, but many sites are typically counted between September and March inclusive and so at best only provide an index of change for waterbirds outside of the breeding season.
  - iii. Near-comprehensive surveys of breeding seabirds have been undertaken at periodic intervals (1969-70, 1985-88 and 1998-2002) but coverage of inland sites (particularly relevant for gulls) was either not attempted (1969-70) or was incomplete. The 2015-2019 breeding seabird census (Seabirds Count) is in its final year and is therefore not yet complete. However, all Welsh seabird colonies have now been surveyed and the data were used to compare changes in abundance. The Seabird Monitoring Programme provides annual counts of breeding seabirds for some colonies since 1986 but reports changes in addition to those covered by the periodic surveys for **Great black-backed gull** only amongst the species included in this review

### 3.11 Stage 6. *Birds of Conservation Concern*

All UK breeding or wintering bird species have been assessed against a set of objective criteria in order to be placed on the 'Red', 'Amber' or 'Green' list – indicating their level of conservation concern for the UK (Eaton *et al.* 2016) and for Wales (Johnstone & Bladwell, 2016). Any species remaining on GLs 001-004 after application of stage 5 above that are listed as either Red or Amber in 'Birds of Conservation Concern 3 Wales' (Johnstone & Bladwell, 2016) were recommended to be removed from the General Licences.

**(Q 2) Does the evidence base support the position underpinning NRW's decision to issue General Licences 001 to 004 in Wales, namely that there is no other non-lethal satisfactory solution available?**

*(a) Search and selection of relevant literature*

3.12 A literature search was conducted, following the principles of a formal systematic review, to determine whether there is a robust evidence base to answer question 2 in relation to GLs001, 002 and 004. Utilising the literature search approach by Newson *et al* (2019) and Roos *et al* (2018), the following approach was taken:

- Online literature databases *Web of Science (WOS)* and *Google Scholar* were used to search for relevant literature. Search phrases were defined and used to determine the relevance of each publication. References in these publications were then searched to identify relevant 'grey literature', or more obscure papers that may have been missed through the systematic literature search;
- Information available on the internet was searched using the Google search engine and by visiting relevant websites;
- Any previous reviews and books on similar and related topics were searched to identify additional literature (eg Bishop *et al* 2003; Madden *et al.* 2014; Roos *et al* 2018). Primary studies referred to in these reviews, as well as in other literature that were encountered, were also included where they provided a clearer or more direct link to information or a line of reasoning relevant to this review;
- Colleagues and stakeholders at non-governmental organisations (NGOs) and statutory agencies were asked to identify relevant peer-reviewed papers and PhD theses as well as 'grey literature' (e.g. reports from NGOs, statutory agencies and universities);
- Summaries of publications were captured under standardised headings in an MS Excel spreadsheet, so that the evidence underpinning species categorisations was documented in a form that would be easy for others to review.

*(b) Categorisation of 'other satisfactory solution'*

3.13 There is no definition in statute or in case law, of '*other satisfactory solution*' as used in section 16 of the Wildlife and Countryside Act, 1981 (as amended) or Article 9 of the EU Wild Birds Directive. In the absence of a statutory or legally authoritative definition four key criteria were used to assess potential alternatives to lethal control against the statutory test of '*there is no other satisfactory solution*'. These were:

- i) '**Effective**' - the alternative method is considered to be effective in significantly reducing the adverse impact of the target species over the short and long-term;
- ii) '**Practical**' - the alternative method is feasible and not limited in its application;
- iii) '**Sufficient**' - the method does not require extensive application to be effective and does not require other methods to be used in-combination with other methods in order to be effective, and;
- iv) '**Proportionate**' - the method is proportionate to the threat and/or risk.

- 3.14 For each scientific paper that was reviewed, the main findings were assigned a score, based on expert opinion, as to whether an identified satisfactory solution was effective, practical, sufficient, and proportionate:

*Effective:*

- 3 = effective over short and long-term
- 2 = effective over long-term (more than 2 weeks)
- 1 = effective over short-term (less than 2 weeks)
- 0 = No overall effect/mixed effect between study sites

*Proportionate:*

- 2 = proportionate and required only one method
- 1 = costs are acceptable but may require more than one method
- 0 = disproportionate as costs would be unacceptable relative to the threat/risk

*Practical:*

- 1 = Yes
- 0 = No

*Sufficient:*

- 1 = Yes
- 0 = No

- 3.15 The scores for each category were added together to give an overall score for the variable **Satisfactory**.

- 3.16 All known potential solutions for reducing the adverse impact of all the bird species as listed on GL 001-004 were categorised into six 'deterrent themes' as follows:

- (i) **Auditory** (gas canons, pyrotechnics, bio-acoustics (including distress calls), shooting to scare).
- (ii) **Visual** (lasers, human scarers, scarecrows, displaying corvid corpses, predator models, kites and falconry).
- (iii) **Chemical** (condition taste aversion, behavioural repellents)
- (iv) **Exclusion** (nets, tapes and wires)
- (v) **Habitat modification** (vegetation management, supplementary/diversionary feeding, sacrificial crops, control of other predating/competing species)
- (vi) **Lethal** (shooting to kill)

*(c) Categorisation of results from the literature search*

- 3.17 The information was gathered, collated and summarised, focussing wherever possible on findings from published studies that demonstrated whether the deterrent was considered by either the author(s) and/or NRW specialists to be effective, practical, sufficient and proportionate.

- 3.18 The response of a target species population to the deterrent was examined by assessing changes in the number of species-impact events (i.e. numerical changes). However, in many studies multiple species and deterrents were managed / trialled

simultaneously. In these cases, it was impossible to determine at the species level which deterrent was responsible for the response (ie change in impact events).

- 3.19 The scientific quality of published studies was assessed in accordance with the principles adopted by Roos *et al* 2018. Each study was categorised and scored as follows:
- i) **'Fair'** (score = 1) – *observational studies* from a single study area which focused mainly on the correlation between the response of the target species to the deterrent over time (e.g. reduction in the number of damaging events caused by the species);
  - ii) **'Good'** (score = 2) – *comparative studies* which contrasted the response of the target species to the deterrent at multiple sites with varying intervals of operation; and
  - iii) **'Best'** (score =3) - *experimental studies* that compared reduction of threat between areas where target species were excluded, deterred or removed, versus those in which target species were not manipulated.
- 3.20 Published studies which presented a baseline year to determine the number/index of the number of species-impact events and measured how this changed over time when assessing the response of the species to the implemented deterrent, were categorised as **'Best'**.
- 3.21 For each published study, the information provided in the study was used to categorise the 'response' of the target species to the implementation of the deterrent method, with  $P \leq 0.05$  as a statistical threshold.
- 3.22 The strength of evidence and scientific rigour of each study of deterrent effectiveness was then scored using a similar method (Newson *et al* 2019) to that applied to the assessment the strength and scientific rigour of studies of evidence of impact (see paragraph 3.4 above).
- 3.23 The scores derived from the processes described paragraph 3.19 and 3.22 above were then amalgamated to give an overall score for scientific quality, evidence strength and scientific rigour of each scientific study that investigated a given deterrent method, to give an overall value for the variable **'Evidence'**.
- 3.24 Based on the above method, a 'decision flow diagram' was then used in relation to each deterrent 'theme' (paragraph 3.16 above) to inform the recommendation on whether a species currently listed in the General Licence suite (001-004) for Wales should be either removed or retained, on the basis of whether or not there is sufficient evidence that there are available satisfactory alternatives to lethal control (see Figures 2a-e).
- 3.25 There are four scenarios where the conclusion from the review process described above would support the retention of a species on one or more of the General Licences 001-004. These are:
- Well established scientific and anecdotal evidence that the species may cause serious damage/impact + well established evidence that there is no other satisfactory solution.  
**Retain species on the General licence.**

- In the absence of scientific evidence but where expert opinion (anecdotal evidence) suggests there is a high and/or some likelihood that the species may cause serious damage/impact + there is some evidence that there are other satisfactory solutions that work in combination, but the quality and strength of the evidence is weak – **Retain species on the general licence subject to further review.**
- Some scientific evidence that the species may cause serious damage/harm + expert opinion suggests there is a medium to low likelihood that the species may cause serious damage/harm + there is well established evidence that there are no other satisfactory solutions except lethal measures **Retain species on the general licence subject to further review**
- Well established evidence that the species may cause serious damage/harm + there is some evidence that there are other satisfactory solutions that work in combination, but the quality and strength of the evidence is weak - **Retain species on the general licence subject to further review**

3.26 There are four scenarios that would support **removal of a species from the General Licences 001-004**. These are:

- Absence of established scientific evidence + expert opinion (anecdotal evidence) suggests there is low if any likelihood that the species may cause serious damage/impact, therefore no requirement to assess whether there are other satisfactory solution(s).
- The species has declined in abundance by 25% or more in the short-term and long-term (1995-2017) and would qualify on either the 'Red' or 'Amber' list using the established criteria of Birds of Conservation Concern. Therefore, authorising lethal control under a General Licence is inappropriate in terms of the conservation of the that species, and lethal control should be regulated through the individual licensing process.
- The species is currently 'Red' or 'Amber' listed on 'Birds of Conservation Concern 3 Wales (Johnstone & Bladwell, 2016). Therefore, authorising lethal control under a General Licence is inappropriate in terms of the conservation of that species, and lethal control should be regulated through the individual licensing process.
- A species is listed on General Licence 003 – preserving air safety. This General Licence is recommended to be revoked, such that lethal control of birds for aviation safety purposes is regulated through the individual licensing process.

## 4. Results and interpretation

**(Q 1) What is the extent and quality of evidence available to support inclusion of each of the 15 species of wild bird listed on General Licences 001-004 in Wales?**

*Stage 2 and 3: Literature review of evidence to support inclusion (strength of evidence)*

4.1 The findings of the SNH literature review assessed 493 published scientific studies and provided a measure of the strength of evidence and scientific rigour for each study (Newsom *et al* 2019). To synthesise their results, the maximum score for strength of



evidence and scientific rigour for each species-licence purpose combination was added together (Table 2). This identified three levels of scientific evidence: (i) well established evidence (maximum score of 4); (ii) some established evidence (score of 2-3) and (iii) little or no evidence base (score of 0 or 1).

- 4.2 **Magpie** *Pica pica*, **carrion crow**, **jackdaw** *Coloeus monedula* and **collared dove** (all GL001) and **rook** *Corvus frugilegus* (GL004) scored 0 for both strength of evidence and scientific rigour indicating there was little or no published evidence that these species have a serious impact on livestock and/or crops and that **rook** are not an important predator of the eggs/chicks of wild birds. However, the absence of scientifically published studies on the impacts of these four species on agricultural practices may represent an evidence gap, rather than providing evidence of no impact.
- 4.3 Nine avian species have some established scientific evidence (evidence strength of 1 or 2 and scientific rigour of 1 or 2). Seven avian species have well established scientific evidence (evidence strength of 2 and scientific rigour of 2) for evidence of causing serious damage and/or public harm, for GL001 these were **Canada goose**, **wood pigeon**, for GL002 they were **magpie**, **feral pigeon** *Columba livia* and for GL004 these were **carrion crow**, **magpie** and **jay** *Garrulus glandarius* (Table 2).
- 4.4 The summed values of strength of evidence and scientific rigour were used to determine the variable '**Evidence**' for each species and General Licence activity (Table 3).

**Table 2 (Q1 - Stage 3).** Strength of evidence and scientific rigour of evidence from the literature review for each species - General Licence combination in Wales (from Newson *et al*, 2019). Situations where there is little/no evidence to support a species' inclusion on a General Licence are highlighted in orange shade. Three species - Licence purpose combinations were not assessed by Newson *et al* (2019), namely **jay** -GL001, **jay** - GL002 and **feral pigeon** - GL00.4.

Target species	GL001– prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease			GL002 – preserving public health and public safety			GL004 - conserving flora and fauna		
	Strength	Rigour	Maximum	Strength	Rigour	Maximum	Strength	Rigour	Maximum
Magpie	0	0	0	2	2	4	2	2	4
Carrion crow	0	0	0	1	1	2	2	2	4
Jackdaw	0	0	0	1	2	3	1	2	3
Jay	Not assessed			Not assessed			2	2	4
Rook	1	2	3	1	1	2	0	0	0
Canada goose	2	2	4	Not listed		NA	1	1	2
Great black-backed gull	Not listed		NA	Not listed		NA	Not listed		NA
Lesser black-backed gull	Not listed		NA	Not listed		NA	Not listed		NA
Black-headed gull	Not listed		NA	Not listed		NA	Not listed		NA
Common gull	Not listed		NA	Not listed		NA	Not listed		NA
Lapwing	Not listed		NA	Not listed		NA	Not listed		NA
Herring gull	Not listed		NA	Not listed		NA	Not listed		NA
Collared dove	0	0	0	1	1	2	Not listed		NA
Feral pigeon	2	1	3	2	2	4	Not assessed		
Woodpigeon	2	2	4	1	1	2	Not listed		NA

**Table 3 – Q1 Stage 3.** Summary of the evidence assessment for inclusion of 15 avian species on General Licences 001, 002 and 004 in Wales (derived from the findings of Newson *et al* 2019). Green shaded cells = well established scientific evidence of impact (maximum score of 4), Amber shaded cells = some established scientific evidence of impact (score of 2-3) and Red = little or no evidence base (score of 0-1). Cells referenced ‘not assessed’ are not listed on the relevant General Licence in Scotland and were therefore not included within scope of the review of Newson *et al* (2019).

Species	GL001– prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease	GL002 – preserving public health and public safety	GL004 - conserving flora and fauna
Carrion crow	Red	Amber	Green
Magpie		Green	Green
Jackdaw		Amber	Amber
Rook		Amber	Red
Jay	Not assessed	Not assessed	Green
Collared dove	Red	Amber	Not listed
Feral pigeon	Amber	Green	Not assessed
Wood pigeon	Green	Amber	Not listed
Canada goose	Green	Not listed	Amber
Great black-backed gull	Not listed	Not listed	Not listed
Lesser black-backed gull	Not listed	Not listed	Not listed
Herring gull	Not listed	Not listed	Not listed
Black-headed gull	Not listed	Not listed	Not listed
Common gull	Not listed	Not listed	Not listed
Lapwing	Not listed	Not listed	Not listed

*Stage 4: Expert opinion and anecdotal evidence of the likelihood of a species causing serious damage/harm*

4.5 Expert opinion in combination with anecdotal evidence is summarised in Table 4 and suggests there were:

- i) five species- Licence purpose combinations where it was considered there was a high likelihood that these species may cause serious damage/harm, these were: **carrion crow** (GL001 & GL004), **Canada goose** (GL001), **wood pigeon** (GL001) and **feral pigeon** (GL002);
- ii) seven species- Licence purpose combinations where there was some likelihood that these species may cause serious damage/harm, these were: **rook** (GL001), **feral pigeon** (GL001), **magpie** (GL001 & GL004), **jackdaw** (GL001), **jay** (GL004) and **Canada goose** (GL004).
- iii) twelve species-Licence purpose combinations where there was no/low likelihood that these species may cause serious damage/harm.

**Table 4 – Q1 Stage 4.** Summary of the combination of expert opinion and anecdotal evidence of the likelihood of a species causing serious damage/harm in relation to a Welsh General Licence purpose (GLs 001, 002 & 004). Cells shaded in Green = high expert opinion/likelihood, amber = some expert opinion/likelihood and red = no/low expert opinion/likelihood.

Species	GL001– prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease	GL002 – preserving public health and public safety	GL004 - conserving flora and fauna
Carrion crow	Green	Red	Green
Magpie	Amber	Red	Amber
Jackdaw	Amber	Red	Red
Rook	Amber	Red	Amber
Jay	Red	Red	Amber
Collared dove	Amber	Red	Not listed
Feral pigeon	Amber	Green	Red
Wood pigeon	Green	Red	Not listed
Canada goose	Green	Not listed	Amber
Great black-backed gull	Not listed	Not listed	Not listed
Lesser black-backed gull	Not listed	Not listed	Not listed
Herring gull	Not listed	Not listed	Not listed
Black-headed gull	Not listed	Not listed	Not listed
Common gull	Not listed	Not listed	Not listed
Lapwing	Not listed	Not listed	Not listed

*Stage 3 & 4: Assessment of the scientific quality of the evidence and expert opinion/anecdotal evidence to support a species inclusion on GL 001, 002 and 004*

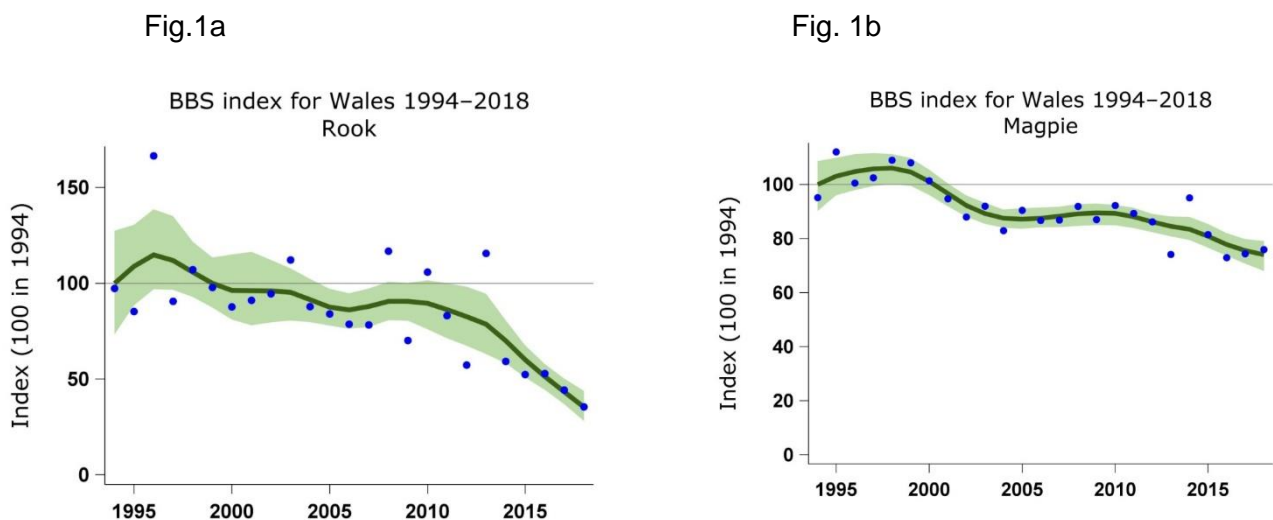
- 4.6 The findings from the literature review to assess the evidence base together with a combination of expert opinion and anecdotal evidence to support inclusion of 15 avian species on GL001, GL002 and GL004 in Wales are summarised in Table 5.
- 4.7 There were three species-Licence purpose situations which were not assessed by Newson *et al* (2019) due to these species not listed on the relevant General Licence in Scotland. However, they do occur on a similar themed Welsh General Licence. These were **jay** (GL001 & GL002) and **feral pigeon** (GL004). In these circumstances, a rapid assessment of published studies together with anecdotal evidence suggested there was no evidence to support inclusion (Table 5).

**Table 5 – Q1 Stages 3 & 4.** A summary table of the evidence (stage 3) and expert opinion and anecdotal evidence (stage 4) to support a species inclusion on GL 001, 002 and 004. Cells in the ‘Evidence’ column that are marked with an asterisk are species- Licence purpose combinations that were assessed and determined by NRW. Cells shaded in green = well established scientific evidence + high expert opinion, amber = some established scientific evidence + some expert opinion, red = low/no scientific evidence + low/no expert opinion.

Target species	GL001– prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease		GL002 – preserving public health and public safety		GL004 - conserving flora and fauna	
	Evidence	Expert opinion	Evidence	Expert opinion	Evidence	Expert opinion
Carrion crow	Red	Green	Amber	Red	Green	Green
Magpie	Red	Amber	Green	Red	Green	Amber
Jackdaw	Red	Amber	Amber	Red	Amber	Red
Rook	Amber	Amber	Amber	Red	Red	Red
Jay	Red *	Red	Red *	Red	Green	Amber
Collared dove	Red	Red	Amber	Red	Not listed	
Feral pigeon	Amber	Amber	Green	Green	Red *	Red
Woodpigeon	Green	Green	Amber	Red	Not listed	
Canada goose	Green	Green	Not listed		Amber	Amber
Great black-backed gull	Not listed		Not listed		Not listed	
Lesser black-backed gull	Not listed		Not listed		Not listed	
Herring gull	Not listed		Not listed		Not listed	
Black-headed gull	Not listed		Not listed		Not listed	
Common gull	Not listed		Not listed		Not listed	
Lapwing	Not listed		Not listed		Not listed	

Stage 5: Changes in distribution or abundance of avian species referenced in GL001-004.

- 4.8 The status of 15 species listed on GLs 001-004 in Wales were assessed by Balmer & Noble (2019) to determine whether their spatial distribution and/or abundance had markedly changed in Wales in the past 25 years sufficiently for their conservation status and any threat or impact posed by them to have potentially changed (Table 6).
- 4.9 Population change assessment based on Breeding Bird Survey (BBS) for Wales suggests six of the focal species based on population trends increased markedly overall (indices of abundance had positively changed by 25% or more) during the period considered (1994-2017), these were **jay, Canada goose, herring gull, collared dove, wood pigeon and feral pigeon**. In total five species decreased markedly overall, these were **magpie, rook, lesser black-backed gull, black-headed gull and lapwing**. All these species except **magpie and rook** were listed on General Licence 003 (preserving air safety). Six species showed marked increases in their distribution (**Canada goose, great black-backed gull, lesser black-backed gull, herring gull, collared dove and feral pigeon**) this may suggest that any threat or impact these species might have in relation to the general licensing purposes could have increased locally or regionally.
- 4.10 BBS population trend data show **rook** and **magpie** have declined in the long-term (1995-2017) by 60% and 27% respectively, with **rook** significantly declining by over 50% between 2007-17 (Table 6, Figure 1). **Due to the significance of the decline, rook is recommended to be removed from the Welsh GL suite 001-004.**



**Fig. 1a-b.** Breeding Bird Survey (BBS) Index for rook (a) and magpie (b) between 1994–2018 (Balmer & Noble, 2019).

Stage 6: Birds of Conservation concern

- 4.11 General Licence 003 (preserving air safety) is the only General Licence within the suite (GL001-004) where species are either Red or Amber listed under Wales Birds of Conservation Concern, five are Red listed – **great black-backed gull, herring gull, common gull, black-headed gull and lapwing** and one is Amber listed – **lesser black-backed gull** (Johnstone & Bladwell, 2016). **General Licence 003 is recommended to be withdrawn, so that control of birds for the purpose of preserving aviation safety is regulated through individual licences, where the wild bird species for which control is sought will be carefully assessed against the applicant's evidence base of impact and non-lethal measures implemented.**

**Table 6 – Q1 Stage 5.** Summary statistics describing changes in the status of species listed on General Licences 001, 002, 003 & 004 in Wales and included in the current review. Cells shaded in light green highlight species that show ‘marked’ decline in abundance and where denoted with an asterisk represent significant decline (from Balmer & Noble, 2019). Species cells shaded in red represent ‘Red’ listed birds of Conservation Concern, species cells shaded in amber represent ‘Amber’ listed Birds of Conservation Concern (see Johnstone & Bladwell, 2016).

Species	Breeding Bird Atlas <sup>a</sup>			Breeding Bird Survey trend <sup>b</sup>			Wetland Bird Surveys		Other sources <sup>c</sup>
	Hectads occupied 1988-91	Hectads occupied 2008-11	Change in occupied hectads	10-year (2007-17)	23-year (1995-2017)	CI of 23-year trend	10-year (2006/07–2016/17)	25-year (1991/92–2016/17)	
Magpie	279	281	+0.7%	-14%*	-27%*	-38% to -14%	NA	NA	
Carrion Crow	280	285	+1.8%	-6%*	+6%	-14% to +30%	NA	NA	
Jackdaw	278	278	0%	-15%	+9%	-31% to +84%	NA	NA	
Jay	240	262	+9.2%	+17%*	+49%	+18% to +115%	NA	NA	
Rook	259	257	-0.8%	-51%	-60%*	-72% to -43%	NA	NA	
Canada Goose	85	240	+182.4%	+47%	+433%	+168% to +1316%	7	718	
Great Black-backed Gull	34	52	+52.9%	No data available	No data available	No data available	6	NA	SMP 1969–1988 -69% SMP 1988–2002 +47%
Lesser Black-backed Gull	46	78	+69.6%	-7	-59%	-10 to +225	36	NA	SMP 1969–1988 +74% SMP 1988–2002 +3%
Herring Gull	80	121	+51.2%	+3	+121*	+34 to +278	62	NA	SMP 1969–1988 -77% SMP 1988–2002 +26%
Common Gull	0	0	0	No data available	No data available	No data available	-42	NA	SMP 1969–1988 -100% SMP 1988–2002 NA

Species	Breeding Bird Atlas <sup>a</sup>			Breeding Bird Survey trend <sup>b</sup>			Wetland Bird Surveys <sup>c</sup>		Other sources <sup>d</sup>
	Hectads occupied 1988-91	Hectads occupied 2008-11	Change in occupied hectads	10-year (2007-17)	23-year (1995-2017)	CI of 23-year trend	10-year (2006/07–2016/17)	25-year (1991/92–2016/17)	
Black-headed gull	58	37	-36.2%	-9	-89*	-10 to+225	5	NA	SMP 1969–1988 +25% SMP 1988–2002 -15%
Lapwing	219	150	-31.5%	-14	-70*	-91 to-6			
Collared Dove	237	269	+13.5%	-17	+28	-12 to+102			
Feral Pigeon / Rock Dove <sup>e</sup>	174	198	+13.8%	+14	+42	-10 to +106			
Woodpigeon	276	281	+1.8%	-9	+19	-1 to+40			

Notes:

<sup>a</sup> The number of hectads (10 by 10 km squares) in which the species was recorded during the breeding season in each of the two atlas periods and the percentage change from the 1988-91 to the 2008-11 periods;

<sup>b</sup> Changes in indices of abundance derived from the BBS between 2006 – 2016 and 1995 – 2016. Statistically significant changes are marked with an asterisk. The 95% confidence intervals (CI) are shown for the 1995-2016 trends. Not including zero within the CI indicates a statistically significant trend. The closeness of a confidence limit to zero is an indication of how close to statistical significance is the trend. For Jay, the 10-year trend is reported only as the species has been too scarce over much of the period since 1994 for the longer-term trend to be derived;

<sup>c</sup> Wetland Bird Survey (WeBS: the change in index of abundance of non-breeding waterbirds between the winter seasons shown)

<sup>d</sup> The Seabird Census (changes in the counts of apparently occupied territories for coastal breeding seabirds between the periods 1985-88 and 1998-2002) and the Seabird Census (the change reported by annual monitoring of sample colonies between 1998 and 2002);

<sup>e</sup> Changes are reported for feral pigeon and rock dove combined as the two forms are widely integrated. In reality, the indices will be measures of change for the much more abundant and widespread feral pigeon 'form'



*Licence determinations to support inclusion on GLs 001-004*

4.12 NRW has assessed the available evidence base to support the inclusion of 15 avian species across 38 species-General Licence combinations for GLs 001-004 in Wales.

4.13 In summary, there are 27 species-General Licence combinations that are recommended to be removed, as summarised in Table 7, these are **rook** (GL001, GL002, GL003 and GL004) **jay** (GL001 & GL002), **collared dove** (GL001, GL002 & GL003) and **feral pigeon** (GL003 & GL004), **carrion crow** (GL002 & GL003), **magpie** (GL002 & GL003), **jackdaw** (GL002 & GL003), **wood pigeon** (GL002), **Canada goose** (GL003 & GL004), **wood pigeon great black-backed gull**, **lesser black-backed gull**, **herring gull**, **black-headed gull**, **common gull** and **lapwing** (all GL003).

**Table 7. – Q1 Stages 1-6.** Summary of the recommendations for each species-General Licence combination following an assessment of the evidence base from a systematic literature review, expert opinion and anecdotal evidence. Cells marked with a single asterisk \* = retain but requires further evidence review, cells marked with a double asterisk \*\* = established evidence that the species has the potential to cause human harm by carrying harmful pathogens, but the likelihood of this occurring is extremely low. Cells shaded green are species to be recommended to be retained and cells in orange are species recommended to be removed from the General Licence suite.

Species	GL001– prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease	GL002 – preserving public health and public safety	GL003 - preserving air safety	GL004 - conserving flora and fauna
Carrion crow	Retain	Remove**	Remove	Retain
Magpie	Retain*	Remove**	Remove	Retain*
Jackdaw	Retain*	Remove**	Remove	Retain*
Rook	Remove	Remove	Remove	Remove
Jay	Remove	Remove**	Not listed	Retain*
Collard dove	Remove	Remove**	Remove	Not listed
Feral pigeon	Retain	Retain	Remove	Remove
Wood pigeon	Retain	Remove**	Remove	Not listed
Canada goose	Retain	Not listed	Remove	Remove
Great black-backed gull	Not listed	Not listed	Remove	Not listed
Lesser black-backed gull	Not listed	Not listed	Remove	Not listed
Herring gull	Not listed	Not listed	Remove	Not listed
Black-headed gull	Not listed	Not listed	Remove	Not listed
Common gull	Not listed	Not listed	Remove	Not listed
Lapwing	Not listed	Not listed	Remove	Not listed

**(Q2) Does the evidence base support the position underpinning NRW's decision to issue General Licences 001 to 004 in Wales, namely that there is no other non-lethal satisfactory solution available?**

*Literature review*

- 4.14 A search of published information using online literature databases such as Web of Science and the online search engine *Google Scholar* and extensive information held by stakeholders, manufacturers and distributors of deterrent devices, peer reviewed papers on wildlife management deterrent methods were located. Literature cited in the papers and reviews identified in the primary search methods were also examined. This resulted in a collection of 145 peer-reviewed documents. Of 114 papers examined, 83 published studies were able to be scored using the methods outlined in paragraphs 3.4 and 3.19 above. Information from these studies was extracted and collated, following the method as outlined in 3.12-3.26, to examine whether there are non-lethal deterrents that could be applied to meet the legal test of 'no other satisfactory solution' for GLs 001, 002 and 004.
- 4.15 The findings confirmed that the number of published studies available was too small to assess against each of the 28 deterrent methods identified, with the exception of shooting to kill, to provide quantitative and robust evidence to meet the test of other satisfactory solutions. Therefore, for the purposes of this review, all 28 deterrent methods were brigaded and categorised into seven groups or themes: auditory, visual, chemical, habitat modification, exclusion, various (ie multiple methods tested in combination) and lethal control. Full information regarding deterrent methods and associated wildlife management themes is provided in Appendix 1.

*Evidence that there are other satisfactory solutions*

- 4.16 Of the published papers that were assessed, 28 studies were associated with lethal control, 19 for visual studies, 10 for chemical and exclusion, 6 for audio and various and 4 for habitat manipulation (Table 8). The most frequently studied deterrent in the reviewed papers was associated with the theme 'Lethal' (lethal predator control,  $N=28$  studies), followed by 'Exclusion' (enclosures over/around nests,  $N=7$  studies), 'Chemical' (taste aversion,  $N=6$  studies), 'Visual' (falconry,  $N=4$  studies and decoys  $N=4$  studies) (see Appendix 1).
- 4.17 The results suggest that of the seven wildlife deterrent themes that were reviewed and scored only lethal, exclusion, habitat manipulation and 'various' had a mean 'Effective' score  $>2$  (Table 8). Several limitations to the overall scoring for 'exclusion', 'habitat manipulation' and 'various' were identified:
- i) The majority of published studies labelled as 'Exclusion' were related to nest enclosures around breeding wader nests to improve their productivity. However, though the published studies suggested that this method was effective at improving hatching success, it was considered that this method was probably ineffective at reducing overall breeding success as the chicks would be vulnerable to predation once they leave the nest and the protection of the nest enclosure.
  - ii) For the theme 'Various', which had a mean effective score of 2, it was difficult to determine the effect of any one single method that led to a reduction in serious damage/impact, and the sample size of reviewed scientific studies was relatively small ( $N=6$  studies)

iii) Studies examining the effect of 'Habitat manipulation' suggested a mean score of 2.5. This score was treated cautiously as the sample of published studies reviewed was very small ( $N = 4$  studies).

- 4.18 Each published study was given a score depending on its scientific quality. Accordingly, the most common scientific quality category of all published studies was 'Best' ( $N = 49$  studies), with 22 cases of 'Good' and 12 cases in the 'Fair category. (These categories are defined in paragraph 3.19.). Summarised information regarding published studies and evidence categories is presented in Table 9.
- 4.19 Some of the inadequacies of experimental design that were recorded included: no appropriate control, insufficient replication, non-random allocation of treatments, insufficient trial period to detect habituation, and plots not large enough to prevent interference between treatments. None of the 83 studies assessed and scored provided a full cost-benefit analysis. Though a few studies provided a measure of damage, none provided costs to implement the deterrent. In the absence of quantitative evidence, it was assumed that in terms of cost effectiveness, predator exclusion may be the costliest deterrent (ie anti-predator fencing), followed by chemical techniques such as condition taste aversion and contraception. Visual and auditory deterrents may be less expensive. It is recognised that the absence of a fully appraised cost analysis is a limitation of this review, particularly on how the proportionality of a given deterrent (in relation to the nature of the threat posed by the species) is assessed.
- 4.20 There were proportional differences in country locations where the studies were conducted with 51% ( $N = 42$  studies) carried out in the UK, 33% ( $N = 27$ ) in North America, 11% ( $N = 9$  studies) in South Africa and 6% ( $N = 5$  studies) in New Zealand. Of the total number of studies assessed and scored 75 (90%) were on species and licensed activities that are relevant to Wales. In relation to those studies reviewed that were undertaken outside the UK, there was no consideration of whether the method and/or intensity of treatments applied would be legal in Wales. For example, the application of chemicals not licensed in the UK, or detonation frequencies above the recommended rate for gas cannons (NFU guidelines).
- 4.21 To inform the recommendations of whether there are non-lethal satisfactory solutions, a decision framework was developed. This is presented for five non-lethal deterrent themes: audio, chemical, exclusion, habitat manipulation and visual (Figures 2a-e). In this framework each deterrent theme was addressed by four questions where a threshold score had to be met. These were:
- i. Are the methods effective (average score  $>2$ )?
  - ii. Are the methods proportionate (average score  $>1$ )?
  - iii. Are the methods practical (average score  $>0.5$ )?
  - iv. Are the methods sufficient (average score  $.0.5$ )?

If the threshold score was met for all questions the deterrent theme was considered to be satisfactory. Of the five deterrent themes, the review indicated only those methods associated with 'exclusion' could present an alternative satisfactory solution to deter avian species listed in GL001-004. However, this finding needs to be treated cautiously for two reasons. Firstly, the review only considered a relatively small number of scientific published studies ( $N = 10$ ). Secondly, seven of the ten exclusion studies reviewed were related to wire framed nest excluders that protect the nests of waders of conservation concern, such as lapwing and black-tailed godwit *Limosa limosa*. It should be noted that the nest protectors would only have an anti-predator effect during incubation, and although the majority of these studies reported

improved hatching success, they would not necessarily address levels of post hatching predation that may result in decreased chick survival (ie overall breeding success).

- 4.22 Although the focus of this review was to determine whether there are other non-lethal satisfactory solutions available to deploy in relation to GLs 001-004 the applicability of several key deterrent themes was often restricted to a specific or restricted combination of General Licences. For example, the studies that were reviewed under the themes 'Chemical' and 'Exclusion' were only specific to General Licence 004. The applicability of the studies reviewed to the General Licence type is referenced in Figures 2a-e.
- 4.23 The findings of this review support the conclusions drawn from Bishop *et al* (2003) and Defra (2019), that following assessment, there are no other satisfactory solutions except lethal control for General Licences 001, 002, 003 and 004. However, **an economic appraisal of several potentially effective non-lethal deterrents methods is recommended**, such as the costs associated with habitat manipulation and enclosing crops with temporary or permanent netting to reduce serious damage to crops often caused by **wood pigeon** and **feral pigeon**. Such an appraisal should determine whether the deployment of these measures are proportionate to the threat.

**Table 8.** Summary of the literature review to assess 'other satisfactory solutions' for seven avian deterrent themes.

Deterrent theme	Papers scored	Effective					Practical			Sufficient			Proportionate			
		0	1	2	3	mean	0	1	mean	0	1	mean	0	1	2	mean
Lethal	28	2	4	10	12	<b>2.11</b>	2	26	<b>0.80</b>	15	13	<b>0.50</b>	1	20	7	<b>1.62</b>
Audio <sup>1</sup>	6	1	3	2	0	<b>1.17</b>	1	5	<b>0.83</b>	3	3	<b>0.50</b>	0	6	0	<b>1.00</b>
Chemical <sup>2</sup>	10	3	2	1	4	<b>1.60</b>	7	3	<b>0.30</b>	10	0	<b>0</b>	8	2	0	<b>0.20</b>
Exclusion <sup>3</sup>	10	0	0	8	2	<b>2.20</b>	1	9	<b>0.90</b>	2	8	<b>0.80</b>	1	7	2	<b>1.1</b>
Habitat manipulation <sup>4</sup>	4	0	0	2	2	<b>2.60</b>	1	3	<b>0.80</b>	2	2	<b>0.40</b>	1	3	0	<b>0.80</b>
Visual <sup>5</sup>	19	4	3	5	7	<b>1.79</b>	0	19	<b>1.06</b>	12	7	<b>0.33</b>	3	14	2	<b>0.94</b>
Various <sup>6</sup>	6	1	1	1	3	<b>1.86</b>	2	4	<b>0.86</b>	5	1	<b>0.29</b>	1	4	1	<b>1.00</b>

Notes

1. Audio included: gas canons, pyrotechnics, bio-acoustics (including distress calls), shooting to scare
2. Chemical included: condition taste aversion, behavioural repellents
3. Exclusion included: nets, tapes and wires, nest excluders
4. Habitat manipulation included: vegetation management, supplementary/diversionary feeding, sacrificial crops, control of other competing species
5. Visual included: lasers, human scarers, scarecrows, displaying corpses/effigies, predator models, kites and falconry
6. Various is defined as multiple methods used in combination

**Table 9.** An assessment of the scientific quality of published studies for seven avian deterrent themes. Shaded cells represent the deterrent theme where the percentage of studies have a scientific quality, strength of evidence and scientific rigour >50%.

Deterrent theme	Papers scored	Scientific quality			Strength of evidence			Scientific rigour		
		Best	Good	Fair	0	1	2	0	1	2
Lethal	28	17 (60%)	8	3	0	11	17 (60%)	0	9	19 (68%)
Audio <sup>1</sup>	6	2	3	1	1	5 (83%)	0	2	4 (67%)	0
Chemical <sup>2</sup>	10	6 (60%)	3	1	4	1	5 (50%)	4	1	5 (50%)
Exclusion <sup>3</sup>	10	8 (80%)	1	1	0	1	9 (90%)	0	1	9 (90%)
Habitat manipulation <sup>4</sup>	4	3 (75%)	0	1	0	1	3 (75%)	0	1	3 (75%)
Visual <sup>5</sup>	19	8 (49%)	6	5	3	8	8	3	5	11 (58%)
Various <sup>6</sup>	6	5 (83%)	1	0	1	3 (50%)	2	1	3 (50%)	2

Notes

1. Audio included: gas canons, pyrotechnics, bio-acoustics (including distress calls), shooting to scare
2. Chemical included: condition taste aversion, behavioural repellents
3. Exclusion included: nets, tapes and wires, nest excluders
4. Habitat manipulation included: vegetation management, supplementary/diversionary feeding, sacrificial crops, control of other competing species
5. Visual included: lasers, human scarers, scarecrows, displaying corpses/effigies, predator models, kites and falconry
6. Various is defined as multiple methods used in combination

**Fig 2a.** Audio measures (applicable to GL001, GL002 and GL003)

Audio		
1. Are the methods effective (average score >2)?	YES	NO
2. Are the methods proportionate (average score >1)?	YES	NO
3. Are the methods practical (average score >0.5)?	YES	NO
4. Are the methods sufficient (average score >0.5)?	YES	NO
Are the methods satisfactory?	YES	NO

**Fig. 2b.** Chemical measures (applicable to only GL004)

Chemical		
1. Are the methods effective (average score >2)?	YES	NO
2. Are the methods proportionate (average score >1)?	YES	NO
3. Are the methods practical (average score >0.5)?	YES	NO
4. Are the methods sufficient (average score >0.5)?	YES	NO
Are the methods satisfactory?	YES	NO

**Fig. 2c.** Exclusion measures (applicable to only GL004)

Exclusion		
1. Are the methods effective (average score >2)?	YES	NO
2. Are the methods proportionate (average score >1)?	YES	NO
3. Are the methods practical (average score >0.5)?	YES	NO
4. Are the methods sufficient (average score >0.5)?	YES	NO
Are the methods satisfactory?	YES	NO

**Fig 2d.** Habitat manipulation measures (applicable to GL001, GL002, GL003 and GL004)

Chemical		
1. Are the methods effective (average score >2)?	YES	NO
2. Are the methods proportionate (average score >1)?	YES	NO
3. Are the methods practical (average score >0.5)?	YES	NO
4. Are the methods sufficient (average score >0.5)?	YES	NO
Are the methods satisfactory?	YES	NO

**Fig 2e.** Visual measures (applicable to GL001, GL002, GL003 and GL004)

Visual		
1. Are the methods effective (average score >2)?	YES	NO
2. Are the methods proportionate (average score >1)?	YES	NO
3. Are the methods practical (average score >0.5)?	YES	NO
4. Are the methods sufficient (average score >0.5)?	YES	NO
Are the methods satisfactory?	YES	NO

**Fig. 2a-e.** Decision-making tree to assess whether non-lethal themes of wildlife management deterrents (audio, chemical, exclusion, habitat manipulation and visual) were satisfactory. The cells in the left-hand column provide a yes answer to questions 1-4, if the yes cell is highlighted in green you answer the next question and so on. The cells in the right-hand column provide a no answer to the questions 1-4, if any one question is highlighted in red then the theme is considered not to be satisfactory.



4.22 The most frequently studied species reviewed were ‘corvids’ with 36 studies (50%) followed by pigeons with 16 studies (22%) and gulls with 10 studies (14%) (Figure 3).

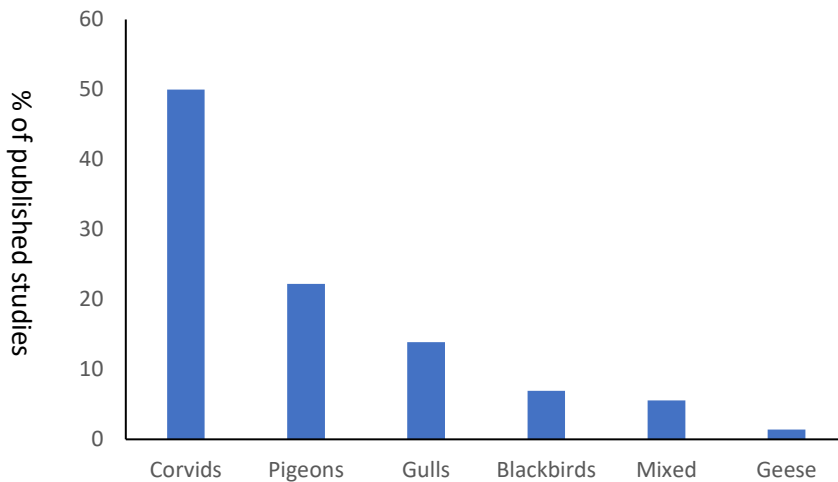


Fig. 3. The proportion of published studies, by avian group, that were reviewed

## 5. Recommendations for General Licensing

- 5.1 The purpose of the work presented in this document is to assess the extent and quality of evidence to inform which species of wild birds should be included on General Licences 001-004 in Wales and to enable NRW as the appropriate licensing authority in Wales to be satisfied that a species is included on GL001-004 only where there are no non-lethal satisfactory solutions.
- 5.2 Following this assessment there are 38 recommendations regarding retention or removal of bird species from General Licences 001-004, these are summarised in Table 10.
- 5.3 Our review of the collective evidence base suggests there is a need for a further in-depth scientific review of published papers. For example, further clarification is needed as to whether **magpie**, **jackdaw** and **jay** have significant national-scale impacts on avian prey populations and on the observation that many of the published studies that were reviewed only examined the effect of the simultaneous removal of several predators (eg carrion crow and magpie) on wild bird populations.

**Table 10.** Systematic review of evidence to support inclusion of species of wild bird listed on General Licences 001-004 and assessment of existence of other satisfactory solutions. Cells shaded in green = species recommended to be retained, cells shaded in red = species recommended to be removed. Cells marked with a single asterisk = a species-General Licence purpose combination where further review of whether the species is causing serious damage is recommended, cells marked with a double asterisk = a species-General Licence purpose combination where further review of other satisfactory solutions is recommended

Species	GL001– prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease	GL002 – preserving public health and public safety	GL003 - preserving air safety	G004 - conserving flora and fauna
Carrion crow		*		
Magpie	*	*		*
Jackdaw	*	*		*
Rook				
Jay			Not listed	*
Collard dove				Not listed
Feral pigeon	**			
Wood pigeon	**			Not listed
Canada goose		Not listed		
Great black-backed gull	Not listed	Not listed		Not listed
Lesser black-backed gull	Not listed	Not listed		Not listed
Herring gull	Not listed	Not listed		Not listed
Black-headed gull	Not listed	Not listed		Not listed
Common gull	Not listed	Not listed		Not listed
Lapwing	Not listed	Not listed		Not listed

5.3 For each General Licence determination (GL001-004) a synthesis of the findings and recommendations of this report is provided as follows:

**GL001** - Licence to kill or take certain wild birds to prevent serious damage to agriculture, forestry or fisheries, or prevent the spread of disease

**Recommendation:** rename to ‘Licence to kill or take certain wild birds to prevent serious damage to livestock, foodstuffs for livestock, crops, vegetables or fruit or to prevent the spread of disease to livestock, foodstuffs for livestock, crops, vegetables or fruit’

*Carrion crow*

- No published scientific evidence that this species may cause serious damage/harm to livestock or crops, though the possibility cannot be excluded that this represents an evidence gap, rather than providing evidence of no impact, (Newson *et al.* 2019).
- Expert opinion and anecdotal evidence suggests there is potential for serious damage/harm to livestock, mainly concerning sheep (ie ewes and lambs stuck on their backs and unable to rise, ewes giving birth and new born lambs) being susceptible to attacks from carrion crows.
- There are no non-lethal satisfactory solutions that are effective, practical and proportionate.

- Recommendation – **RETAIN**

#### *Magpie*

- No published scientific evidence that this species may cause serious damage/harm to livestock or crops, though the possibility cannot be excluded that this represents an evidence gap, rather than providing evidence of no impact, (Newson *et al.* 2019).
- Expert opinion and anecdotal evidence suggests there is i) potential for serious damage/harm to livestock, mainly concerning sheep (ie ewes and lambs stuck on their backs and unable to rise, ewes giving birth and new born lambs) being susceptible to attacks from magpies and ii) damage to newly drilled and mature arable crops, though anecdotal evidence base is weak.
- There are no non-lethal satisfactory solutions that are effective, practical and proportionate.
- Recommendation – **RETAIN** but requires further collation and assessment of anecdotal evidence specific to Wales

#### *Jackdaw*

- No published scientific evidence that this species may cause serious damage/harm to livestock or crops, though the possibility cannot be excluded that this represents an evidence gap, rather than providing evidence of no impact, (Newson *et al.* 2019).
- Expert opinion and anecdotal evidence suggests there is damage to newly drilled and mature arable crops, though the anecdotal evidence base is weak.
- There are no non-lethal satisfactory solutions that are effective, practical and proportionate.
- Recommendation – **RETAIN** but requires further collation and assessment of anecdotal evidence specific to Wales.

#### *Rook*

- Well established scientific evidence that this species may cause serious damage to arable crops (ie wheat, barley, oats, corn, root crops and legumes) (in Newson *et al.* 2019).
- Expert opinion and well established anecdotal evidence suggests rooks will cause serious damage to newly drilled and mature arable crops.
- Significant decline of 60% (in Breeding Bird Survey trend) between 1995-2017.
- Recommendation – **REMOVE** due to significant decline in numbers, with control of rook to be regulated through the individual licensing process.

#### *Jay*

- No published scientific evidence that this species may cause serious damage to livestock or crops, (Newson *et al.* 2019).
- Low expert opinion and no established anecdotal evidence that this species may cause serious damage/impact to livestock or crops.
- Recommendation – **REMOVE**

### *Collared dove*

- No published scientific evidence that this species may cause serious damage/harm to crops, though the possibility cannot be excluded that this represents an evidence gap, rather than providing evidence of no impact, (Newson *et al.* 2019).
- Low expert opinion and no established anecdotal evidence that this species may cause serious damage/impact to crops.
- Recommendation – **REMOVE**

### *Feral pigeon and wood pigeon*

- Well established scientific evidence that these species may cause serious damage to arable crops (ie wheat, barley, oats, corn, root crops and legumes) (in Newson *et al.* 2019).
- Expert opinion and well established anecdotal evidence suggests feral pigeons will cause serious damage to newly drilled and mature arable crops.
- No well-established scientific or anecdotal evidence that there are non-lethal satisfactory solutions available that demonstrate they are effective, practical and proportionate.
- Recommendation – **RETAIN** but also recommend further review of non-lethal satisfactory solutions

### *Canada goose*

- Some established scientific evidence that this species may cause serious damage to some crops and newly re-seeded pasture but little information on the direct impact on yield and associated financial cost of damage (in Newson *et al.* 2019).
- High expert opinion and some established anecdotal evidence suggests Canada geese will cause serious damage to newly drilled crops and re-seeded pasture.
- No well-established scientific or anecdotal evidence that there are non-lethal satisfactory solutions available demonstrating that they are effective, practical and proportionate
- Recommendation – **RETAIN**

**GL002** – Licence to kill or take certain wild birds for the purpose of preserving public health and public safety

**Recommendation:** rename to ‘Licence to kill or take certain wild birds for the purpose of preserving public health and preventing the spread of disease to humans’

### *Carrion crow, magpie, jackdaw, jay*

- Well established evidence that some or all of these species are vectors of human enteropathogens (eg *Cryptosporidium parvum*, *Giardia lamblia*). However, there is little/no published scientific literature to demonstrate transmission of enteropathogens to humans (in Newson *et al.* 2019).
- Recommendation – **REMOVE** but keep under review, with exception of **jay**

### *Rook*

- Significant decline of 60% in abundance between 1995-2017.
- Recommendation – **REMOVE** due to significant decline in population.

### *Collared dove, wood pigeon*

- Some established scientific evidence that these species are a potential reservoir and vector of microorganisms (eg *Chlamydia psittachi*) which could cause infections and allergic disease in humans, though there is little data on the prevalence of disease in collared doves (in Newson *et al.* 2019).
- Recommendation - **REMOVE**

#### *Feral pigeon*

- Well established scientific evidence that feral pigeons are reservoirs and potential vectors of microorganisms (eg *Chlamydia psittachi*) and a source of antigens of zoonotic interest that could cause infections, allergic diseases and even death in humans (in Newson *et al.* 2019).
- No strong, well-established scientific and anecdotal evidence that there are non-lethal satisfactory solutions available that demonstrate they are effective, practical and proportionate.
- Recommendation - **RETAIN**

#### **GL003 – preserving air safety**

Recommendation: **revoke this General Licence**, such that control of birds for aviation safety purposes is regulated through the individual licensing process. All Red and Amber-listed Birds of Conservation Concern in Wales (see Johnstone & Bladwell, 2016) will be carefully assessed against the applicant’s evidence base and whether there are satisfactory non-lethal solutions

#### **GL004 – Licence to kill or take certain wild birds for the purpose of conserving flora and fauna, including wild birds**

Recommendation: **rename to ‘Licence to kill or take certain wild birds for the purpose of conserving wild birds’**

#### *Carrion crow*

- Well established evidence that i) the eggs and chicks of wild birds form a substantial part of carrion crow diet and ii) that carrion crow can reduce the local productivity and abundance of wild birds, where this species occurs at high density, particularly breeding waders, gamebirds and seabirds (Fletcher *et al* 2010; Sage & Aebischer 2017; Roos *et al* 2018; Newson *et al* 2019).
- Analyses of large scale and extensive national monitoring data provides little evidence that carrion crows have driven UK-scale declines in songbird populations (Thompson *et al* 1998, Newson *et al* 2010). Though it is recognised that these studies cannot exclude the possibility that impacts of predation by carrion crow on some avian populations could be significant at a local scale
- Expert opinion and well established anecdotal evidence suggests carrion crow will have an impact on wild bird populations.
- No well-established scientific and anecdotal evidence that there are non-lethal satisfactory solutions available that demonstrate they are effective, practical and proportionate.
- Recommendation - **RETAIN**

#### *Magpie*

- Some strong scientific evidence that magpie may reduce the local productivity and abundance of wild bird prey species (White *et al* 2008; Sage & Aebischer 2017, Capstick 2018).

- Analyses of large scale and extensive national monitoring data provide little evidence that magpies have driven UK-scale declines in songbird populations (Gooch *et al* 1991; Thompson *et al* 1998, Newson *et al* 2010). Though it is recognised that these studies cannot exclude the possibility that impacts of predation by magpie on some songbird populations could be significant at a local scale as may be the case with White *et al* 2008; Sage & Aebischer 2017 and Capstick 2018.
- Most of the published scientific studies found that removing multiple avian predator species (eg carrion crow and magpie) is more likely to lead to a detectable increase in avian prey numbers than removal a single predator species. However, it is noted that most published studies and reviews do not assess the impact of magpie alone on avian populations.
- Expert opinion and some anecdotal evidence suggest magpie will have an impact on wild bird prey populations.
- No established scientific and anecdotal evidence that there are non-lethal satisfactory solutions available that demonstrate they are effective, practical and proportionate.
- Recommendation - **RETAIN** but recommend further assessment of scientific evidence particularly those studies where only magpie were removed and strong changes in songbird populations were observed.

#### *Jackdaw*

- Some established scientific evidence that jackdaw can feed on the eggs and young of wild birds (in Newson *et al* 2019).
- Low expert opinion and no anecdotal evidence to suggest jackdaw will have an impact on wild bird prey populations.
- No established scientific and anecdotal evidence that there are non-lethal satisfactory solutions available that demonstrate they are effective, practical and proportionate.
- Recommendation - **RETAIN** but recommend further assessment of the scientific evidence. particularly those studies where only jackdaw were removed and strong changes in songbird populations were observed.

#### *Jay*

- Some established scientific evidence that jay can feed on the eggs and young of wild birds, particularly woodland birds (in Newson *et al* 2019).
- Some expert opinion and anecdotal evidence suggest jay may have an impact on wild bird prey populations.
- No established scientific and anecdotal evidence that there are non-lethal satisfactory solutions available that demonstrate they are effective, practical and proportionate.
- Recommendation - **RETAIN** but recommend further assessment of the scientific evidence, particularly those studies where only jay were removed and strong changes in songbird populations were observed.

#### *Rook*

- Significant decline of 60% in Breeding Bird Survey trend between 1995-2017.
- Recommendation – **REMOVE** due to significant decline in numbers.

#### *Canada goose*

- No established scientific and anecdotal evidence that this species predate on wild bird eggs and chicks or causes significant changes in the abundance of any wild bird population.
- Recommendation – **REMOVE** as the General Licence will be renamed to Conservation of wild birds from conserve flora and fauna.

*Feral pigeon*

- No published scientific evidence that this species may cause serious damage/harm to flora and fauna, (Newson *et al.* 2019).
- Low expert opinion and no established anecdotal evidence that this species may cause serious damage/impact to flora and fauna
- Recommendation – **REMOVE**

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**Appendix 1.** The number of published studies on methods of wildlife management deterrents that were reviewed by NRW.

Deterrent theme	Deterrent method	No. of studies examined	No. of studies scored
Audio	Gas canons	4	2
	Pyrotechnics (rope bangers, blanks)	3	0
	Bio-acoustics (including distress calls)	3	1
	Noise bombs	0	0-
	Shooting to scare	2	3
	Sonic	2	0
Chemical	Condition taste aversion	8	8
	Contraception	2	2
	Behavioural repellents	0	0
Exclusion	Nets, tapes, wires	1	1
	Enclosure around nests	7	7
	Anti-predator fences	3	2
Habitat manipulation	Vegetation management	4	3
	Supplementary/diversionary feeding	0	0
	Sacrificial crops	0	0
	Control of other competing species	0	0
	Artificial dovecots	1	0
	Perches and ledges	1	1
Visual	Lasers	1	0
	Human scarers	1	1
	Decoys	4	4
	Scarecrows	1	1
	Corpses/effigies	2	1
	Predator models	2	2
	Kites	4	3
	Falconry	5	4
Mirrors	5	3	
Lethal	Shooting/trapping to kill	31	28
Various combined	One or more of the above	19	6
<b>Total</b>		<b>114</b>	<b>83</b>