A Review of The Ecological Effects of Gamebird Release and Management in Wales

Report No: **681**

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Mae rhyddhau a rheoli adar hela (ffesantod *Phasianus colchicus* a phetris coesgoch *Alectoris rufa*) ar gyfer saethu hamdden yn weithgaredd hirsefydlog ledled Cymru. Gall y gweithgareddau hyn gael effaith ar fflora a ffawna na chânt eu hela, yn enwedig mewn ardaloedd sy'n agos at safleoedd rhyddhau, a gallent esbonio cynnydd a gostyngiadau ym mhoblogaethau'r rhywogaethau hyn nad ydynt yn rhywogaethau hela. Mae canlyniadau economaidd-gymdeithasol hefyd i'r gweithgareddau hyn (nad ydynt yn rhan o'r adolygiad hwn). Er mwyn asesu effeithiau ecolegol net y gweithgareddau hyn yn gywir, mae'n hanfodol fod gennym ddata dibynadwy ar sut mae rhyddhau a rheoli adar hela yn berthnasol i newidiadau yn ansawdd neu ehangder cynefinoedd, newidiadau yn niferoedd neu gyfansoddiad cymunedol ffawna a fflora lleol, a sut y gall y newidiadau hyn aflonyddu ar rwydwaith ecolegol ehangach i ysgogi effeithiau anuniongyrchol. Gan fod rhyddhau a rheoli adar hela yn weithgaredd a gaiff ei gyrru gan ddyn, mae angen deall hefyd beth yw cymhellion a gweithredoedd y bobl sy'n ymwneud â'r arferiad, a thrwy wneud hynny, gosod yr effeithiau o fewn rhwydwaith gymdeithasol-ecolegol.

Y dystiolaeth a oedd yn ymwneud ag effeithiau ecolegol y gweithgaredd hwn ar draws y DU yn gyffredinol oedd testun tri adolygiad a gynhaliwyd yn 2020, gan dair set o wahanol ymchwilwyr, pob un â chwmpas, methodoleg a chymhellion a oedd ychydig yn wahanol. Er gwaethaf y gwahaniaethau hyn, roedd y tri adolygiad yn ymdrin â setiau o lenyddiaeth a oedd bron union yr un fath a daethant i gasgliadau cyffredinol tebyg. Y safbwynt y cytunwyd arno'n fras oedd:

a) bod y camau rheoli a ysgogir gan y gweithgaredd o ryddhau adar hela, gan gynnwys creu a chynnal cynefinoedd, rheoli ysglyfaethwyr yn gyfreithlon a bwydo ychwanegol, yn cael effaith ecolegol a ystyrir yn fuddiol yn gyffredinol ac a allai effeithio ar gynefinoedd, fflora a bywyd gwyllt na chaiff ei hela dros raddfa'r dirwedd;

b) mae gweithredoedd uniongyrchol yr adar a ryddheir, gan gynnwys y newidiadau y maent yn eu hachosi i lefelau maethynnau a chymunedau blodau ac infertebratau, eu rôl fel fectorau clefydau, a'r bwyd ychwanegol y mae eu carcasau yn ei ddarparu ar gyfer ysglyfaethwyr a sborionwyr, yn cael effaith y gellid ei hystyried yn negyddol yn gyffredinol, gydag amryw o'r rhain yn gweithredu mewn ardal leol neu ar raddfa leol, ond gydag eraill yn effeithio ar dirwedd ehangach;

c) bod y camau rheoli hyn a gweithredoedd yr adar yn digwydd o fewn rhwydwaith gymdeithasol-ecolegol cymhleth, ac er mwyn deall effeithiau ecolegol net y gweithgaredd hwn, mae'n bwysig ein bod yn deall yr effeithiau anuniongyrchol sy'n deillio o'r rhyngweithio rhwng yr adar, bywyd gwyllt a chynefinoedd a'r tirfeddianwyr a chiperiaid sy'n cymryd rhan yn y gweithgaredd yn ogystal â'r gynnau a gaiff eu defnyddio.

Nododd y tri adolygiad hefyd set o fylchau tebyg yn yr wybodaeth yn gyffredinol. Roedd y rhain yn cynnwys ymateb ysglyfaethwyr i ollyngiadau a'r effaith ar fywyd gwyllt na chaiff ei hela; rôl adar hela a gaiff eu rhyddhau fel ffynonellau neu gronfeydd i barasitiaid a chlefydau sy'n effeithio ar y bywyd gwyllt na chaiff ei hela; a deall p'un a yw adar hela yn ysglyfaethu fertebratau bach, yn arbennig ymlusgiaid, a ph'un a yw hyn yn effeithio ar eu poblogaethau. Roedd y bylchau eraill yn yr wybodaeth a nodwyd mewn dau o'r adolygiadau yn cynnwys gwybodaeth gywir a chyfredol am raddfa a lleoliad y gollyngiadau a maint y gweithgareddau rheoli sy'n gysylltiedig â nhw; sut mae arferion rheoli yn cyd-fynd

â maint y gollyngiadau; pa ffactorau sydd y tu ôl i'r cynnydd mewn gollyngiadau dros y blynyddoedd diwethaf; a gwell gwybodaeth am ladd adar ysglyfaethus yn anghyfreithlon sy'n gysylltiedig â rhyddhau adar hela a lladd bywyd gwyllt ar gam yn ystod saethu. Mae'r bylchau cyhoeddedig hyn yn yr wybodaeth wedi ysgogi corpws newydd o waith ymchwil o dan arweiniad y llywodraeth, sefydliadau saethu a chadwraeth, a phrifysgolion. Mae'r dystiolaeth newydd hon a'r dystiolaeth sydd ar ddod yn debygol o wella ein dealltwriaeth o effeithiau ecolegol y gweithgaredd yn sylweddol.

Yn yr adolygiad hwn, rwy'n gwerthuso tystiolaeth newydd a gyhoeddwyd ers 2020 ac yn asesu'r dystiolaeth sefydliadol a gyflwynwyd i CNC mewn ymateb i'w galwad, gan ganolbwyntio'n benodol ar ei pherthnasedd i'r sefyllfa yng Nghymru. Rwy'n cymharu ac yn cyferbynnu'r tri adolygiad yn 2020 i geisio cytundeb rhwng eu casgliadau. Yna byddaf yn integreiddio'r dystiolaeth newydd a gyhoeddwyd ac a gyflwynwyd â'r dystiolaeth a ystyriwyd gan yr adolygiadau cynharach er mwyn diweddaru'r sefyllfa gyfredol o ran gwybodaeth a nodi'r bylchau sy'n weddill yn ein dealltwriaeth.

Yn seiliedig ar gyfuno perthnasedd yr astudiaethau a'u niferoedd (gan gynnwys y rhai a ystyriwyd yn y tri adolygiad yn 2020 a deunydd newydd) yn ymwneud â phob un o'r 22 dosbarth o effeithiau a nodwyd gan Madden a Sage (2020), mae tystiolaeth resymol i gefnogi ein dealltwriaeth o chwe effaith ecolegol, gan gynnwys y canlynol: yr effeithiau uniongyrchol a gaiff clefydau ar fertebratau bach; yr effaith uniongyrchol a gaiff y carcasau sydd ar gael ar ysglyfaethwyr; yr effaith gysylltiedig a gaiff rheoli tir ar blanhigion coediog; yr effaith gysylltiedig a gaiff rheoli ysglyfaethwyr ar ysglyfaethwyr; yr effeithiau anuniongyrchol a gaiff plannu a rheoli planhigion coediog ar fertebratau bach; a'r effaith uniongyrchol a gaiff twrio am fwyd ar infertebratau. Mae tystiolaeth gymedrol i gefnogi ein dealltwriaeth o saith effaith ecolegol, gan gynnwys y canlynol: yr effeithiau cysylltiedig a gaiff bwydo ychwanegol ar fertebratau bach; yr effeithiau uniongyrchol a gaiff gweithredoedd adar ar bridd, dŵr ac aer; yr effeithiau anuniongyrchol a gaiff plannu a rheoli planhigion coediog ar infertebratau; yr effeithiau cysylltiedig a gaiff rheoli tir ar blanhigion nad ydynt yn goediog; yr effeithiau uniongyrchol a gaiff gweithredoedd adar ar blanhigion coediog / nad ydynt yn goediog; yr effeithiau uniongyrchol a gaiff twrio am fwyd ar fertebratau bach; a'r effeithiau anuniongyrchol a gaiff plannu a rheoli planhigion nad ydynt yn goediog ar fertebratau bach. Nid oedd llawer o dystiolaeth i gefnogi ein dealltwriaeth o'r naw effaith arall.

Erys nifer o fylchau allweddol yn yr wybodaeth ac mae'n hanfodol ein bod yn eu llenwi os ydym am sicrhau dealltwriaeth gywir o'r canlyniadau ecolegol net presennol a/neu os ydym am fodelu a rhagweld canlyniadau senarios yn y dyfodol pan fydd y ffordd a gaiff adar eu rhyddhau a'u rheoli yn newid o ganlyniad i newidiadau mewn amodau deddfwriaethol, cymdeithasol neu ecolegol. Mae'n debygol bod y data am raddfa a lleoliad gollyngiadau adar hela ledled y DU yn anghyflawn, sy'n golygu ei bod yn anodd creu cysylltiad rhwng y gweithgaredd a'r newidiadau neu wahaniaethau mewn ffawna a fflora na chânt eu hela. Mae ein dealltwriaeth o'r rhwydwaith cymdeithasol-ecolegol ble caiff y gweithgaredd ei gynnal yn wan, ac mae hyn yn ei gwneud yn anodd i ni allu cyfrifo'r effeithiau ecolegol net sy'n deillio o aflonyddu ar elfennau penodol, a allai arwain at ganlyniadau anfwriadol neu annisgwyl. Mae'r dystiolaeth sydd gennym am yr elfen ddynol o'r gweithgaredd hwn, sef cymhellion a gweithredoedd tirfeddianwyr, ciperiaid a gynnau, yn brin, ac yn aml yn adlewyrchu'r amodau a oedd yn bodoli dros 20 mlynedd yn ôl pan oedd amodau deddfwriaethol, cymdeithasol ac ecolegol yn wahanol iawn, ac nid oes llawer o ddealltwriaeth gadarn o'r ffordd y gallai'r cymhellion a chamau gweithredu hyn newid

mewn senarios yn y dyfodol. Yng Nghymru yn benodol, er ei bod yn ymddangos yn debygol bod y digwyddiadau saethu a gynhelir yno yn debyg i'r rhai yng ngweddill y DU, mae rhai gwahaniaethau o ran y prae sydd dan sylw ac efallai'r tirweddau a'r cymhellion amaethyddol sy'n bresennol yn y lleoliadau lle caiff yr adar eu saethu, a byddai'n ddefnyddiol pe byddem yn deall hynny'n well. Mae'n debygol y bydd nifer o'r bylchau hyn yn cael sylw yn y ffrwydrad diweddar o astudiaethau newydd sydd wedi bod, gyda'r canlyniadau yn cael eu cyhoeddi dros y ddwy neu dair blynedd nesaf, a bydd hyn yn cynyddu ein hyder yn ein dealltwriaeth o'r effeithiau presennol ac unrhyw newidiadau y gallai senarios yn y dyfodol eu hysgogi.

Mae ein dealltwriaeth o'r effeithiau ecolegol a gaiff rhyddhau a rheoli ffesantod a phetris ar gyfer saethu hamdden yn y DU yn datblygu. Mae'n galonogol gweld 18 o gyhoeddiadau newydd yn y maes hwn ers i dri adolygiad 2020 gael eu cyhoeddi. Mae hefyd yn galonogol gweld bod nifer fawr o astudiaethau wedi dechrau ers 2020 gyda'r bwriad penodol o fynd i'r afael â'r bylchau yn yr wybodaeth a nodwyd yn yr adolygiadau hynny, a chlywed am setiau eraill o ddata a grybwyllwyd yn y cyflwyniadau tystiolaeth i CNC sy'n swnio'n berthnasol. Bydd y deunydd newydd hwn yn gwella ein dealltwriaeth o'r effeithiau ecolegol net sy'n deillio o weithredoedd yr adar eu hunain, gweithredoedd y bobl sy'n ymwneud â'u rheoli a'u hela, a'r effeithiau anuniongyrchol a gaiff y gweithredoedd hyn trwy rwydwaith cymdeithasol-ecolegol ehangach. Mae deall yr effeithiau hyn yn hollbwysig, o ystyried eu bod yn ymwneud â rhyddhau degau o filiynau o adar yn flynyddol, ac yn ôl yr hyn a ddeallir, yn dylanwadu ar reolaeth ardaloedd mawr o iseldir gwledig y DU. Drwy gyfuno'r corff presennol, sefydledig o waith ar effeithiau ecolegol y weithred o ryddhau a rheoli adar hela â'r dystiolaeth a gyhoeddwyd yn ddiweddar a'r dystiolaeth sydd ar ddod, mae ein gallu i ddeall effeithiau ecolegol cyfredol a rhagfynegi canlyniadau ecolegol newidiadau mewn senarios yn y dyfodol o ganlyniad i newidiadau deddfwriaethol, cymdeithasol neu amgylcheddol yn gwella'n fawr. Drwy ddefnyddio'r ddealltwriaeth fanylach hon i lywio cyngor, deddfwriaeth a pholisi, mae gennym well siawns o gyflawni deilliannau ecolegol net cadarnhaol ar gyfer y cynefinoedd a'r bywyd gwyllt a gaiff eu heffeithio gan yr arferiad o ryddhau a rheoli adar hela yng Nghymru, a'r DU yn ehangach.

Executive summary

The release and subsequent management of gamebirds (pheasants *Phasianus colchicus* and red-legged partridges *Alectoris rufa*) for recreational shooting in Wales is a long-standing and widespread activity. These activities can exert effects on non-game fauna and flora, especially in areas close to release sites and may explain both increases and decreases in populations of these non-game species. The activities also have socioeconomic consequences (not covered by this review). In order to accurately assess the net ecological effects of these activities, it is essential to have reliable data on how the release and management of gamebirds relates to changes in the quality or extent of habitats, changes in the abundances or community composition of local fauna and flora, and how these changes may perturb a broader ecological network to drive indirect effects. Because gamebird release and management is a human-driven activity, it is also necessary to understand the motivations and actions of people involved with the practice and thus place the effects within a socio-ecological network.

The evidence relating to the ecological effects of this activity across the UK generally was the subject of three Reviews conducted in 2020, by three different sets of researchers,

each with slightly different scopes, methodologies and motivations. Despite these differences, all three reviews covered almost identical literature sets and arrived at similar general conclusions. The broadly agreed position is that:

a) the management actions motivated by the release of gamebirds, including habitat creation and maintenance, legal predator control and supplementary feeding generally have ecological effects that are considered beneficial and which may affect habitats, flora and non-game wildlife over a landscape scale;

b) the direct actions of the released birds, including the changes that they cause to nutrient levels, floral and invertebrate communities, their role as disease vectors and the additional food their carcasses provide for predators and scavengers generally have effects that are considered negative with many of these operating at a local or patch scale, but others having wider, landscape, consequences;

c) these management actions and the actions of the birds occur within a complex socio-ecological network and in order to understand the net ecological effects of this activity it is important to understand the indirect effects that arise from the interactions between the birds, wildlife, habitats and the land owners, gamekeepers and guns who participate in the activity.

The three Reviews also identified a generally similar set of knowledge gaps. These included the response of predators to releases and the effects that this may have on other, non-game wildlife; the role of released gamebirds as sources or reservoirs of parasites and disease with consequences for non-game wildlife; and an understanding of whether gamebirds might predate small vertebrates, specifically reptiles and if this has consequences for their populations. Other knowledge gaps identified by two of the Reviews included accurate and up-to-date information about the scale and location of releases and the extent of management activities associated with them; how management practices scale with release sizes; what factors have been driving the increases in releases seen over recent years; and better information about the illegal killing of raptors associated with gamebird releasing and the mistaken killing of wildlife during shooting. These published knowledge gaps have stimulated a new corpus of research led by government, shooting and conservation organisations and Universities. This new and forthcoming evidence is likely to greatly improve our understanding of the ecological effects of the activity.

In this Review, I evaluate new evidence that has been published since 2020 and assess the organisational evidence submitted to NRW in response to their call, with a particular focus on its relevance to the situation in Wales. I compare and contrast the three 2020 Reviews to seek agreement in conclusions. I then integrate the new published and submitted evidence with that considered by the earlier reviews so as to update the current state of knowledge identify remaining gaps in our understanding.

Based on an integration of the relevance and number of studies (comprising those considered in the three 2020 reviews and new material) concerning each of the 22 classes of effects identified by Madden & Sage (2020), there is reasonable evidence to support our understanding of six ecological effects including: Direct effects of diseases on small vertebrates; Direct effect of carcass availability on predators; Associated effect of land management on woody plants; Associated effect of predator control on predators; Indirect effects of planting and management of woody plants on small vertebrates and; Direct

effect of foraging on invertebrates. There is moderate evidence to support our understanding of seven ecological effects including: Associated effects of supplementary feeding on small vertebrates; Direct effects of bird actions on soil, water and air; Indirect effects of planting and management of woody plants on invertebrates; Associated effects of land management on non-woody plants; Direct effects of bird action on woody/non-woody plants; Direct effects of foraging on small vertebrates and; Indirect effects of planting and management of non-woody plants on small vertebrates. There was only weak evidence to support our understanding of the other 9 effects.

There remain several key knowledge gaps that are essential to plug if we are to gain an accurate understanding of current net ecological effects and/or if we wish to model and predict outcomes from future scenarios under which releasing and management of gamebirds changes due to changes in legislative, social or ecological conditions. It is likely that data about the scale and location of gamebird releases across the UK are incomplete, meaning that it is difficult to associate the activity with changes or differences in non-game fauna and flora. We currently have a poor understanding of the socio-ecological network in which the activity occurs and this makes it hard to calculate net ecological effects that arise from the perturbation of particular elements which may have unintended or unexpected consequences. The evidence that we currently possess about the human element of this activity, the motivations and actions of land-owners, game keepers and guns, is sparse and often pertains to conditions over 20 years ago when legislative, social or ecological conditions were very different, and there is little robust understanding of how these motivations and actions may change in future scenarios. With particular respect to the conditions in Wales, although it seems likely that shoots operating there are similar to those in the rest of the UK, there are some differences in terms of the quarry involved and perhaps the landscapes and agricultural incentives present where the shoots occur which would be helpful to understand better. Several of these gaps are likely to be addressed by the recent burst of new studies with results expected in the next two to three years, which will greatly increase confidence in both our understanding of current effects and any changes that future scenarios may provoke.

Our understanding of the ecological effects of the release and management of pheasants and partridges for recreational shooting in the UK is growing. It is encouraging to see 18 new publications in this area since the three 2020 Reviews were published. It is also encouraging to see the large number of studies that have started since 2020 with the explicit intention of addressing the knowledge gaps identified in those Reviews, and to hear of other datasets mentioned in the evidence submissions to NRW that sound relevant. This new material will improve our understanding of the net ecological effects that arise from the actions of the released birds themselves, the actions of people involved in their management and hunting, and the resulting indirect effects that these actions have via a wider socio-ecological network. Understanding these effects is imperative, given that they involve the annual release of some tens of millions of birds at the UK scale, and reportedly influence the management of large areas of lowland rural UK. By combining the existing, established body of work on the ecological effects of gamebird release and management with the recently published and forthcoming evidence, our ability to understand current ecological effects and predict the ecological consequences of changes in future scenarios with changed legislative, social or environmental conditions is greatly improved. By using this enhanced understanding to inform advice, legislation and policy there is a greater chance of achieving net positive ecological outcomes for the habitats and

wildlife influenced by the release and management of gamebirds in Wales, and the UK more broadly.

1. INTRODUCTION

The release and management of gamebirds, predominantly pheasants *Phasianus colchicus* and red-legged partridges *Alectoris rufa*, for recreational hunting (hereafter shooting) has been common in the UK for at least a century (Martin 2011, 2012). This activity involves the annual release of some tens of millions of birds, and reportedly influences the management of two-thirds of lowland rural UK, worth an estimated £2 billion GVA annually (PACEC 2014). Within Wales, it is likely that these values are smaller, but still constitute an important influence on the habitats and wildlife of the nation.

In 2020, three reviews set out to assess the evidence regarding the ecological effects that the release of gamebirds and their associated management (Madden & Sage 2020, Mason et al. 2020, Sage et al. 2020 – henceforth often referred to as the three 2020 reviews). Several events followed the publication of these Reviews. First, DEFRA altered the licencing conditions necessary for releasing pheasants and partridges (https://www.gov.uk/government/publications/gamebirds-decision-to-issue-the-gamebird-general-licence-for-2022) with a view to review these changes in following years. Second, the RSPB adjusted its stance on the release of gamebirds and gave an 18 month deadline for shooting interests to show reductions in the ecologically negative aspects of the activity, without which the Society would press for stronger legislation. Third, a series of new studies, designed to address knowledge gaps identified in the three 2020 reviews, were planned and initiated by government bodies, conservation and shooting organisations, and universities. This has led to the emergence of new evidence that can inform our understanding of current and future ecological effects of gamebird release and management. The aim of this Review is to evaluate this new evidence and assess the organisational evidence submitted to NRW in response to their call, with a particular focus on its relevance to the situation in Wales, and to integrate this material with existing evidence so as to update the current state of the art and knowledge gaps.

Terms of Reference

Welsh Government Ministers have asked Natural Resources Wales and officials from Welsh Government to consider options for regulating gamebird releases in Wales. Currently in Wales, whilst releases within the boundary of Sites of Special Scientific Interest (SSSI) usually require consent, there is little regulation outside of protected sites. Concerns have been raised about the effectiveness of the current regulatory provisions to effectively monitor and manage potential environmental impacts, particularly on European protected sites. Following a legal challenge, Defra has introduced an interim regulatory approach. However, that approach applies only to releases in England. NRW have been tasked with reviewing the available evidence and develop proposals for a proportionate regulatory approach to gamebird releases in Wales. In 2020 three reviews relating to the impacts from the management and release of gamebirds were released. In August of 2022 NRW undertook a call for evidence to invite the submission of new or additional evidence not included in these reviews. This call for evidence has concluded. In addition, NRW has commissioned work looking at the scale and distribution of gamebird releases in Wales and indicative work on levels of compliance with the APHA poultry register (Madden 2023). There is now a need to re-examine the findings of the three 2020 reviews in light of the call for evidence, and NRW's commissioned research. Such a re-examination would need to considered in the context of Wales.

The review will:

1) Review the evidence in relation to the impacts of gamebirds, from their management and release in the form of a report that examines of Madden and Sage (2020), Mason et al. (2020), and Sage et al. (2020) to:

- Provide a comparison of the approaches taken by the three reviews
- Identify main findings of the three reviews, highlighting areas of commonality and divergence between the three reports. This should take into consideration commonality/divergence in the scope of the three reviews.

2) Provide an assessment of the strength of the evidence for each of the main findings.

3) Assess the material submitted to NRW's recent call for evidence, limited to organisational level representations.

4) With respect to the main findings identified above, assess the degree to which the additional evidence, supports or challenges them, or identifies any new evidence gaps with regard to Wales, or leads to any new conclusions. Where the evidence allows the above should make particular reference to Wales, and limited to red-legged partridge and common pheasants.

The following topics were not included in the scope of this assessment: lead shot, socio-economics, and the release of mallard.

2. SUMMARY OF THE PREVIOUS REVIEWS

A) Scope and Methodologies of Previous Reviews

Three recent 2020 reviews have collated the available evidence pertinent to the issue of the ecological effects of gamebird release and management. They each might be considered to represent a different perspective on recreational shooting:

- Madden & Sage (2020) was commissioned by Natural England (the UK government's advisory body for the natural environment in England which is neutral towards shooting) and part funded by them and the British Association for Shooting and Conservation (an organisation which actively promotes shooting), and conducted by employees of the University of Exeter, which holds no position on recreational shooting, and of the Game and Wildlife Conservation Trust (GWCT), a charity that researches and advises on wildlife conservation alongside economic land-use including sustainable gamebird management;
- Mason et al. (2020) was written by current and former employees of the Royal Society for the Protection of Birds (RSPB), a conservation charity that is neutral in its policy on shooting, although in the light of the review is now calling for tighter regulation of large-scale gamebird releases if substantial reform is not forthcoming. The review was a response to growing public and member concern, about the

environmental impact (including for water, carbon and biodiversity) and associated land management arising from the large-scale release of non-native gamebirds;

- Sage et al. (2020) was predominantly written by employees of the Game and Wildlife Conservation Trust (GWCT).

The three reviews also took slightly different approaches, differing in the way that evidence was collated, evaluated and what aspects of shooting were included. Madden & Sage (2020) was a Rapid Evidence Assessment meaning that material was assessed for relevance and presented within a conceptual model that assisted its interpretation. A designated search strategy was used to find peer-reviewed, grey and unpublished literature. In addition, a small amount of novel data was presented relating to the scale and distribution of releases based on information from a Freedom of Information request to the APHA Poultry Register and scouring of online adverts from commercial game shoots. The Review focussed tightly on ecological effects, deliberately excluding material relating (exclusively) to socio-economic factors (game meat as food, mental and physical health benefits, economic justifications, damage to vehicles or crops by birds, zoonotic diseases) and any consideration of moral, ethical or welfare consequences for either the birds or humans. There was also a deliberate exclusion of data relating to the ecological, welfare or health effects arising from use of lead ammunition, with the acknowledgement that these had been very recently reviewed in detail by Pain and colleagues (2019). The evidence was assigned to one of 22 effects, broadly aggregated into direct, associated and indirect effects. The effects of any gamebirds released in the UK were considered and as such evidence relating to mallard *Anas platyrhynchos* was included. Although the review stated that ecological effects should be considered holistically and are likely to be complex, no attempt was made to calculate net effects either overall or for any particular wildlife or habitat. This review was subject to peer review by employees of DEFRA.

Sage et al. (2020) used the same data from Madden & Sage (2020), excluding material relevant to releases of mallard and the data on the scale and distribution of releases. They conducted a simple numerical synthesis classifying 25 effects as being ecologically positive, negative or neutral, based on what the authors describe as the ‘broadest possible view of ecological effects’ although the authors acknowledge that these attributions may differ according to perspective. They also considered the spatial scale over which those effects acted (local – part of a wood/field; patch – a whole wood/field, landscape – the whole area that a shoot occupies and beyond). These 25 effects were aggregated into six broader categories. They also considered how some of the effects might be expected to scale with the density of birds being released or how economically dependent they were. This paper was accepted in a scientific journal after independent peer review.

Mason et al. (2020) built on the literature database and structure of an earlier review (Bicknell et al 2010), updated with a new systematic literature search to find peer-reviewed and grey literature published up to 2020. This material was assessed for relevance and a simple scoring system was developed that incorporated the direction of ecological effects on native wildlife, the importance of the ecological impact and the quality of the study. Their review included material relating to the environmental effects of lead shot and aspects of the socio-economic effects of released gamebird shooting that were deliberately excluded by the other two reviews. The scores were arranged into a series of 19 secondary impact themes, which were then combined into six primary impact themes. The grouping of themes proved contentious, with a detailed critique of the methods used

provided in the GWCT submission to NRW's call for evidence. The core of this objection is that the reasoning for the selection of themes was not transparent with the accusation that by 'lumping' positive management benefits into a single theme, the balance of positive and negative effects was distorted and misrepresented. However, this objection pertains to the interpretation of the evidence rather than the collection or basic analysis of the evidence itself.

All three reviews sought a clear overview of the current evidence pertaining to the ecological effects of gamebird release and despite the different emphases and analytical approaches that each took, all synthesised a very similar number of sources (Mason et al. 2020 = 122 sources scored; Madden & Sage 2020 = 118 sources classed as highly/moderately relevant; Sage et al. 2020 = 139 items of primary and other literature). Variation in the numbers of sources considered was primarily a result of the differences in scope of each review e.g. whether they considered mallards, lead shot, release scale or how they defined socio-economic factors. This inspires confidence that the vast majority of relevant literature was covered by at least one, and predominantly all three, reviews. All three reviews drew heavily on the grey literature and unpublished reports and theses, with these sources comprising almost half of the highly relevant material considered (Madden & Sage 26/58 sources, 45%; Mason et al. 72/122 sources, 59%). The new post-2020 publications reviewed here (see section 3) that were concerned with ecological effects (n = 11) or the scale and extent of releases (n = 3) were all peer-reviewed, with the new grey literature being restricted to a single item in the submissions (see section 4) as well as two pieces of evidence contained within the submissions (both deemed of low relevance). The peer-reviewed scientific papers were reasonably evenly distributed across areas of interest with nine reporting effects on invertebrate populations, eleven on vertebrate populations, five on predator populations, six on habitat management, five on habitat damage, eight on disease and three on genetic effects (some papers covered more than one topic). Most highly relevant studies, whether peer-reviewed or not made use of 'natural experiments', contrasting areas that hosted game shoots with those that did not. In some cases, an attempt was made to pair treatment and control sites. Site selection often (but not always) relied on voluntary participation both by game shoots and 'control' areas, and none deliberately experimentally manipulated gamebird release patterns and monitored associated change. Such experimental manipulations are highly desirable in order to determine causality in complex ecological systems.

There were some differences between the three reviews assessing the quality of evidence available to evaluate particular ecological effects. Partly, this is because each review used somewhat different categories between which the authors assigned specific studies making direct comparisons difficult. Partly, this is because the authors evaluated evidence differently. Madden & Sage (2020) focused on the relevance of the study, including its quality in terms of methodology, sample size and relevance to UK conditions (but not their recency or spatial extent), but did not weight by reported effect size or direction, and crudely designated each study as high, moderate or weakly relevant. They then reported the number of each level of study that supported each of their categories (their Fig 8a). Mason et al. (2020) incorporated crude quantitative indices of study design quality (fair or good) and a weighting for grey vs. peer reviewed literature (down-weighting grey literature) when generating their ecological impact scores. However, from the published review it is not possible to separate out the quality of the work from the reported raw effect size of the impact, nor from the likely spatial scale/national level of any such effects which were considered at a UK population level. Sage et al. (2020) report the form of each reference in

their Appendix 1 (ranging from website to report to thesis to peer reviewed paper) but any weighting of these different sources is not applied in their Results where they simply report the number of sources informing each section, whether they considered them to be positive, neutral or negative in the broadest ecological sense, and the spatial scale over which effect is expected to operate.

To summarise the evidence, permitting at least some form of comparisons to be made between the review, given the variation in categories considered and scoring approaches taken, I have taken the finest level of divisions that each review considered (Madden & Sage 2020: 22 effects; Mason et al. 2020, 19 themes; Sage et al. 2020, 25 groupings) (Table 1). Some of the categorisations of one review overlap with categorisations of those of others, so I have assigned them to six broad categories of ecological effects. For Madden & Sage (2020) I report the strength of evidence that they reviewed, calculated by weighting the number of sources relating to each effect by their assigned relevance (5 = highly relevant, 3 = moderately relevant; 1 = weakly relevant). For Mason et al. (2020), I report the number of impact scores that they considered for each theme (indicating the amount of evidence available) and the median value of those scores indicating the strength of evidence for a population-level impact in the UK. For Sage et al. (2020), I report the number of publications that they considered to be relevant to each of those effects and whether the publication indicated that the effect was positive, negative or neutral. I then further summarised these data for each of the six new categories that I had used so that the reviews could be more directly compared (Table 2). For Madden & Sage (2020), this is the sum of the weighted evidence scores, telling us something about the availability of evidence concerning that particular effect. For Mason et al. (2020), I multiplied the number of impact scores by the median population impact scores for each theme and then summed those composite scores in each category to reveal a measure of the availability of evidence for generally positive or negative ecological effects. For Sage et al. (2020), I summed the total publications related to effects of each type (+ve, neutral, -ve) in each category and then combined them to calculate a net impact score.

Broad ecological effect	**Madden & Sage (2020)** Strength of evidence for relationship between gamebird release/management and ecological effect derived from the number of sources weighted by their relevance	**Mason et al. (2020)** Theme with number of impact scores considered and their median value	**Sage et al. (2020)** Number of publications relevant to the topic and whether the effects that they reported were considered to be +ve, neutral or -ve.
Effects caused directly by the released gamebirds	Direct effects of foraging on invertebrates (56) Direct effects of bird actions on soil, water and air (31) Direct effects of bird action on woody/non-woody plants (24) Direct effects of foraging on small vertebrates (16) Direct effects of foraging on Direct effects of competition on small vertebrates (6) non-woody plants (11)	Predation by gamebirds (14, -1) Browsing by gamebirds (12, -1) Soil enrichment (12, -1) Resource competition (4, -1)	Impacts of released pheasants on hedgerows (0 +ve, 1 ntl, 1 -ve) Gamebirds and grassland invertebrates (0 +ve, 2 ntl, 0 -ve) Direct impact on reptiles (0 +ve, 0 ntl, 1 -ve) Ground flora effects in woodland-based pheasant release pens (0 +ve, 0 ntl, 3 -ve) Soil effects in woodland-based pheasant release pens (0 +ve, 0 ntl, 2 -ve)

			Woodland ground invertebrates in pheasant release pens (0 +ve, 1 ntl, 2 -ve) Direct impact on butterflies (0 +ve, 1 ntl, 0 -ve) Woodland bryophytes and lichens on trees (0 +ve, 0 ntl, 1 -ve)
Effects on disease, parasites and genetic integrity	Direct effects of disease on small vertebrates (83) Direct effects of genetic disruption of wild populations (28)	Disease transmission (13, -1)	Endoparasites of pheasants and partridges (0 +ve, 2 ntl, 3 -ve) Pheasants, ticks and Borrelia (0 +ve, 0 ntl, 1 -ve) Diseases of gamebirds and wildlife (0 +ve, 1 ntl, 3 +ve)
Effects relating to predators	Direct effect of carcass availability on predators (67) Associated effects of predator control on predators (53) Indirect effects of predator control on small vertebrates (9)	Food sources for predators (12, -1) Legal predator control (22, +1) Illegal killing of predators (18, -1) Predator abundance (4, -1)	The effect of predator control (3 +ve, 1 ntl, 0 -ve) The impact of releases on predators (0 +ve, 1 ntl, 6 -ve)

		Predation rates: impacts on native prey species (3, 0)	Releasing and illegal killing of raptors (0 +ve, 0 ntl, 3 -ve)
Effects of habitat creation, retention and management	Associated effects of land management on woody plants (62) Indirect effects of planting and management of woody plants on small vertebrates (52) Indirect effects of planting and management of woody plants on invertebrates (25) Associated effects of land management on non-woody plants (24) Indirect effects of planting and management of non-woody plants on small vertebrates (22) Indirect effects of planting and management of woody plants on other plants (15) Associated effects of land management on soil, water and air (6)	Farmland management (32, +1) Woodland management (46, +0.5) Woodland creation and retention (8, +1)	Woodland planting and retention for pheasants (2 +ve, 0 ntl, 0 -ve) Vegetation and breeding birds in lowland woodland interiors (3 +ve, 0 ntl, 0 -ve) Shrubs, butterflies and bees at woodland edges (1 +ve, 0 ntl, 0 -ve) Woodland rides in game woods (1 +ve, 0 ntl, 0 -ve) Songbird use of pheasant woods in winter (1 +ve, 0 ntl, 0 -ve) Small mammals in pheasant woods (1 +ve, 0 ntl, 0 -ve) Hedgerows and other edge habitats on farmland (2 +ve, 0 ntl, 0 -ve)

			Songbirds using game crops planted on farmland (6 +ve, 0 ntl, 0 -ve)
Effects related to supplementary feeding	Associated effects of supplementary feeding on small vertebrates (35)	Supplementary feeding (15, +1) Rodent pest control (2, -1.5)	Supplementary feeding of gamebirds (3 +ve, 0 ntl, 0 -ve)
Effects caused by guns and keepers during shooting and management	Associated effects of disturbance on small vertebrates (14) Associated effects of shooting on small vertebrates (11) Associated effects of disturbance on soil, water and air (10)	Accidental shooting of non-target species (2, -1)	Red-legged partridges and over-shooting wild partridges (0 +ve, 1 ntl, 1 -ve)

Table 1. Detailed summary of the evidence for ecological effects presented in the three 2020 reviews. Each of the effects classes considered by the reviews have been assigned to one of 6 broad ecological categories. Broad ecological effects ordered as being direct -> associated or indirect effects

Broad ecological effect	Madden & Sage (2020) Total evidence score	Mason et al. (2020) Amount of evidence x median effect	Sage et al. (2020) Sum of evidence for direction of each effect and net value
Effects of habitat creation, retention and management	206	+63	(17 +ve, 0 ntl, 0 -ve) +17
Effects caused directly by the released gamebirds	144	-42	(0 +ve, 5 ntl, 10 -ve) -10
Effects relating to predators	129	-12	(3 +ve, 3 ntl, 9 -ve) -6
Effects on disease, parasites and genetic integrity	111	-13	(0 +ve, 3 ntl, 7 -ve) -7
Effects related to supplementary feeding	35	+12	(3 +ve, 0 ntl, 0 -ve) +3
Effects caused by guns and keepers during shooting and management	35	-2	(0 +ve, 1 ntl, 1 -ve) -1

Table 2. Summary of the amount of evidence supporting each broad ecological effect and whether it is generally indicative of overall positive, neutral or negative ecological effects. Ecological effects ordered by the amount of evidence supporting them. Green text indicates effects considered to be

broadly ecologically positive. Red text indicates effects considered to be broadly ecologically negative

B) Summary of Findings from the Reviews

Despite differing perspectives, scope, classification of specific effects, and selection and weighting of evidence, there was reasonably high consensus between the reviews in both the key conclusions that could be drawn from the available evidence and the knowledge gaps that remained.

All three reviews agreed that there was most evidence relating to the creation, retention and management of habitats associated with the release and shooting of gamebirds. These effects were considered to be net positive by Mason et al. and Sage et al. with no negative effects identified at the theme level, although Mason et al. did identify some individual studies reporting negative effects (Table 2). These include the creation, retention and maintenance of habitats typically including woodlands, hedgerows and game crops, all of which provide a habitat that is attractive to the released gamebirds and so encourage them to remain on the releasing estate so that they are available to shoot. Typically there are more of these habitats on land where releasing and shooting occurs than other land. These managed habitats also host higher abundances of some plants, invertebrates and non-game small vertebrates than unmanaged areas.

The next strongest set of evidence concerned the direct effects that the released birds themselves had on the fauna, flora and nutrient levels in areas where they were released. These effects were considered to be net negative by Mason et al. and Sage et al. with no positive effects identified at a theme level although Mason et al. did identify some individual studies reporting positive effects (Table 2). These include the physical disturbance of soil, nutrient enrichment of water and soil, reductions in non-woody plants due to damage or enrichment, reductions in abundance and/or diversity of at least some invertebrate groups at or close to release sites. There was also limited evidence that the released gamebirds predate small vertebrates (reptiles) and posed a direct competition to native species.

The third strongest set of evidence related to the relationships between gamebird releases and predators, including legal and illegal predator control, effects on predator populations and changes to predator-prey relationships and food webs. These effects were considered to be net negative by Mason et al. and Sage et al. although both positive and negative effects were reported (Table 2). Reductions in generalist predators may reduce predation pressures on local non-game species, including those of conservation interest. However, this control needs to account for any increases in predators either drawn to an area or whose population increases are supported by abundant gamebird prey. It also must be conducted legally.

Next, there was a body of evidence relating to effects of released gamebirds on parasites and pathogens in other species and any risk of genetic contamination of wild populations. These effects were considered to be net negative by Mason et al. and Sage et al. with no positive effects report (Table 2). The released birds acted as carriers of a variety of pathogens, ecto- and endo-parasites and thus have the potential to transmit these to other wildlife although evidence of these causal links in the UK was lacking. In areas where released birds may encounter and interbreed with wild conspecifics, there is a risk of

introgression, but in the UK, no such native wild populations exist so this risk is of little concern.

There was less evidence regarding the effects of supplementary feeding associated with the release of gamebirds. This involves the provision of supplementary food, typically grains supplied either via feeders or broadcast, or in the form of seeds on plants in game crops. The effects that were reported were considered to be net positive by Mason et al. and Sage et al. although Mason et al. considered rodent control to be a negative effect (Table 2). This supplementary feed is eaten by both game and non-game species, typically small vertebrates, which may explain higher abundances of many of these non-game species both in areas where feeding occurs compared to areas without such feeding, and where feeding is more intensive e.g. with higher densities of feeders. This is ecologically positive especially when the benefitting species are of conservation or ecosystem interest. However, increased abundance of some of these species may cause ecological problems if this disrupts ecological networks or community structures.

Finally, there was a body of evidence concerning the effects caused by the activities of people involved with shooting due to their impacts on disturbance or their shooting behaviour. The effects that were reported were considered to have a small net negative effect by Mason et al. and Sage et al. (Table 2). Such human activities may result in non-game species being shot mistakenly, or may cause physical damage to soil or habitats.

Sage et al. (2020) explicitly considered the spatial scale over which these effects may act and commented on how they may scale with the density of releases and how economically dependent they were on the scale of releases, although for these last two mediating factors, little evidence currently exists. In most cases, the effects of management activities (habitat management, predator control and supplementary feeding) operate over a landscape scale including all the area of a shoot and with some effects extending beyond. In contrast, the effects of the birds themselves was usually localised to the woods or particular pens where the releases occurred, and were especially apparent in areas with high densities of the release gamebirds such as their release pens and feeder sites to which they were attracted. In general, the size of these negative effects scales with the density of the released birds, with effects being especially marked in areas where birds were released at densities greater than 700-1000 per hectare. Some of these effects, both positive and negative, such as the direct impacts of gamebirds or woodland management, may persist over many years.

The reviews all concluded that unravelling the effects that this extensive and intensive activity has on habitats and wildlife and humans in the UK is likely to be complicated. Two reviews provided a figure that illustrates how the various effects are related to one another in an ecological network (Madden & Sage 2020, their Fig 1; Mason et al. 2020, their Fig 7). Although the precise structures of the two networks differ, each include both the ecological factors such as the gamebirds, non-game wildlife, flora and nutrients, as well as the human factors involved such as the landowners, gamekeepers and guns. This then constitutes a socio-ecological network (Liu et al. 2007, Colding & Barthel 2019). Gamebirds become part of the ecological web in and surrounding their release locations, serving as both predators and prey for native species, contributing nutrients to the ecosystem via their droppings and carcasses, and serving as hosts of pathogens that may also affect non-game species. The management of those locations for gamebirds by human releasers also affects resident wildlife, through habitat creation, retention and alteration, provision of

supplementary food – usually grain – and the reduction in resident predators. These effects (of gamebirds and humans) combine to alter the local environment which in turn affects the subsequent management decisions of releasers and the structure of the ecosystem. The three reviews describe and interpret these interactions somewhat differently, but all three emphasise that such interactions are web-like and multifactorial. They also conclude that understanding the net ecological effects of gamebird releases and management will require considering such networks and how perturbation of one element exerts wider effects that may be unexpected as communities, habitats and resource availabilities alter.

Finally, all three reviews concluded that there were marked gaps in our knowledge of the specific effects of non-native gamebirds and their managers, the underlying ecological processes that were involved, and the basic data in terms of numbers and locations of gamebirds released annually (Table 3). Perhaps because of the different scope and foci of the reviews, or the perspectives of their authors, there were some differences in the knowledge gaps identified. However, there was generally a high level of agreement with all three noting a lack of knowledge about the response of predators to releases and the effects that this may have on other, non-game wildlife, the role of released gamebirds as sources or reservoirs of parasites and disease with consequences for non-game wildlife, and an understanding of whether gamebirds might predate small vertebrates, specifically reptiles and if this has consequences for their populations. Other knowledge gaps identified by two of the reviews included accurate and up-to-date information about the scale and location of releases and the extent of management activities associated with them, how management practices scale with release sizes, what factors have been driving the increases in releases seen over recent years, and better information about the illegal killing of raptors associated with gamebird releasing and the mistaken killing of wildlife during shooting.

Knowledge Gap	Madden & Sage 2020	Mason et al. 2020	Sage et al. 2020
How do predators respond to the release of gamebirds at and around the release site	☑	☑	☑
The relationship between gamebird release, predator numbers and the consequences for predation of native wildlife	☑	☑	☑
The effect of disease and parasites from released gamebirds on native wildlife	☑	☑	☑
Extent and effects of direct predation on vertebrates especially amphibians and reptiles	☑	☑	☑
Scale of releases nationally	☑	☑	
Locations of releases nationally	☑	☑	
Levels of (unintentional) killing of non-released resident wildlife during shooting	☑	☑	
Occurrence of illegal killing associated with gamebird releasing and any effects on populations of protected raptors	☑	☑	
The socio-economic and ecological drivers behind the large-scale increases in the numbers of gamebirds released	☑	☑	
Relationships between the scale of releasing and land management practices, predator control and supplementary feeding	☑		☑
Accurate measures of areas of habitat created/maintained/preserved as a result of shooting/release	☑		☑
Effects of disturbance by gamekeepers and guns on resident wildlife and habitats	☑		

Potential competition for food and space between gamebirds and native wildlife	☑	
The impacts of lead pollution from ammunition used to shoot gamebirds on terrestrial UK wildlife	☑	
Effects on invertebrate populations beyond woodland release pens		☑

Table 3. Knowledge gaps identified by the three 2020 Reviews. Ticks indicate that this knowledge gap was highlighted by the Review.

3. ASSESSMENT OF NEW PUBLISHED EVIDENCE

For this Review, I examined any relevant scientific or grey literature relating to the subject that has been published since 2020. I included literature that: had been included in the submissions made to NRW as part of their call for evidence; or was revealed in a Google Scholar search on 12 December 2022 using the terms ‘gamebird’ or ‘pheasant’ or ‘partridge’ with date constraints 2020-present; or had been drawn to my attention during my reviewing or own research; or unpublished research that I have been involved with. Following an initial sift to determine relevance, I was left with 18 new sources that were directly relevant to this Review. These included 11 papers that considered specific ecological effects, four further papers that provided information about the scale, extent and temporal changes of gamebird releasing in the UK and three review papers which add little new information but provide different assessments of (some of) the available data.

Ten of the papers were mentioned in the call for evidence by NRW (Blackburn & Gaston 2021, Devlin et al. 2021, Fujiwara et al. 2022, Graitson & Taymans 2022, Hall et al. 2021, Hughes et al. 2021, Madden 2021, Medlock et al. 2022, Saad et al. 2021, Swan et al. 2022); six more were known to me through my involvement or own associated research (Duchesne et al. 2022, Harris 2021, Madden (2023, report 680), Raymond et al. in press, Sage et al. 2021, VKM 2022); and two more (Forcina et al. 2021, García et al. 2021) were revealed during the Google Scholar search.

I assigned new evidence relating to specific ecological effects to one of the effects categories described in Madden & Sage (2020). I followed Madden & Sage (2020) in scoring the relevance of the material to our knowledge of ecological effects of gamebird release and management in the UK. They assigned material to one of three relevance categories.

The material most pertinent is that which makes a direct comparison in environmental variables of interest (e.g. wildlife populations or habitat coverage or quality) between sites where gamebirds are released and control sites where they are not, or material that considered correlated changes in environmental variables of interest with variation in the

size of gamebird releases or variation across different areas hosting different amounts of gamebird releases, or material that compares the behaviour of released gamebirds with that of their wild-born conspecifics. This material is classed as highly relevant. Material that quantitatively describes environmental variables of interest or the actions of game managers and/or guns at release sites or on game shoots is also informative even though there may not be a direct comparison with control sites. Equally, material that describes the behaviour of released gamebirds such as their diet composition, activity budgets or habitat preferences may be informative. Even though the study design precludes a formal comparison between these measures at sites with and without releasing (because data were not collected at control sites within the study), it may be possible to obtain control values from other studies and make such comparisons. Such material also provides baseline values that might permit quantification of regional or national scales of releases and/or their effects. This material is classed as moderately relevant. Finally, there is a body of material that describes variables of interest, human actions or the behaviour or natural history of released gamebirds in a more qualitative manner. Even though such material cannot be formally evaluated or used to conduct quantitative comparisons, it may provide indications of where future work might focus efforts or indicates whether particular effects do or do not occur. This material is especially important for understanding those effects that are suspected to be likely to occur but which have not yet been formally investigated. This material is classed as weakly relevant. A single publication may be given a different relevance class depending on the data set and analysis being cited from it. This is especially likely for theses and larger pieces of work.

A) Papers considering specific ecological effects

i. Direct effects of disease on small vertebrates

a) Fujiwara, M., Auty, H., Brown, I., & Boden, L. (2022). Assessing the Likelihood of High Pathogenicity Avian Influenza Incursion Into the Gamebird Sector in Great Britain via Designated Hatcheries. *Frontiers in Veterinary Science*, *9*. 1-19

This paper focuses on the risk of High Pathogenic Avian Influenza (HPAI) moving through the gamebird breeding and rearing industry in the UK. Most attention is paid to the sources of eggs (imported, overwintered stock, recaptured breeding stock) and biosecurity practices pertaining to access to hatcheries and rearing fields. They conclude that HPAI introduction to hatcheries due to movement of eggs is low (but with high uncertainty), and transmission from hatchery to rearing fields when moving day-old chicks is also low (with a medium uncertainty). The work acknowledges that free-living adult gamebirds may carry HPAI. However, it makes no assessment of risk or likelihood of transmission of HPAI from rearing fields to the wild when gamebirds are released, and so adds little to our knowledge of effects of gamebird releases. This work is weakly relevant.

b) García, J. T., Viñuela, J., Calero-Riestra, M., Sánchez-Barbudo, I. S., Villanúa, D., & Casas, F. (2021). Risk of infection, local prevalence and seasonal changes in an avian malaria community associated with game bird releases. *Diversity,* 13(12), 657.

This paper focusses on the prevalence and distribution of avian malaria (AM) in red-legged partridges in Spain. The detailed picture was somewhat complicated with different lineages of AM found a higher prevalence at specific sites, regardless of whether they released partridges there or not and varying with the time of year. However, a crude overall pattern was that, overall, there a was a high prevalence of AM at all sites (>50%). This prevalence remained fairly constant between Spring and Autumn at sites where no releases occurred, whereas as sites where releases did occur AM levels in Autumn (when the release occurred) were higher than in Spring. The authors conclude that human activity in the form of gamebird releasing may drive avian parasite dynamics. Given that these effects were seen in particular lineages of AM but not in others, it remains unclear how applicable these findings might be to releases in the UK. This work qualifies as being highly relevant due to the study design, but is of moderate relevance to this review due to likely different forms of AM and release practices in Spain from those seen in the UK and the fact that it focusses on partridges that are less commonly released in Wales.

c) Medlock, J.M., Vaux, A.G.C., Gandy, S., Cull, B., McGinley, L., Gillingham, E. et al. (2022) Spatial and temporal heterogeneity of the density of *Borrelia burgdorferi*-infected *Ixodes ricinus* ticks across a landscape: A 5-year study in southern England. *Medical and Veterinary Entomology*, 36 (3), 356– 370.

This paper describes distributions of Borrelia infected ticks in Wiltshire. The authors note that the study area hosts high levels of released gamebirds and that these may play a role in the dynamics of the disease, but no explicit analysis of such a relationship is conducted in this study. The authors suggest the kinds of studies that could explore such a relationship and call for further work. This work is weakly relevant.

ii. Direct effects of foraging on invertebrates

a) Hall, A., Sage, R. A., & Madden, J. R. (2021). The effects of released pheasants on invertebrate populations in and around woodland release sites. *Ecology and Evolution*, *11*(19), 13559-13569.

This paper used pitfall trapping to assess changes in invertebrate population indices at 49 gamebird release pens at 13 sites in Central England over two years, comparing indices pre, during and post releases. Overall, there were changes in total invertebrate biomass suggestive that released gamebirds were either predating them directly or changing the vegetation in the release pen or surrounding local area after dispersal. Surprisingly, these effects were not seen specifically in taxa previously reported or presumed to be especially susceptible to gamebird foraging (beetles and arachnids). Slugs and detritivores showed small increases inside the release pens. There was an overall decline in indices in the second year of the study, but the authors attribute this to weather that year rather than a chronic effect of stocking at pens that had been in operation for up to 15 years. This work occurred at sites with very high release densities. The transects only extended to 25m outside the pen so it is difficult to assess effects at a wider scale than this. This work is highly relevant. The main results from this paper were considered in Madden & Sage 2020.

b) Devlin, J. J., Jones, T. H., & Thomas, R. J. (2021). Preliminary observations of the impact of non-native Pheasants, *Phasianus colchicus*, on the abundance and diversity of invertebrates in upland pasture in mid-Wales. *Milvus: The Journal of the Welsh Ornithological Society*, *18*(1), 81-87.

This paper looked at a site in south-central Wales in the uplands, situated about 3km from a small pheasant shoot and there set up two quadrats: one open to gamebirds (and all other wildlife) and the other fenced to prevent gamebirds (or other wildlife) walking in. The quadrats were monitored for 10 weeks to assess pheasant presence and more pheasants were seen in the treatment compared to the control quadrat. Invertebrate numbers were assessed by non-lethal means (sweeping and sample blocks). Overall invertebrate abundance was negatively related to records of pheasants in the treatment quadrat but not the control quadrat. No relationships were found for species diversity or any individual taxa. The authors acknowledge that this is a preliminary work. It has been subject to a formal, published, critique (GWCT Submission p21-24) that notes the lack of randomisation, replication, analytical assumptions and ineffective control conditions. Any conclusions drawn from the original paper should account for these criticisms. This work is highly relevant. The main results from this paper were considered in Madden & Sage 2020.

iii. Direct effects of foraging on small vertebrates

a) Graitson, E. & Taymans, J. (2022). Impacts of massive releases of colchid pheasants (*Phasianus colchicus* L.) on squamates (Reptilia Squamata). *Bulletin de la Société Herpétologique de France*, 180. doi:10.48716/bullshf.180-2

[I have based my assessment of this paper on a translation of the original French derived from Google Translate] The paper compares numbers of reptiles at 6 sites where gamebird released occur with 261 other sites across Wallonia (Belgium) where releases do not occur. It also considers a single site (divided into 5 subsites) where releases stopped and the site was converted to a cycle/footpath which was compared with an extension of the site where releases had not occurred and so were unchanged. No reptiles were detected on any of the 6 release sites during surveys spanning 2001-2019, whereas a mean of 3.2 reptile species were detected at non-release sites and every such site hosted at least one species. At the focal site, 0/5 subsites held *Zootoca vivipara* before releasing stopped and 4/5 held them eight years after releases had stopped. This is suggestive of negative effects of released gamebirds on reptile numbers. However, there are several potential confounds that should be considered when interpreting these results. First, the choice of sample sites is unclear and is currently highly skewed in number (6 release vs 261 control sites), habitat type (all release sites are ‘quarry and wasteland’ whereas 87% of control sites have naturalistic descriptions) and spatial clustering (all release sites are in the NW of the region while the great majority of the control sites are in the SE of the region). Second, the form of releases at the different sites is unclear and varied (their Table 1). Finally, there is likely strong spatial autocorrelation between the subsites at the focal site which makes the independence of data from there difficult to assess. This work qualifies as being highly relevant due to the study design, but is of moderate relevance to this review due to likely different reptile populations and release practices in Belgium from those seen in the UK.

b) Duchesne, T., Graitson, E., Lourdais, O., Ursenbacher, S., & Dufrêne, M. (2022). Fine-scale vegetation complexity and habitat structure influence predation pressure on a declining snake. *Journal of Zoology*, 318(3), 205-217.

This paper uses an artificial predation approach to explore predation pressures on adders *Vipera berus* in Belgium. It was not primarily designed as a study to assess impacts of released gamebirds, but the inclusion of data presented at the level of the predator species, including pheasants, means that a crude secondary analysis can be conducted. The authors presented 2400 plasticine model adders at 12 sites in Belgium, 7 of which hosted pheasants. They report that over 12 days/site predation by 'birds' including but not discriminating corvids and raptors as well as pheasants where present totalled ~1.6% compared with 4.8% by 'mammals' i.e. there was three times more predation by mammals over birds of all types. An analysis of the data illustrated in their Figure 4 comparing total bird predation rates at sites with and without pheasants (given in their Table S2) shows no difference in total predation ($z = 0.49$, $p = 0.62$). The authors also report that predation rates by birds may be decreased by increasing habitat structural complexity. With respect to release gamebirds, I conclude that this study suggests that predation of (fake) adders by any birds is relatively much lower than predation by mammals and that predation by pheasants is not markedly different from predation rates by other birds (specifically corvids and raptors). However, no measures of predator density/numbers are provided so it is hard to assess how these results may correspond to sites where large numbers of gamebirds are released in a concentrated area. This work is moderately relevant given the lack of explicit focus on differences in gamebird releases.

iv. Direct effects of genetic disruption of wild populations

a) Forcina, G., Tang, Q., Cros, E., Guerrini, M., Rheindt, F. E., & Barbanera, F. (2021). Genome-wide markers redeem the lost identity of a heavily managed gamebird. *Proceedings of the Royal Society B,* 288(1947), 20210285.

This paper reassesses whether extensive releases of gamebirds (hybrid red-legged partridges crossed with chukar partridges) affects the genetic integrity and biogeographic structure of native populations of red-legged partridges in western and southern Europe. Following widescale sampling of red-legged partridges across their range, the authors found unexpectedly limited and spatially uneven introgression by chukar genes. They conclude that this means that previous concerns over the direct effects of genetic disruption of wild populations (if any) by released captive bred birds may be less serious than believed. For the UK, where we do not native populations of pheasants or red-legged partridges, and where the release and management practices differ from those in the bulk of the areas studied in the paper, it is not clear how well these findings would translate to a UK scenario. This work is weakly relevant to this review given the absence of native red-legged partridge (or pheasant) populations in Wales.

v. Direct effect of carcass availability on predators

a) Swan, G. J., Bearhop, S., Redpath, S. M., Silk, M. J., Padfield, D., Goodwin, C. E., & McDonald, R. A. (2022). Associations between abundances of free-roaming gamebirds and common buzzards *Buteo buteo* are not driven by consumption of gamebirds in the buzzard breeding season. *Ecology and Evolution*, *12*(5), e8877.

This paper explored associations between territory size, prey delivery to chicks by parents, and breeding success of 37 buzzard nests at three sites in Cornwall, centred around shoots. Gamebirds comprised 14.4% of prey delivered to nestlings (mammals comprised 61.5%, other birds = 10.4%, herptiles = 6.8%) and rates of gamebird provisioning were unrelated to local gamebird abundance, whereas they were positively related to local rabbit and vole abundance. Nest productivity increased with increasing rabbits being provisioned, but was unrelated to gamebird provisioning. Buzzard territories were (somewhat) denser in areas with a higher gamebird abundance index. These results present a mixed picture of the effects of gamebirds on buzzard populations and productivity. The authors suggest that buzzards benefit from the associated management that accompanies releases such as predator control and/or habitat management leading to high densities of preferred prey. They also suggest that the availability of prey/carrion from gamebirds during the winter may support denser buzzard territories through the year. This work is highly relevant. The main results from this paper were considered in Madden & Sage 2020.

vi. Associated effects of predator control on predators

a) Hughes, J., Mason, H., Bruce, M., & Shorrock, G. (2021). Crimes against raptors in Wales 1990-2019. *Milvus: The Journal of the Welsh Ornithological Society*, *18*(1), 3-19.

This paper reports a relationship at the 10km2 tetrad between the presence of driven game shooting (so including shooting of wild as well as released game, although the contribution of wild game shoots is likely low) and the persecution of raptors in the form of direct killing, the use of poisons or traps against raptors, or any attempts to do so. The index of shoot presence is provided by an analysis of advertising game shoots on the Guns on Pegs website (n = 65). The methods do not make it clear whether the number or size of shoots in a tetrad was considered such that a small farm shoot was distinguished from a large commercial shoot. The authors conclude that in tetrads containing an advertising game shoot, there is a three times greater probability of persecution activity being recorded. The paper also considered cases of egg and chick theft but these are treated separately from illegal killing that might be linked to gamebird releases. The paper is subject to a critique of its methods, specifically its use of reports of persecution that may not be considered reliable evidence under legal definitions, in the BASC submission to the NRW evidence review. Any conclusions drawn from the original paper should account for these criticisms. This work is highly relevant.

vii. Associated effects of supplementary feeding on small vertebrates

a) Saad, S. M., Sanderson, R., Robertson, P., & Lambert, M. (2021). Effects of supplementary feed for game birds on activity of brown rats *Rattus norvegicus* on arable farms. *Mammal Research*, *66*(1), 163-171.

This paper looked at changes in rat abundance and activity around six gamebird feeders at a single farm in Northumberland. Indices of rat abundance were highest close to feeders, compared to 10m & 20m away, and were highest when the feeder was full and so giving out lots of food. Indices were also high during cold and wet weather. Indices did not seem to be affected by the surrounding habitat or whether rodenticide was deployed at the feeder. The results suggest that rats may concentrate around feeders but these concentrations may not persist once the feeder is moved, although with rat range reported as being ~50m, the authors recommend movement of at least 100m. The study does not provide information about effects of feeding on the growth of the resident population of rats in an area or whether a fixed population simply tracks shifting food resources. This work is moderately relevant given its limitation to a single site/6 feeders and lack of explicit link to changes in releases/gamebird numbers.

B) The scale and extent of gamebird releasing

These four publications do not directly contribute to our understanding of the ecological effects of interest to this review, but rather provide detail about some mediating factors that should be considered when considering any such effects at a regional or national scale. As such, they are not scored for relevance as those that refer to specific ecological effects, but are included here for reference and to provide an indication of the gross spatial and temporal patterns of gamebird releases across the UK. It is likely that in order to determine particular ecological effects, detail at a local scale is necessary which is not provided by any of these four publications.

a) Blackburn, T. M., & Gaston, K. J. (2021). Contribution of non-native galliforms to annual variation in biomass of British birds. *Biological Invasions*, *23*(5), 1549-1562.

This paper is an extension of Blackburn & Gaston (2018). The authors account for the fact that the biomass of released gamebirds fluctuates markedly over the year corresponding to the release and hunting season. They also correct for the fact that non-gamebird biomass changes through the year due to breeding, migration and mortality. Basing their estimates of released gamebird numbers on Aebischer (2019), (57 million pheasant and partridges), they estimate that in August, when most gamebirds have just been released, they comprise 52.5% of the total UK bird biomass. In April they comprise 12% of the biomass. Across the year, the authors estimate that 16-31.6% of UK bird biomass comprises pheasants and 0.6-2.5% comprises partridges. These values may change (decline) if the lower release estimates derived by Madden 2021 are used.

b) Madden, J. R. (2021). How many gamebirds are released in the UK each year?. *European Journal of Wildlife Research*, *67*(4), 1-14.

This paper is an extension of Aebischer (2019). The author incorporates Aebischer's estimate and adds a further 11 approaches to try to provide a better understanding of the numbers involved. By combining various permutations of datasets and variances present in them, 4329 values were calculated. This produces estimates ranging from 14.7-106.1 million gamebirds being released annually, with a mean of 43.2 million (95% CI 29.0–57.3 million). This suggests that 31.5 million pheasants (range 29.8–33.7 million), 9.1 million red-legged partridges (range 5.6–12.5 million) and 2.6 million mallard (range 0.9–6.0 million) are released annually in the UK. These values are ~75% of the previously published figure and if accurate would suggest that neither the scale of negative ethical or ecological effects of release, nor the positive economic benefits are as high as are currently assumed.

c) The impact of the COVID-19 lockdowns on wildlife-vehicle collisions in the UK. Raymond, S; Spencer, M; Chadwick, E; Madden, J; Perkins, S. (In press) *Journal of Animal Ecology*

This paper uses a Citizen Science data set covering wildlife vehicle collisions reported in the UK to explore how the two lockdown periods due to COVID in 2020-2021 changed roadkill patterns. Much of the paper is irrelevant to this review, but pheasants are commonly reported and from changes in their records we can obtain some crude estimates of how the scale of their releases might have changed under the impact of COVID. Because all records were reduced due to lower travel rates, the authors used compositional analysis to analyse relative changes. The number of WVC involving pheasants was 83% lower than predicted for both lockdown 1 and 2. The decline in pheasants being reported during the second lockdown may be partially explained by an estimated reduction in pheasant releases of 20-30% in late summer 2020 due to lockdown restrictions. However, this does not explain the similarly large reduction in pheasants involved in WVC during lockdown 1 when pheasants were the survivors of those released in 2019 and thus at numbers comparable to those present in previous years. Additionally, even during lockdown 2, the reduction in observed numbers of pheasants reported as WVC compared to those expected is four times greater than the reduction in pheasants being released.

d) Madden, J.R. (2023). Patterns of Gamebird Release, Management, and Shooting in Wales. NRW Report No: 680. NRW pp38

This review for NRW provides a depiction of the scale, extent and history of gamebird release and management in Wales based on a range of datasets. It concludes that there are somewhere between 0.8-2.3 million gamebirds released annually at somewhere between 171 and 431 shoots in Wales. Shoots in Wales appear to be fairly similar to those in the rest of the UK, with a strong rightward skew in size distributions, comprising many small shoots (releasing and shooting relatively few birds over a few hundred acres) and a few very large ones (releasing large numbers of birds and shooting them over several thousand acres on many days during the shooting season). Around three-quarters of Welsh shoots release fewer than 3000 birds annually. This skew, which may be even stronger in Wales than the UK in general, may explain why the mean number of birds released on a Welsh shoot (4,692) is around 20% higher than on shoots in the rest of the UK (3,908) but the median numbers released in each area don't differ (both = 1000). There are proportionately fewer partridges being released in Wales and fewer shoots offering them as quarry, probably because of gross habitat differences. Of the advertising shoots in

Wales, 17% were registered as part of the voluntary British Game Assurance Scheme (BGA) whose audit considers a range of minimum standards likely to influence ecological effects. The review also tried to estimate compliance by shoot operators with the APHA Poultry Register, concluding that compliance levels were between 29-73%. It also made a crude assessment of proximity of release locations to protected areas, with ~4-16% of locations being <500m from a SPA/SAC and ~30% of locations being <500m from a SSSI.

C) Reviews

These three reviews do not contribute new evidence to our understanding of ecological effects (but see Sage et al. (2021) for some preliminary crude modelling based on assumed data about gamebird dispersal which may have relevance for the areas susceptible to some direct effects), but rather re-present the existing evidence from three different perspectives. As such, they are not scored for relevance as those that refer to specific ecological effects, but are included here for reference and to provide an indication of how the raw data that is available may be interpreted and presented in a variety of differing contexts from the shooting industry, from opponents to shooting and from a non-UK perspective where similar issues are encountered albeit at a markedly different scale.

a) VKM, Eli K. Rueness, Maria G. Asmyhr, Dean Basic, Katrine Eldegard, Andrew Janzcak, Hans Christian Pedersen, Bjørnar Ytrehus, Angelika Agdeseten, Paul Ragnar Berg, Sonya R. Geange, Kjetil Hindar, Lars Robert Hole, Lawrence Kirkendall, Anders Nielsen, Erlend B. Nilsen, Brett Sandercock, Eva Thorstad, Gaute Velle (2022). The release of common pheasants and grey partridges for pointing dog training- consequences for biodiversity, animal welfare and health. Scientific Opinion of the Panel on Biodiversity of the Norwegian Scientific Committee for Food and Environment. VKM Report 2022: 32, ISBN 978- 82-8259-408-0:,ISSN: 2535-4019. Norwegian Scientific Committee for Food and Environment (VKM), Oslo, Norway.

This report focusses on the release of gamebirds in Norway for training gundogs rather than primarily for hunting. As such, it involves markedly smaller numbers of birds being released (~8000/year in total) and very different techniques for their release and subsequent management. There is a particular focus on welfare aspects of releases but there is also a detailed assessment of risks to biodiversity from the released birds. Those identified include disease transmission to wildlife (low to high risk), competition with farmland birds, predation of invertebrates, and impact on flora (moderate risk), and risk of hybridisation and predation on herptiles (low risk). The associated management of the released birds (e.g. predator control or supplementary feeding) in Norway is poorly understood so any effects associated with these activities are difficult to evaluate.

b) Harris, S. (2021). A review of the animal welfare, public health, and environmental, ecological and conservation implications of rearing, releasing and shooting non-native gamebirds in Britain. A report to the Labour Animal Welfare Society.

This review is broader in scope than the three original reviews, stating that it reviews the animal welfare, public health, and environmental, ecological and conservation implications of rearing, releasing and shooting non-native gamebirds in Britain. Much of the material covered by the three original reviews is included as well as much material that is not directly related to the release and management of gamebirds. The review is critiqued extensively in the submissions to NRW by both the GWCT (pp.15-20) and BASC (pp.31-

80). Both of these organisations point out critical flaws in the paper's conception (lack of search/inclusion/exclusion criteria, bias in questions being addressed, lack of assessment of evidential quality) and the interpretation and deployment of literature to make arguments (with a detailed examination of how studies have been misinterpreted and citations used incorrectly). My assessment of the critiques is that the concerns that they raise are predominantly valid and as such this paper should be treated as a piece of advocacy rather than primary scientific literature and so the conclusions presented within it should be evaluated carefully.

c) Sage, R.B., Brewin, J., Stevens, D.C. and Draycott, R.A.H. 2021. Gamebird Releasing and Management in the UK. A review of ecological considerations, best practice management and delivering net biodiversity gain. Game & Wildlife Conservation Trust, Fordingbridge.

This review is predominantly a synthesis of Madden & Sage (2020) and Sage et al. (2020) made accessible to a non-scientific audience. The same material included in those reviews is used albeit presented in slightly different categories. Some new material is presented relevant to the dispersal of released gamebirds, with a very crude model of expected densities of gamebirds at varying distances from release pens.

D) Summary of New Evidence Arising from Publications post 2020

The publications add eleven pieces of evidence regarding specific ecological effects of gamebird release and management to add to that included in the three previous reviews. These comprise:

1) three studies concerning *Direct effects of disease on small vertebrates* including two rather speculative studies of how HPAI and Borrelia might be associated with gamebird rearing, release and management, considered to be of weak relevance, and one study from Spain relating levels and forms of avian malaria to release of partridges, considered to be of moderate relevance;

2) two studies concerning *Direct effects of foraging on invertebrates* which are both considered to be of high relevance (although Devlin et al. 2021 is the subject of methodological critique by Sage 2022), but the main effects described in these studies have already been considered in Madden & Sage as a PhD & MSc theses so although they gain the authority of being peer-reviewed, they add little new to the existing knowledge base;

3) two studies concerning *Direct effects of foraging on small vertebrates* which focus on adder predators and changes in reptile populations in Belgium and both are considered to be moderately relevant to our understanding of ecological effects under conditions normally found in Wales;

4) one study concerning *Direct effects of genetic disruption of wild populations* with a focus on patterns of introgression in wild populations of red-legged partridges, considered to be of weak relevance - given that there is little concern about genetic integrity in UK wild or released gamebird populations;

5) one study concerning *Direct effect of carcass availability on predators* which finds ambiguous links between the availability of released gamebirds providing supplementary prey and the breeding biology of buzzards in SW England, considered to be of high significance, but the main effects described in these studies have already been considered in Madden & Sage as a PhD thesis so although they gain the authority of being peer-reviewed, they add little new to the existing knowledge base;

6) one study concerning *Associated effects of predator control on predators* describing patterns of reported illegal raptor killing/disturbance in Wales and relating them to general areas where advertising commercial game shoots (predominantly shooting released gamebirds) operate. This work is considered to be of high relevance but please note that it is subject to a critique on methodological/legal grounds in the BASC submission;

7) one study concerning *Associated effects of supplementary feeding on small vertebrates* showing that local rat abundances fluctuate with feeder presence and other environmental features on a farm in Northumberland, considered to be moderately relevant.

Four other studies provide additional detail about the scale and temporal trends of gamebird releasing in Wales and across the UK: Madden (2021) revises estimates of the total numbers of gamebirds being released attempting to triangulate across multiple approaches, although it adds no further information as to where these releases may be occurring or information on temporal trends; Blackburn & Gaston (2021) revises estimates about how the biomass of released gamebirds relates to the rest of the UK avifauna across the year (again adding no further spatial or inter-annual detail); Raymond et al. (in press) describes how pheasant roadkill levels have changed over the past 2 years likely due to reductions in releases or management because of COVID. Madden (2023) describes spatial and temporal patterns of releases in Wales with particular attention paid to compliance with legal requirements and industry management recommendations. These findings add some clarity to the UK wide patterns of gamebird releases but because they have poor spatial and ‘normal’ temporal resolution they do not assist in understanding local patterns of release, management or the accompanying ecological effects.

The three reviews add little if any relevant new material. VKM 2022 focusses on a release system very different in scale, extent and location (Norway) to that practiced in the UK. Sage et al. 2022 is mainly a rewriting of material and interpretations covered by Madden & Sage 2020 and Sage et al 2020. Harris 2021 covers a broader range of material (fox biology, antibiotic and other drug use, dogs used in shooting, animal welfare, scavenging and disease spread) than the three 2020 reviews but as described above, some of the use and interpretation of evidence is incorrect or inappropriate and so its conclusions should be treated with caution. The limits and repetition of these reviews means that they do not provide new evidence to understand local patterns of release, management or the accompanying ecological effects.

4. ASSESSMENT OF NEW EVIDENCE SUBMITTED TO NRW

I read the eight organisational level submissions made to NRW and considered any material beyond that covered by Madden & Sage (2020), Mason et al. (2020) & Sage et al. (2020), that they presented including new analyses, anecdotes, and critiques. Where new published work was cited, I evaluated that in Section 3. For each submission, I considered

whether there was any new material pertaining to either the scale and extent of gamebird release and management or specific ecological effects, and whether the material might be considered as evidence, in which case I assigned it to one of the effects categories described in Madden & Sage (2020) and scored the relevance of the material to our knowledge of ecological effects of gamebird release and management in the UK. If material was anecdotal or purely qualitative I noted this and did not include it in any future assessment of the available evidence.

The submissions often also presented their interpretations of existing data. The data that they chose to present was unsurprisingly predominantly that which supported particular positions in favour of or in opposition to (elements of) gamebird release, management and shooting. I have not commented on all of their interpretations, however where data appear to have been interpreted incorrectly or inappropriately (for example if recent papers have been ignored in favour of older ones or conflicting or alternative data have not been presented concurrently) then I have noted this and arguments and assertions based on these interpretations should be treated with circumspection.

A) Amphibian and Reptile Conservation Trust

The submission describes three anecdotal reports (including two from named site in Wales) describing cases when a) reptiles have been attacked by pheasants and b) reptiles have appeared to become scarce or disappear when gamebird releases have started or increased in the local area. The authors acknowledge that these reports are hard to interpret with unstructured data collection and multiple potential explanations may pertain. They also report two old (pre 1900) texts describing negative direct and population impacts of released pheasants on reptiles, whilst again acknowledging problems with their interpretation in current conditions. They note that they have not encountered any anecdotal reports of increases in reptile populations corresponding to the local start or increase of gamebird releases. The submission also includes material pertinent to our understanding of the scale and extent of gamebird releases in Wales, comprising two sets of observations of increased numbers of gamebirds by ARC surveyors in Wales at three specific locations, noting that at least some of these occur in areas that support nationally important reptile populations. At present this takes the form of anecdote but the submission states that further detail may be available.

B) Animal Aid

The submission reports anecdote from an investigation by Animal Aid in Wales in 2022 during which they observed dead breeding birds being disposed of. No further information is given about the scale of this investigation or behaviours at other locations, or about the ecological impacts of this activity. As such this material falls outside the remit of this review.

C) Countryside Alliance

The submission reports that a new Value of Shooting report is being conducted to update the PACEC 2014 report, due March 2023. No further details are given about this. The

submission reports that DEFRA are conducting a three year project to address evidence gaps raised by Madden & Sage.

The submission reports four case studies that illustrate socioeconomic effects of shooting in Wales (Coed Cwm Mynach, LLanarmon, two gun shops, Bettws Hall). These focus on socioeconomic effects and as such are beyond the remit of this review.

Some of the interpretation of evidence in this submission appeared to be based on a partial, biased or incomplete consideration of the available data. The submission states that the pheasant has been in Wales since Roman times. Evidence for this is weak with it being more plausible that the birds have been resident since the 12th Century (Lever 1977). The submission relies heavily on the PACEC 2014 Value of Shooting Report, using data from it to support statements about socioeconomic effects of shooting. As described in the Animal Aid and League Against Cruel Sports submissions, some aspects of this submission have been subject to criticism for the methods used to calculate values. The submission reports change in bird populations on a deserted grouse moor, but this pertains to upland wild bird shooting, not the shooting of released lowland gamebirds and as such is not relevant to this review.

D) British Association for Shooting and Conservation

Although this submission presents no new original evidence itself (instead mainly highlighting material from previous work that supports the position of BASC), it identifies several reports or papers that were not covered by Madden & Sage 2020 and asks for them to be considered (see section 3). Three of these reports/papers (Harris 2021, Hughes et al. 2021, Devlin et al. 2021) are subjected to detailed criticism in this submission over their methodologies and interpretations. These criticisms generally match those that I make of the papers (see section 3). The extremely detailed critique of Harris 2021 (Annex 1 pp.32-80) is thorough and benefits from a clear approach to assessing the (un)cited literature, highlighting when a statement made is wholly or partly unsupported by evidence or when evidence has been misrepresented.

The submission includes details of ongoing or proposed work that BASC is aware of which is expected to produce evidence that would be highly relevant to this NRW assessment. These include: a new ‘Value of Shooting’ survey (p 5, due March 2023); a series of studies commissioned by the GWCT considering effects of releases on fox populations and behaviour, dispersal of released birds and the effects of late-season large-bag shooting (p14-15, outputs due end 2023-2025); and a series of projects conducted or commissioned by DEFRA considering scale and extent of releasing, dispersal, effects on nutrients, flora and fauna by released birds, disease, and effects on predator populations (p15, no dates given for these outputs, but likely end of 2024/early 2025 to fit within the time period for DEFRA’s review of interim regulations).

E) Game and Wildlife Conservation Trust

The submission presents new data (from both inside and outside Wales) relating to ecological and socioeconomic effects of gamebird releasing with a focus on the situation in Wales. It also includes a number of detailed critiques of material relevant to this NRW assessment including: p7-9, Mason et al. (2020) (how evidence is weighted when drawing

conclusions about the effects of gamebird release and management); p13-20 Harris (2021) (how evidence is selected, cited and interpreted when considering effects of gamebird release and management); p21, popular press reports about the effects of gamebird release on adders (a critique of the material used to derive and support statements about extinction risks to adders); p21, Devlin et al. 2021 (a critique of the methods and conclusions from this paper – this critique will be published in the same journal as the original paper).

This submission reports a series of studies that are currently being conducted by the GWCT and others that they are aware of that sound highly relevant to this NRW assessment (p4-5). Their own work includes: field studies on whether fox activity is affected by gamebird releases and how released gamebirds disperse, and a review of the direct effects of released birds on invertebrates beyond release sites. They also report work planned or underway by others including: survey of stakeholders about effects of released gamebirds on designated sites, illegal raptor killing associated with releases, effects of releases on reptiles, effects of releases on general non-game wildlife populations, modelling dispersal of released birds, relationships between ticks, *Borellia* and game management, and the new Value of Shooting report. Again, no further details are provided so this evidence cannot be evaluated until it is released more fully or published, likely in late 2023 to 2025.

i. New Evidence Pertaining to Specific Ecological Effects of Gamebird Release and Management

The submission presents some preliminary data (p13) from an NRW commissioned survey of a SSSI woodland where a release pen was situated in a non-designated woodland 200-300m away. Parts of the survey report were cited focussing on indicators of air quality and two lichen populations of conservation interest (*Collema fragrans* and *Bacidia circumspecta*). The presence and abundance of these populations and the general assemblages observed in the woodland prompted the conclusion that the released pheasants were not having notable effects at the distance of a few hundred metres away from their release pen. This data relates to a single site with no formal spatial or temporal controls. This material concerns *Direct effects of bird actions on soil, water and air* and is of moderate relevance.

The submission presents preliminary results (p25) from a field study in Exmoor (considered by GWCT as similar to landscape use in Wales). The study, partially written up as an article in the GWCT Annual Review counted breeding songbirds encountered in hedgerows at varying distances from game crops that had been present overwinter. For resident species, numbers were higher closer to game crop sites (twice as many <150m compared to >500m in April/May) and this difference persisted albeit at a lower level later in the year. These effects were not evident for migratory species, suggesting that the residents used seed reserves in the game crops over winter to support their territory formation/condition. These results were then extrapolated to suggest that if game-crops were provided in Wales in the manner seen in the area of Exmoor studied, over-winter farmland bird numbers might be increased six-fold and breeding bird numbers increased two-fold. Workings to support this assertion are not provided. This work extends work in Sage (2018a,b) that was considered in previous reviews, but these data were collected in 2021. This material concerns *Indirect effects of planting and management of non-woody plants on small vertebrates* and is of high relevance.

The submission reports a poll (p12) commissioned by GWCT regarding public attitudes towards the WG response to the NRW review of the use of firearms on its land. This focuses on socio-political issues of gamebird release and management and as such is beyond the remit of this review.

F) League Against Cruel Sports

The submission includes an anecdotal report of multiple (number unspecified) dead gamebirds being disposed of in a cavern at a site in mid Wales described as being next to "…one of Wales' most sensitive and protected pieces of land…". It is not clear what the ecological effects of this disposal practice are, nor how prevalent it may be.

The submission also reports a DEFRA estimate that "up to 51,000 snares can be found in the Welsh countryside at one time". Their citation actually states an estimate of between 17,200 and 51,600 snares and is based on a report WM0315. I cannot access this original report to evaluate it.

G) National Gamekeepers Organisation

The submission comprises seven testimonials. They almost exclusively relate to the socio-economic and personal health implications of game shooting and concerns about its restrictions. As such they fall outside the remit of this review.

H) Royal Society for the Protection of Birds

The submission deliberately avoids repeating material covered by Madden & Sage (2020) and Mason et al. (2020), and instead presents new data, analysis, anecdote and discussion about the scale, extent, ecological and socioeconomic effects of gamebird releasing with a focus on the situation in Wales.

This submission reports a series of studies that are currently being conducted by the RSPB that sound highly relevant to this NRW assessment (p4-5). These include: a survey of stakeholders about effects of released gamebirds on designated sites, illegal raptor killing associated with gamebird abundances, effects of releases on reptiles. No data from this work was presented but results of these studies are likely due 2023-2025.

i. New Evidence Pertaining to the Scale and Extent of Releasing

The submission presents data (p1) from an analysis of the APHA Poultry Register data cited as being from June 2022. It reports that 725,328 gamebirds are registered in Wales at 203 locations. This number differs from that used by Madden (2023) drawn from the 2019 Poultry Register, being around 130,000 more birds at around 90 more locations. If these new data are accurate, it is surprising because by June 2022, import restrictions from France due to HPAI were in place such that the numbers of pheasants are estimated to be 50% lower than in 'normal' years and reductions in partridges even greater. These figures also follow two previous years (2020-21) during which gamebird releases and shooting were disrupted by COVID restrictions with the assumption that shoots closed and releases were reduced during that time. It is interesting to note that, using this

interpretation of the data, the percentage of GB birds included in the Poultry Register in Wales in the June 2022 is 4.67% compared to 4.1% in 2019. If these two analyses are comparable then it appears that either compliance with the register has increased in Wales compared to the rest of GB, or that releases in the rest of GB have declined compared to those conducted in Wales. An alternative explanation is that this analysis of the Poultry Register data has included locations and birds registered for reasons other than releasing for shooting (e.g. breeding and rearing), leading to some double counting.

The submission makes use of a number of different surveys at a national and local level to explore patterns of abundance, distribution and temporal change (p2-4). These are predominantly surveys designed to assess wild bird populations. The authors of the submission are aware of this and describe the limitations of this approach, including warnings about changes in survey patterns over recent years due to changed surveyor behaviour following COVID. The authors also note that data collected as part of the BBS produce values that indicate numbers in the Spring/Summer and may relate poorly to numbers being released. There are some further limitations relating to these data to consider. The extrapolation is further complicated by the fact that pheasants exhibit a polygynous breeding system (Hill & Robertson 1988) so it is unclear how the number of (presumably breeding) hens might relate to the number of males in the population.

The submission considers the distributions of shoots/gamebird releases across Wales (p2), searching for agreement across a range of datasets. The author(s) presents a map from 2013 showing the data from the Poultry Register (p13, Fig 1) and compares it with the map of advertising game shoots from Hughes et al. (2021) (p13, Fig 2). The 2013 PR map is difficult to interpret in this way. First, it appears to plot numbers of birds reported at locations that include breeding/rearing sites. This accounts for the single very high density location in North Powys, likely to indicate a large scale rearing set up. Second, it smooths estimated gamebird numbers in some form of interpolation, suggesting distribution patterns that may not reflect the likely highly localised clustered patterns of releases on particular shoots. Nevertheless, the general pattern matches that described in Madden (2023) indicating concentrations of releases along the borders region.

The submission attempts to illustrate temporal trends in gamebird numbers, specific to Wales, using two data sets. The first, based on the BBS index, is subject to the same caveats described above, being indicative of birds in the breeding season likely away from shoots and therefore the link to numbers being released is hard to interpret. An alternative explanation could be that the habitat for breeding pheasants has improved in that time and so more can now survive to the BBS survey period. Contrary to this is the observation that the index has fallen over the past three years, suggested to be due to the restrictions on shooting due to COVID over those years. This would suggest that this index does relate in some way to the numbers being released. However, it is notable that in the rest of the UK, the index shows no such decline, but instead an increase from 142 (CI = 139-146) to 151 (CI = 147-157) over the same period. It seems unlikely that COVID restrictions did not affect shooting to a similar extent across the UK.

The submission reports incidental records of gamebirds from the RSPB's GIS database of observations on their reserves, including SSSIs (p4). Observations are reported from a number of locations, but in most cases, no numbers of observations are given, other than at a single site (Lake Vyrnwy) and no indication is given of the period of time covered by these records nor any detail of absences or search effort.

ii. New Evidence Pertaining to Specific Ecological Effects of Gamebird Release and Management

The submission presents material relating to HPAI with a focus on gamebirds in order to attempt to evaluate how disease in general and HPAI in particular may be affected by releasing and managing gamebirds (p5-6). Much of this material is tangential with rather weak links to released gamebirds. A number of potential risks are presented (transmission at shared feeding sites, scavenging of dead birds, transmission between breeding/rearing facilities, introduction of infected individuals from breeding/rearing locations). However, given the recency of the situation and the very poor epidemiological and behavioural data available, especially that relating to wild populations in the UK and game rearing practice, the links that are made are currently highly speculative. The authors recognise this and call for a risk assessment, which would presumably entail a detailed exploration of the mechanisms and consequences of transmission of HPAI and indeed other diseases that may involve both gamebirds and wild birds. Currently, such data are unavailable. This material concerns *Direct effects of disease on small vertebrates* and is of weak relevance.

iii. Anecdotal Material Pertaining to Specific Ecological Effects of Gamebird Release and Management

The submission reports a series of anecdotes relating to fox control and gamebird releases. The first (p2) is that some shoots may have reduced predator control and increased release numbers to economise on gamekeeper wages. A second anecdote (p10) is reported that lethal fox control in Wales is primarily motivated by protection of livestock (mainly sheep) rather than for game management. No data is presented to support this assertion or allow formal comparisons. A third (p11) concerns a RSPB contracted hunter observing fewer foxes in winter 2021/22 than usual when shooting them over two areas of RSPB reserves/ICAs which the author(s) attribute to the cessation of local releases due to COVID. They report that a long term data-set detailing fox kills and effort exist, but this has yet to be analysed.

The submission reports an anecdote (p10) based on observations by RSPB staff of gamebird release pens in Powys where ground flora has been trampled and scraped bare, with ‘strong aroma of droppings’, compared to adjacent areas although it is not specified how far these differences were detectable, nor any further details about the release and management practices at the site(s).

Some of the interpretation of evidence in this submission appeared to be based on a partial, biased or incomplete consideration of the available data. This can lead to an inflated estimation of the effects of released gamebirds. These include four examples: 1) the submission suggests that 2.35 million pheasants and 500,000 partridges are released in Wales annually (p1), calculated by extrapolating the percentage from the Poultry Register data onto the numbers of gamebirds estimated as being released by Aebischer 2019 (57 million). As discussed earlier, this number is subject to debate and so the extrapolated figures may be correspondingly lower. Using Madden’s 2021 average estimate of 42 million, this would suggest values of ~1.7 million pheasants and 370,000 partridges. 2) the authors critique the estimate that 4% of Welsh woodland is managed for pheasants (p9) stating that they are uncertain whether this figure can be correct because 41% of Welsh woodland is Welsh Government estate where gamebird management is not practiced. It is not clear why 4% cannot be encompassed by the 59% of woodland which is

not owned by the Welsh Government. 3) the reported estimates of the biomass of released gamebirds (p11) is based on Blackburn and Gaston (2018) which has since been revised to provide more comparable and accurate values (Blackburn & Gaston 2021 – summarised in see section 3Ba). 4) the statements about the costs of wildlife road traffic accidents (p11) conflate a series of values given in the cited press release. The submission states that after deer, pheasants are the biggest cause of motor vehicle collisions claims in the UK. This is true, but while deer account for 61%, pheasants are 11% (followed by badgers (8%); birds (7%); foxes (5%)), and the value of £63.8 million is the total value of claims, rather than just those for pheasants, and likewise the average cost of £2400 covers damage by all animals. The press release does not attribute specific values to claims involving pheasants and given the relative body sizes of pheasants and e.g. deer it is not clear that simple proportions of cases can be used to calculate these costs.

I) Summary of New Evidence Submitted to NRW

The submissions themselves included only three new pieces of evidence regarding specific ecological effects of gamebird release and management to add to that included in the three previous reviews and the subsequent publications (section 3). These comprise: 1) some material concerning *Direct effects of disease on small vertebrates*, considered to be of weak relevance; 2) a single site study with no controls concerning *Direct effects of bird actions on soil, water and air*, considered to be of moderate relevance; 3) a landscape-scale field study (in SW England) concerning *Indirect effects of planting and management of non-woody plants on small vertebrates*, considered to be of high relevance.

The submission from the RSPB includes a series of new analyses of existing data that provide further information about the scale, extent and temporal trends of gamebird releases specifically in Wales. Like all current attempts to estimate and map gamebird releases, it is based on messy data, but it provides a useful addition to our understanding of these patterns in Wales and generally agrees with analyses by Madden (2023).

The submissions also contain 11 anecdotes. These hint at additional data that may be considered in the future but currently they cannot be used to reliably assess any ecological effects.

5. INCORPORATING NEW EVIDENCE FROM PUBLICATIONS AND SUBMISSIONS WITH THE EXISITING EVIDENCE

Each of the three reviews used slightly different categorisations for the effects that they considered. Madden & Sage (2020) considered 22 effects, categorised as Direct, Associated or Indirect. They reported the number of Highly, Moderately and Weakly relevant studies that support each effect. This is summarised in their Figure 8A. Madden & Sage did not consider the strength of any effects nor do they try to attribute costs or benefits to each category, emphasizing that these may be context or value dependent.

Mason et al. (2020) considered 16 categories (excluding those relating to lead accumulations and socio-economic impacts), separated into 6 broader Themes. This is summarized in their Table 2. Mason et al. (2020) ascribe ecological effects evidenced by each study, considering the quantity of the work and incorporating a crude assessment of whether the effects would be likely detectable at a national population level for taxa of interest (strong, weak, no evidence for effects), with an evaluation of whether the effects might be considered positive or negative. From these, they calculated median effect scores per category. Sage et al. (2020) considered 25 categories, separated into six groups. This is summarised in their Results section. They evaluated whether each study indicated a positive, neutral or negative ecological effect and so generated an overall effect score for each category. Sage et al. also considered the spatial scale over which any such effects might operate including local (part of a woodland or part of a field), patch (the whole of woodland or field) or landscape.

By combining these approaches, it is possible to draw up a three-dimensional scoring system for each type of effect, involving an assessment of their perceived direction (positive, neutral or negative), the spatial scale at which they are assumed to operate (local, patch, landscape), and the combined strength of evidence underpinning their assessment (high, moderate, weak). Because Madden & Sage (2020) evaluated the relevance of the literature associated with each category, I will use their categorisations and try to match the categories presented by Mason et al. and Sage et al. I added the eight new pieces of evidence arising from post 2020 publications (excluding Hall et al. 2021, Devlin et al. 2021 and Swan et al. 2022 as their contents were already incorporated in Madden & Sage 2020 as theses/unpublished data) and the three new pieces of evidence arising from the NRW submissions. I removed references relating to mallards that had featured in previous reviews because mallards fall outside the remit of this review.

I visualised this multidimensional scoring system in three ways. First, I plotted the number of all studies of relevance for each effect, divided into whether the effects were deemed to be positive, negative, neutral/ambiguous or unknown (Figure 1). Second, I concentrated on the highly relevant studies for each effect and arranged the effects by whether they were considered positive, negative, neutral or unknown, and within these divisions by the spatial scale (Local, Patch, Landscape) over which they are thought to operate (Figure 2). Finally, I generated a Composite Evidence Score for each effect by weighting the literature by its relevance (as defined by Madden & Sage 2020 – see see section 3), giving each piece of highly relevant evidence a score of 5, moderately relevant evidence a score of 3 and weakly relevant evidence a score of 1. I then arranged the effects by their composite score and denoted whether they were considered positive, negative, neutral or unknown, and the spatial scale (Local, Patch, Landscape) over which they are thought to operate (Figure 3).

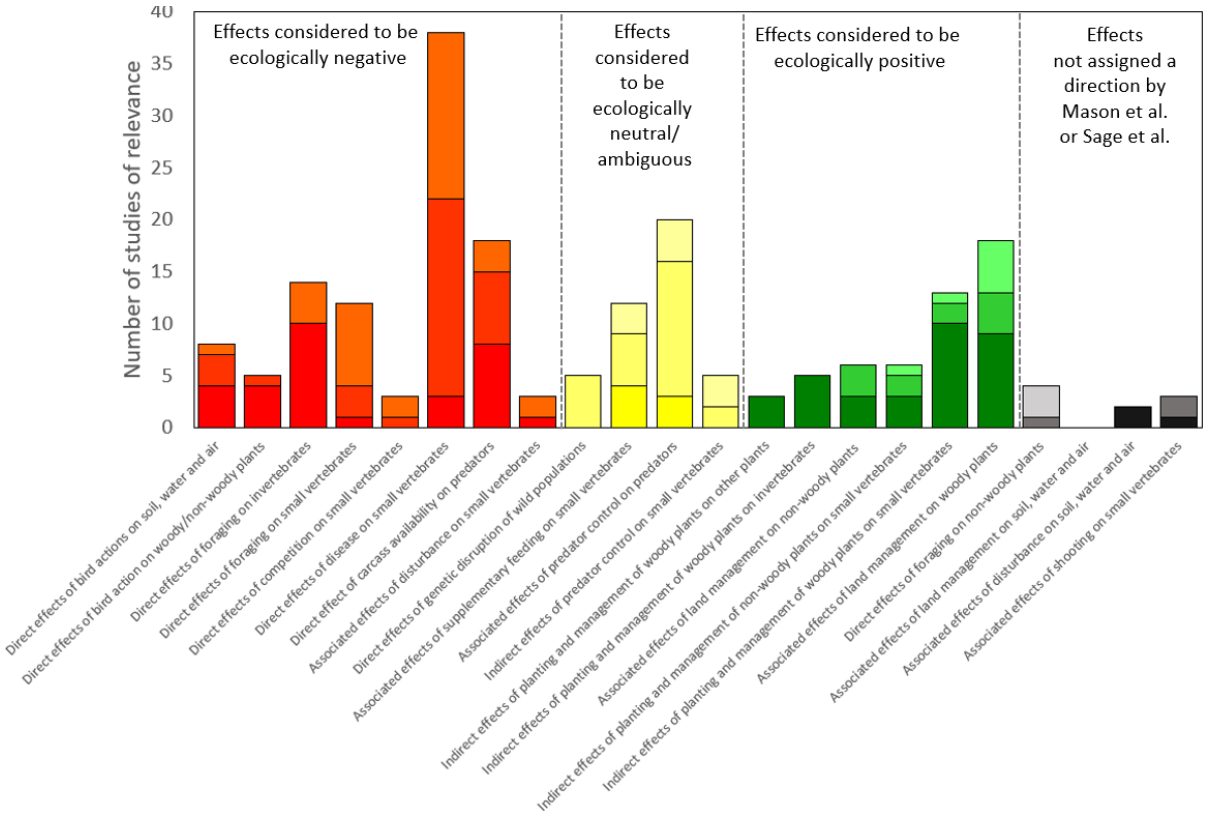

Figure 1. The number of studies including those from the original reviews, new publications post 2020 and the evidence from the NRW submissions pertaining to each of the ecological effects classed by relevance as given in Madden & Sage (highly relevant = dark/bottom shade; moderately relevant = medium/middle shade; weakly relevant = light/top shade), with the direction of the ecological effect as defined by Mason et al. and Sage et al. (negative effects = red; positive effects = green; neutral/ambiguous effects = yellow; unassigned effects = grey)

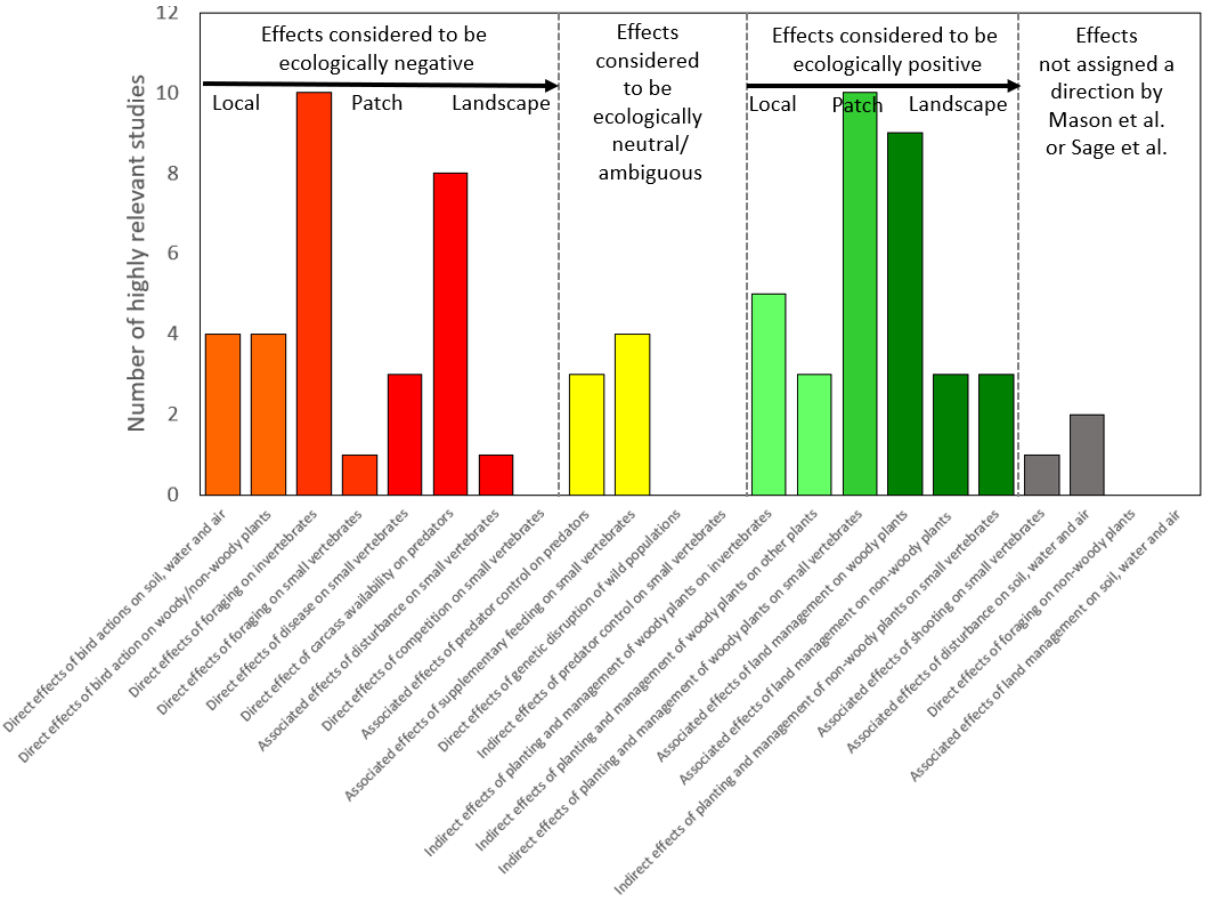

Figure 2. The number of studies including those from the original reviews, and the new publications post 2020 and the evidence from the NRW submissions deemed highly relevant according to Madden & Sage pertaining to each of the ecological effects, with the direction of the ecological effect as defined by Mason et al. and Sage et al. (negative effects = red; positive effects = green; neutral/ambiguous effects = yellow; unassigned effects = grey) and the scale over which the effect was deemed to operate as defined by Sage et al. (light shade = local (part of a woodland/field); medium shade = patch (whole woodland/field); dark shade = landscape).

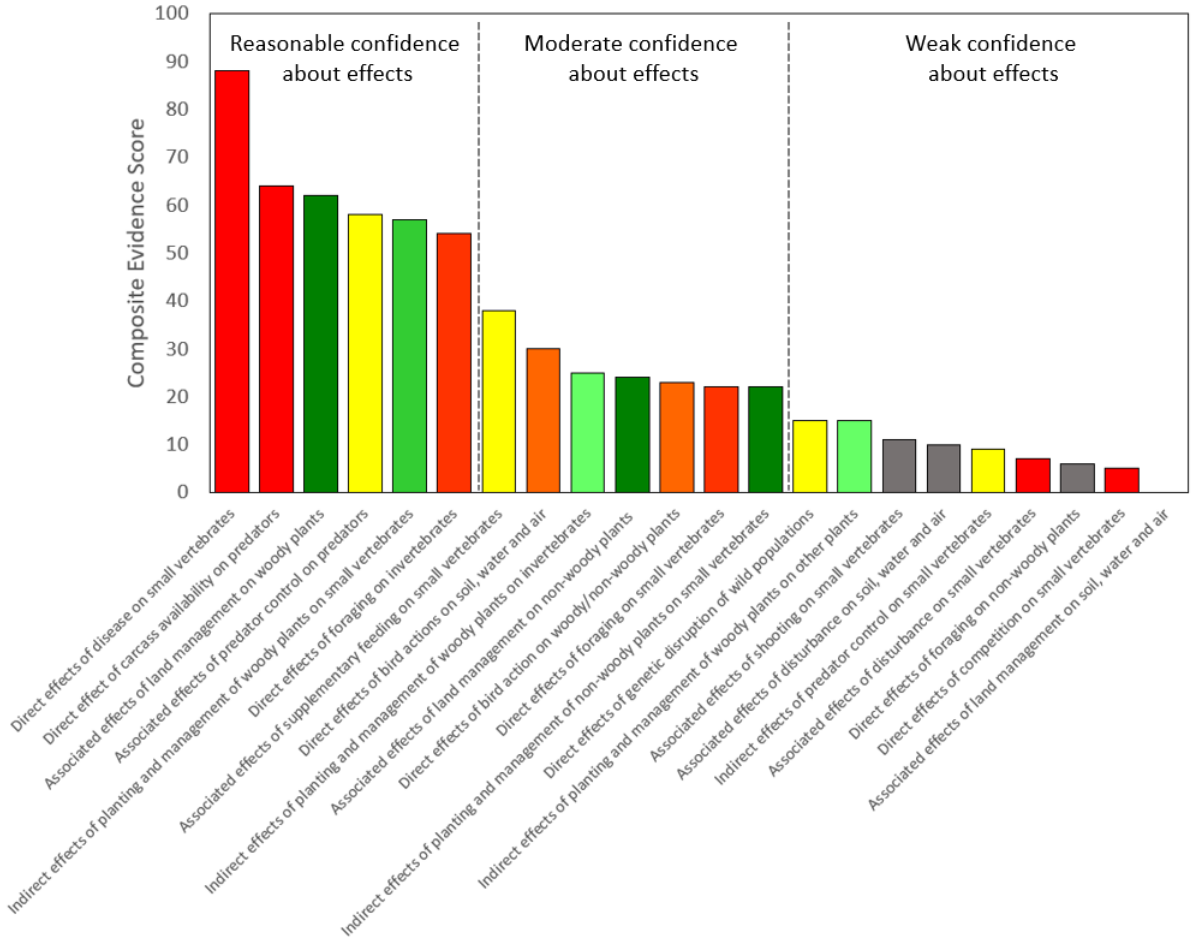

Figure 3. The Composite Evidence Score derived for each of the ecological effects by weighting the relevance of the studies, including those from the original reviews, the new publications post 2020 and evidence from the NRW submissions, as assigned according to Madden & Sage (Highly relevant = 5; Moderately relevant = 3; Weakly relevant = 1), with the direction of the ecological effect as defined by Mason et al. and Sage et al. (negative effects = red; positive effects = green; neutral/ambiguous effects = yellow; unassigned effects = grey) and the scale over which the effect was deemed to operate as defined by Sage et al. (light shade = local (part of a woodland/field); medium shade = patch (whole woodland/field); dark shade = landscape).

6. SUMMARY OF EVIDENCE AND SPECIFIC EVIDENCE GAPS

This section should be read in conjunction with Madden & Sage (2020) (p30-67) and the summary of new publications (Section 3) to obtain specific effect sizes and study details. Here, I outline the general presence and direction of ecological effects, crudely classed by the strength of evidence that underpins them as illustrated in Figure 3.

A) Reasonable Evidence

i. Direct effects of diseases on small vertebrates. This is considered to be a generally negative effect (harming non-game populations) and to operate at a landscape scale. However, the size and prevalence of the effects appear to vary across other species and sites perhaps due to differing disease strains involved (e.g. Tompkins et a. 2002, Ewald & Toureyas 2002, Anderson 2000, Millan et al. 2004, Millins et al. 2017, Welchman et al. 2013, Gortázar et al. 2006, Bertran et al, 2014, García et al. 2021).

There is currently no evidence of causal relationships between infection levels of released gamebirds and changes in populations of non-game species. The proposed study due to be conducted by APHA will explore aspects of disease prevalence and transmission involving released gamebirds and effects on non-game wildlife at European sites. Whether this will focus on mechanisms of transmission or changes in the health and/or abundance of non-game species is uncertain. An associated gap in our evidence, identified in the RSPB submission, is the environmental impacts of veterinary medicines used in gamebird feed. Finally, the role of released gamebirds in zoonotic diseases is of interest and has at least partial ecological consequences. A PhD study run from the University of Exeter in conjunction with Public Health England will investigate relationships between ticks, *Borellia*, released gamebirds and non-game bird populations. This is due for completion in 2025.

An emerging disease issue that may involve released gamebirds is Highly Pathogenic Avian Influenza (HPAI). The RSPB submission presented some material relevant to this, but detailed data is currently sparse. Data from DEFRA relating to cases at premises around which exclusion zone have been imposed (https://www.gov.uk/government/news/bird-flu-avian-influenza-latest-situation-in-england#cases) may tell us little about risks from released gamebirds as birds on premises are contained and if cases are detected, captive gamebirds at the premises will not be released but culled. Therefore, for this review, I examined the reports of wild birds reported to APHA and confirmed as being infected with HPAI (https://www.gov.uk/government/publications/avian-influenza-in-wild-birds). Such data would include released, free-ranging gamebirds. In 2022, 20 of the 736 (2.6%) locations where cases of HPAI in wild birds were reported and detected, and 86 of the 1738 (5.1%) wild birds that tested positive for HPAI were pheasants or red-legged partridges. In 2021, 4 of the 226 (1.8%) locations where cases of HPAI in wild birds were reported and detected, and 18 of the 459 (3.9%) wild birds that tested positive for HPAI were pheasants. In 2020, 0 of the 122 (0%) locations where cases of HPAI in wild birds were reported and detected, and 0 of the 277 (0%) wild birds that tested positive for HPAI were pheasants or partridges. These very coarse data are from just three years with a non-representative

collection and reporting scheme and should be treated accordingly. However, it is interesting to note that the percentage of reported infected birds that were gamebirds increased over the three years, despite the likelihood that in 2022, the numbers of released gamebirds likely fell compared to normal years (explained in Madden 2023 Introduction). It is also interesting that the percentage of reported infected gamebirds was much lower than expected given their biomass as calculated by Blackburn and Gaston (2021), suggesting that gamebirds may be either underreported or proportionately less susceptible. These two alternatives cannot currently be discriminated. Further detailed and representative data about the role that gamebirds play as vectors of HPAI is required.

ii. Direct effect of carcass availability on predators. This is considered to be a generally negative effect, with increases in generalist predators assumed to have a negative impact on populations of non-game prey, although an alternative perspective is that populations of rare predators may increase due to this supplementary food supply. The effect operates at a landscape scale. Generalist predators in the UK including foxes, buzzards, some corvids and other raptors commonly eat released gamebirds (e.g. Robertson 1988, Sage et al. 2001, Woodburn 1999, Parrott 2015, Kenward 1981) and the ~60+% of released gamebirds that are not harvested (Madden et al. 2018) are likely eaten by some scavenger or predator. However, the effects of this additional food on populations of these predators is mixed, with some evidence of local increases in fox activity at release times (Robertson 1986), increases in foxes being killed corresponding to regional increases in the numbers of gamebirds being released (Reynolds 1994), more foxes recorded on release sites in Spain compared to controls (Beja et al. 2009) and a mixture of positive linear and non-linear and a few negative relationships between indices of partridges/pheasants and buzzards and corvids (Pringle et al. 2019 – summarised in Mason et al. 2020 p124). Swan et al. 2022 found a positive relationship between gamebird abundance and buzzard territory density but concluded this was (at least partly) a result of habitat management associated with releases that altered (increased) other non-game prey populations.

The project led by the GWCT on how numbers and diet of foxes change in response to releases will provide important additional data relevant to UK release conditions and will comprise a controlled field experiment allowing this specific effect to be investigated. Similar work should be conducted on other generalist predators including raptors and corvids. Quantifying these effects and making predictions about future scenarios depends on accurate data on the numbers of carcasses available (closely linked to the scale and extent of release data).

iii. Associated effect of land management on woody plants. This is considered to be a positive effect with increased planting, management and retention of woodlands motivated by the release of gamebirds, and activity operates at a landscape scale within areas owned or managed by shoots. Concurrent negative ecological effects could arise from planting of inappropriate woodland species or planting on ecologically sensitive areas. There is good correlational evidence that land where shooting occurs has more woodland and/or hedges (e.g. Rackham 2003, Cox et al. 1996, Oldfield et al. 2003, Firbank 1999, Howard & Carroll 2001, Draycott et al. 2012). There is also survey data of landowners that indicate that those hosting shoots on their land are more likely to plant woodland (Oldfield et al. 2003, Cox et al. 1996, Howard & Carroll 2001, Short 1994) and to manage woodland via coppicing, rides etc. Short 1994, Cox et al. 1996, Capstick et al. 2019b, Hoodless & Draycott 2008). How this activity might change if releases or shooting

patterns were altered is unclear, although 45% of game managers reported that shooting was the primary motivation for planting (Ewald & Gibbs 2020) and that 59% said they would manage their land differently with 20% saying they would stop habitat management in the absence of shooting (PACEC 2006).

Whether changes in releases or shooting patterns would actually provoke these changes is unknown. This is a good example of where our lack of understanding of the motivations and behaviours of land managers, especially how their behaviour scales with release sizes and what their actions may be under alternative scenarios regarding gamebird releases, hampers our understanding of both the current extent of the effect and how tightly it is linked to gamebird releasing and shooting, and how it may change in the future. Such information is critical for robust assessment of net ecological effects both currently and modelling future scenarios.

iv. Associated effect of predator control on predators. This is, ecologically, a rather ambiguous effect, encompassing both the legal killing of predators which may benefit populations of their non-game prey that may be of conservation interest, but it also encompasses illegal killing, which may include killing predator species of conservation interest and/or of ecosystem importance. Any effects operate at a landscape scale. Game managers typically expend a lot of effort controlling predators and report increased effort over recent years (Ewald & Gibbs 2020). This control can reduce local and regional fox abundances (e.g. Reynolds et al. 1993, Tapper et al. 1996, Heydon et al. 2000, Heydon & Reynolds 2000) to levels around half the expected carrying capacity (Porteus et al. 2019), but such reductions do not occur everywhere (Heydon et al. 2000) and among a small sample of sites (n = 5) those where releases were larger had less effective fox control (Porteus 2015). Illegal predator killing, typically of raptors, is difficult to study and quantify. Most game managers perceive that raptors have a negative effect on game (including both wild and release gamebirds), but this does not necessitate that they go on to kill them to remove the effect. There is evidence of disproportionate illegal raptor killing associated with release pens in southern England (Kenward et al. 2001) and general areas (10km^2 tetrads) where driven game shooting (presumably supported by releases) is prevalent in Wales (Hughes et al. 2021). In Portugal, shooting estates that included those which released partridges, had similar numbers of raptors (apart from kestrels which were less common) as control sites (Beja et al. 2009).

I am involved in two pieces of research currently underway based on nation-wide survey data at different scales (1km and 10km grid squares) that suggest that indices of fox numbers are lower in areas where gamebirds are released compared to controls and in areas that host higher numbers of game shoots, suggesting that predator control may reduce fox numbers at a landscape scale. However, until this work is peer-reviewed and published it cannot be considered as robust evidence. An extension of Porteus' (2015) work exploring the link between release scale and predator control effort is desirable to increase the sample size to >5. Quantifying these effects and making predictions for future scenarios demands accurate data about the behaviour and motivations for gamekeepers and indeed any changes in the legal predator control options available to them currently or in the future. The RSPB submission (p8) states that they are investigating the extent of spatial associations between illegal raptor killing and gamebird abundance across the UK, due for completion in December 2022. No further details were provided and it is unclear how well the methods used will separate out relationships with wild gamebird populations and release and management sites.

v. Indirect effects of planting and management of woody plants on small vertebrates. This is considered to be a positive ecological effect with populations of these small vertebrates benefiting from improved habitats such that populations are higher in these woods or hedgerows both during the breeding and non-breeding seasons. Small vertebrates studied include both birds and mammals and therefore increases in populations of some species may be considered ecologically negative if for example they are predatory or it disrupts ecological networks. This effect operates at the patch level. The effects reported are mixed, varying with study and species considered. When comparing woods managed for game, there is evidence of higher abundance of various woodland specialist songbirds in game woods (Robertson et al. 1988, Woodburn & Robertson 1990, Robertson 1992, Draycott et al. 2008a, Sage et al 2018a,b, Hoodless et al. 2006), however, for other some species no differences were detected (Hoodless et al. 2006. Davey 2008). A range of rodent species showed fluctuations in abundances that corresponded to patterns of woodland game management, but these varied between species and across the year, with evidence of dependent changes occurring as species that benefit from management actions outcompeting other species (Davey 2008). Counts of grey squirrels did not differ between game and nongame woods (Draycott & Hoodless 2005).

Given the interest in effects of release of gamebirds on reptiles, it would be helpful to investigate how woodland management may affect those populations to complement studies on instances of direct predation of reptiles (see below). Community level effects may be important here, such that if some species thrive due to the created habitat, how do others respond, either due to changes in competition for resources or because additional (non-game) prey resources are increased. Quantifying these effects also depends on accurate data on the scale and extent of woodland planting and management, and predicting future changes in these effects again rests on robust data about future motivations and behaviours of land managers responsible for woodland management (see see section 6Aiii).

vi. Direct effect of foraging on invertebrates. This is considered to be a negative effect with reduced abundance of invertebrate fauna generally disrupting wider ecological systems such as nutrient cycling or prey for other species, or loss of particular taxa of conservation interest, although if agricultural invertebrate pests are reduced meaning lower levels of pest control this may be seen as an ecological benefit. These effects operate at the patch level. Pheasants and partridges undoubtedly eat invertebrates (e.g. Lachlan & Bray 1973, Hill & Robertson 1988, Stromborg 1979), although this is most common for gamebird chicks and laying hens (Beer 1988, Holland et al. 2006) which are not classes of birds that are released. The reported effects are mixed with studies reporting increases, decreases and no changes in abundances of various taxa depending on sites, study methods (e.g. Clarke & Robertson 1993, Neumann et al. 2015, Hall et al. 2021, Develin et al. 2021, Pressland 2009, Callegari 2006a,b). Direct predation experiments comparing rates of predation on sample invertebrates in areas with and without gamebirds reveal no differences (Clarke &Robertson 1993, Callegari et al. 2014). One explanation for the differences that are detected is that the released birds disturb the vegetation especially when the release occur at high density, and this alters invertebrate abundances (Hall et al. 2021, Clarke & Robertson 1993, Neumann et al. 2015). It seems that the strength, and even the direction, of effects are mixed.

Future work might benefit from focusing on invertebrate taxa of particular conservation or ecosystem interest, deliberately looking for population changes in rare or threatened species in sensitive areas, or changes in taxa that provide food for other non-game species, or that provide ecosystem services. It would also be helpful to understand the spatial extent of these effects – whether changes only occur in the immediate release sites or if wider effects can be detected. Given present evidence this seems less likely, but I am aware that the GWCT are conducting a review of this subject and intend publishing a paper answering this question in the near future.

B) Moderate Evidence

i. Associated effects of supplementary feeding on small vertebrates. This is considered to be a neutral or ambiguous effect operating at the landscape scale. Large quantities of food, mainly grains, are provided either directly via feeders or broadcast, or indirectly as the product of planted gamecrops (Teanby et al. 2019, Ewald & Gibbs 2020, Larkmann et al. 2015). This additional food is commonly eaten by non-game species (Sanchez-Garcia et al. 2015) and this likely explains why there this a greater abundance of birds (Brickle 1997, Caro et al. 2015, Estrada et al. 2015) at gamebird release sites where supplementary feeding occurred, with higher abundances at high densities of feeders for birds (Davey 2008) and mammals (Davey 2008, Saad et al. 2021). However, these effects depend on the distribution of supplementary feed sites (Siriwardena et al. 2006, 2007, 2008) and the size of seeds provided (Larkman et al. 2015) and for some insectivorous birds, there may be a negative relationship with feeder provision (Davey 2008).

Only a single study has so far looked at which non-game species use feeders, and more representative data on this would better indicate which species might be likely to be directly affected. Whilst local changes in abundances in response to feeding appear to be well documented, wider and longer lasting changes in populations or communities remain unexplored. It would also be helpful to understand how the spatial positioning and feeding mechanisms used (feeders/broadcast/plots) interact to alter non-game populations and what net ecological effects each of these methods generates. In order to reliably calculate regional/national scale effects it is desirable to obtain accurate data on the volume and location of supplementary feed being supplied.

ii. Direct effects of bird actions on soil, water and air. This is considered to be a negative effect operating at the patch scale. Released gamebirds, especially at high densities may cause physical damage to soil structure and alter the nutrient chemistry of the soil and local air shown by differences between release and control sites (Sage et al. 2005a, Capstick et al. 2019a, Alsop & Goldberg 2018) which may persist for years when stocking densities have been high (Capstick 2019a). These effects may explain differences in lower flora (lichens and bryophytes) (Bosanquet 2018, Sage et al. 2018a,b, Rothero 2006, Smith 2014) but such differences are not ubiquitous and may be restricted to areas immediately at or around release sites with effects declining rapidly with distance (GWCT submission material, Sage et al. 2018a,b).

Most studies of this issue are poorly controlled, often documenting observations at a single site, making it hard to isolate effects due to the released birds themselves and results appear to be somewhat contingent on the densities of releases. A more rigorous exploration of the mechanisms and outcomes of soil and nutrient changes is desirable and is one of the proposed studies to be commissioned by DEFRA.

iii. Indirect effects of planting and management of woody plants on invertebrates. This is considered to be a positive effect operating at a local scale. Changes to woodland edges or increases in these areas through creation or maintenance of rides and these might explain why higher numbers of butterflies (but not bumblebees) are found in areas of woodland managed for game (Robertson et al. 1988, Woodburn and Sage 2005, but see Capstick et al. 2019b for null effects). Therefore, the effect seems to vary according to species of interest and site location suggesting that the effect is not a general one.

Given the limited number of studies, further work is required to confirm this and consider a wider range of invertebrate species that may be affected by increased woodland edge management. Some aspects of this may be addressed in the proposed study to be commissioned by DEFRA. As for the direct effects of predation on invertebrates, it may be helpful to focus on taxa of conservation interest and/or ecosystem importance. As with other indirect effects, making predictions about future scenarios is dependent on behavioural and motivational data from land managers (see see section 6Aiii).

iv. Associated effects of land management on non-woody plants. This is considered to be a positive effect with increased planting and management of game crops, buffer strips and headlands motivated by the release of gamebirds, and the activity operates at a landscape scale within areas owned or managed by shoots. Concurrent negative ecological effects could arise from planting of inappropriate species or planting on ecologically sensitive areas. Planting game crops is common on land managed for shooting, with typically several acres being planted per shoot (Ewald & Gibbs 2020, PACEC 2006) but uncommon elsewhere (Teanby et al. 2019, Howard & Carroll 2001, Ewald & Gibbs 2020) and leaving field margins may include a reduction in use or increased selectivity of chemicals (Howard & Carroll 2001). Such planting may result in cropping patterns more similar to historic patterns of agriculture with small, mixed units of management compared with large monocultures often seen in contemporary farming (Sage et al. 2018a,b).

The motivations to plant such game crops may extend beyond shooting and game management, and this requires more detailed exploration as does a robust quantification of the areas of planting and the (mixes of) species involved. It is also unclear how motivation to plant might alter with different patterns of releases and shooting. Future work should capture the current extent, scale, locations and precise plant mixes of game crops so that larger-scale (regional/national) ecological effects can be calculated. Making predictions about future scenarios is dependent on behavioural and motivational data from land managers, so this should be collected.

v. Direct effects of bird action on woody/non-woody plants. This is considered to be a negative effect operating at the local scale. Most obviously the birds may trample plants, changing abundances or community compositions, depending on the tolerance of the plants to damage and palatability. These effects may be seen at release pens, where plants differ from those seen at sites further away (Sage et al. 2005a, Sage et al. 2018a). Effects may also be seen in hedges frequented by gamebirds with stretches close to release pens differing from those further away (Sage et al. 2009, but see also Draycott et al. 2012 who did not detect these differences).

One less explored aspect of these effects in the UK is that the gamebirds may serve as seed dispersers (Swank 1944, Case et al. 2022). Additional evidence regarding this effect may arise from the proposed study to be led by DEFRA, with a focus on European sites.

vi. Direct effects of foraging on small vertebrates. This is considered to be a negative effect operating at the patch level. There are a number of anecdotal descriptions of gamebirds eating or injuring reptiles (summarised in the ARC submission), but reptile remains have not been detected in dietary studies (Dalke 1935, Fried 1940, Wright 1941, Stromborg 1979, Whiteside et al. 2015, Dimond et al. 2013) although many of these studies focused on birds during the shooting season (October-January) when reptile activity, and hence encounters with gamebirds, is likely low. Gamebirds may predate (model) reptiles (Berthon 2014, Duchesne et al. 2022), but predation rates by mammals is about three times higher than predation by all birds (including corvids and raptors as well as gamebirds) and sites where pheasants were recorded did not exhibit higher rates of bird predation than sites where they were not recorded (although this was not a primary analysis of the paper and the study design was not set up to explicitly test this hypothesis) (Duchesne et al. 2022). Numbers of reptile species were higher at sites where gamebird releases did not occur (Berthon 2014, Graitson & Taymans 2022), and for one focal species, numbers increased at a site after releases there had ceased (Graitson & Taymans 2022). The small and unbalanced sample sizes for these two studies (see see section 3Aiii) and the differences in both reptile species and release and management behaviour between Belgium and Wales mean that it is uncertain whether effects would be robustly replicated in the UK.

The PhD based at DICE is explicitly designed to gather evidence about this effect and hopefully also consider whether associated management practices also affects reptile abundance, perhaps by altering disturbance levels or habitat structure at release sites compared to controls. This means that net ecological effects may be negative (if predation is common and changes to the habitat are damaging) or positive (if predation is rare and habitats are improved to favour reptiles).

vii. Indirect effects of planting and management of non-woody plants on small vertebrates. This is considered to be a positive effect operating at the landscape scale. Planting of game crops and buffer strips creates habitats that are attractive to a range of farmland bird species (Stoate et al. 2003) and abundances of these birds is typically higher in these planted areas compared to unplanted areas (Sage et al. 2005b, Parish & Sotherton 2004, Henderson et al. 2003). Most of these studies focused on overwinter numbers, but the effects of winter game crops persisted, increasing breeding populations of resident songbirds the following spring (GWCT submission).

It is desirable to understand whether these gamecrops provide additional habitats for birds and hence boost overall abundances and/or breeding success or whether they serve as sinks meaning that only temporary abundance increases are recorded at them. It is also desirable to explore how they may affect abundances of other species such as rodents or herptiles and affect community structures. A better understanding of which species are affected would help determine the net benefits of the activity, e.g. setting increases in ‘pest’ rodents against increases in ‘desirable’ farmland bird species of conservation interest. As with other indirect effects, making predictions about future scenarios is dependent on behavioural and motivational data from land managers (see see section 6Aiii).

C) Weak Evidence

For other effects, the current evidence is weak. This may explain why for some such effects including the *Associated effects of disturbance on small vertebrates*, the *Direct effects of foraging on non-woody plants*, the *Associated effects of disturbance on soil, water and air* and the *Associated effects of land management on soil, wate and air*, the direction of the effect is unknown. For example, without knowing how releases and management alter access to the land and patterns of activity on it, it is not possible to assume whether there is reduced disturbance, likely improving conditions for small vertebrates or reducing traffic and associated physical damage, or if the actions of the game managers and guns increase disturbance. In order to consider these, we require more detail about the behaviours of the land managers, guns and general public in areas where releases occur and an understanding of how these behaviours might change in relation to changes in release activity. Such data would also improve our understanding of the *Associated effects of shooting on small vertebrates*, allowing quantification of what non-game species may be killed, either intentionally or unintentionally during the shooting of released gamebirds. Currently, there has been some attention paid to shooting of wild game (grey partridges) with released game (Watson et al. 2007), but effects on other species are poorly understood. The *Direct effects of genetic disruption of wild populations* in the UK are unlikely to be an issue of ecological concern because pheasants and partridge are not native species (being naturalised) and thus the genetic integrity of wild-breeding populations is not considered of conservation interest. Data from Europe suggests that for partridges, released birds do not lead to high levels of introgression in wild populations (Forcina et al. 2021). This effect currently does not warrant further research in the UK. The *Indirect effects of planting and management of woody plants on other plants* may include increasing abundance or diversity of other species due to coppicing, ride creation or sky-lighting (Draycott et al. 2008a, Woodburn & Sage 2005, Capstick et al. 2019b), all of which may be considered to be positive and operating at a local scale, but evidence currently varies across sites/studies and we have little data on effects on particular species making it hard to unravel whether the ecological effects are positive (boosting species of conservation or ecosystem interest) or negative (reducing such species and boosting common generalists). Additional evidence regarding this effect may arise from the proposed study to be commissioned by DEFRA. The *Direct effects of competition on small vertebrates* considers released gamebirds as competitors for limited resources used by non-game species such as food (grains or invertebrates) or habitat patches. The presence, direction or scale of these effects is uncertain. The effects of gamebirds on invertebrate populations is mixed (see see section 6Avi).and attention has not been paid to effects on particular taxa that are important food for non-game species. Likewise, although the dietary overlap between pheasant chicks and the young of three farmland birds of conservation concern has been quantified (Mason et al. 2020), with a focus on invertebrates, pheasant chicks are not released and the diet of 6-10 week old poults is markedly different to that of chicks comprising much higher percentages of grain, so it is not clear what such overlap means in release areas where natural breeding populations are low. Crucially, there have not been any studies of changes in growth, survival or breeding of non-game species in areas with and without releases where such competition may manifest. This constitutes a clear knowledge gap.

7. GENERAL KNOWLEDGE GAPS

A) Locations and Scale of Releases

The uncertainty in the numbers of gamebirds being released annually in the UK, evident both from the range of figures submitted as part of this NRW assessment (14.8 million – RSPB submission; 61.2 million – League Against Cruel Sports submission). The current data on where, and how many, gamebirds are being released is poor. Attempts have been made to estimate total annual release numbers (Aebischer 2019, Madden 2021), but these methods generate very large confidence intervals indicating a high level of uncertainty in the values presented. Crucially, they do not attempt to estimate where releases occur. Knowing where releases occur and at what levels is critical for a) analysing current effects of gamebird releases and calculating net ecological effects, and b) predicting future effects under differing scenarios. I attempted to map out release sites in Wales (Madden 2023) but although regions of high and low levels of releasing could be identified, it was not possible to accurately extrapolate or interpolate from existing data. This is because there appears to be poor compliance with the APHA Poultry Register which should contain these data. I estimated that, in Wales, 29-73% of shoots comply with the register. Improving our knowledge of where and how many gamebirds are released is vital for both our current understanding and future planning.

The simplest method to fill this knowledge gap is to increase compliance with the APHA Poultry Register. To achieve this, it may help to understand why shoots do not comply and whether this is due to ignorance of the requirement, complications or misunderstanding in the registration process, or deliberate avoidance. The resulting data should also be kept up to date, especially as patterns of releases appear to be changing over recent years due to e.g. COVID and HPAI. This will provide accurate data for future studies. In order to explore historic relationships, which would be helpful to better understand ecological effects and temporal patterns, it is necessary to develop better estimates and ways to extrapolate/interpolate the available incomplete data. This may be possible through a variant of Species Distribution Modelling in which known release sites are used to develop parameters that define where releases likely occur so that new candidate sites can be identified and the model accuracy checked by site inspections.

B) Networks of Effects

All three 2020 Reviews concluded that determining the net ecological effects of releases as being either positive or negative was complicated and required an understanding of the complex web of socio-ecological interactions between the birds, their keepers and the rest of the ecosystem. Although such ecological accounting may be difficult, it is critical, because release and subsequent landscape management likely affects a large part of the lowland Welsh landscape and therefore any consequences of either maintaining or altering release practices are likely to have national implications for biodiversity. The birds exert a series of Direct Effects on the ecosystems where they are released. Such releases motivate game managers to exert Associated Effects on the ecosystem via management. Further Associated Effects may accrue through the actions of ‘guns’ (shooters). These direct and associated effects have downstream consequences for the ecosystem, further altering habitats and wildlife through a series of Indirect Effects operating on the web of interactions between non-game fauna and their habitats. We can now make some

reasonable assumptions about the structure of the ecological web incorporating released gamebirds (Fig 4). However, the scarcity of empirical data for many web-links (see see section 6), and our ignorance of social factors underpinning releases and feedback-loops between the ecological effects and subsequent release behaviour (see see section 7C) mean that accurately modelling the consequences of perturbation of one element within the network for the rest of the ecosystem is currently difficult.

In order to calculate net ecological effect of this activity, it is necessary to consider how perturbations of one part of this network lead to changes elsewhere (see e.g. Lees et al. 2013). Analytical methods exist to allow this and they can incorporate both the ecological and social dimensions of the network (Ulanowicz 2004, Sayles et al. 2019). The evidence presented above (see see section 6 and specific detail in Madden & Sage 2020) can be used to parameterise many of the links and in doing so it will become clearer what key links we lack data for, which will focus future research efforts and prioritise knowledge gaps. However, the data that we do have is often based on single locations or systems and with evidence of variation in effects between sites/studies (e.g. Woodburn & Sage 2005, Heydon et al. 2000).

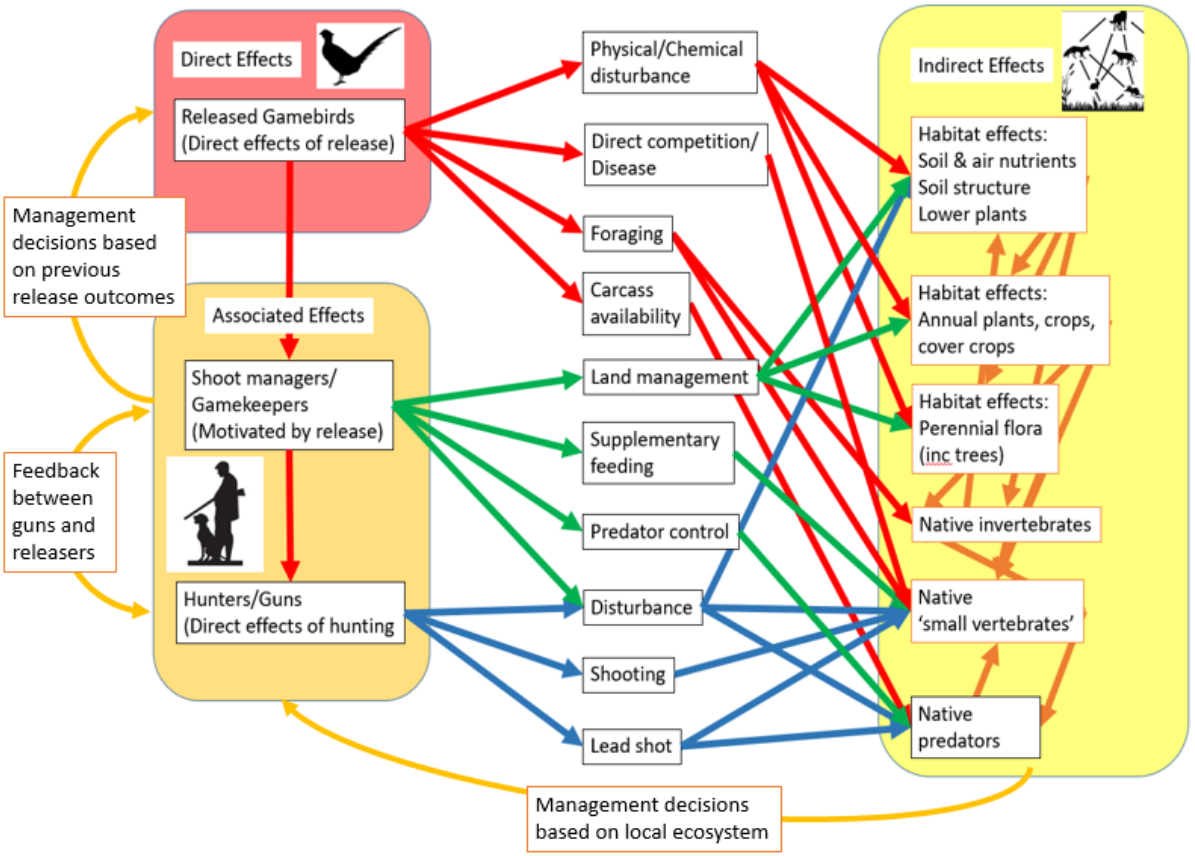

Figure 4. The network of effects simulated by the release and management of gamebirds for shooting in the UK. Effects of the birds themselves are shown in red, those of the gamekeepers in green, and of the hunters in blue. Feedback loops within the socio-ecological system are shown in yellow with game keepers responding to ecological factors and in turn altering their release and management behaviours.

C) Human Behaviour

The release of gamebirds for shooting constitutes a long-standing and deeply rooted ecological and cultural influence on the rural UK landscape. Their release and management is a human-driven activity and so understanding the human dimension is crucial, especially if one is trying to predict future scenarios in which advisory or legislative changes are envisaged. This integration of human behavioural and economic factors with ecological systems constitutes a social-ecological system, and these are now the subject of detailed research (Liu et al. 2007, Colding & Barthel 2019). Our understanding of the human dimension of gamebird release and management is very limited. Knowledge of land managers motivations is based on localised basic interview and questionnaire work (e.g. Cox et al. 1996, Howard & Carroll 2001, Oldfield et al. 2003, Greenall 2007) often conducted nearly 20 years ago (but see Swan et al. 2020, Ewald & Gibbs 2020) in an economic and cultural climate very different from that experienced today or likely post-Brexit when incentives for agricultural land management may differ from those currently available. Almost nothing is known, quantitatively, of the behaviour and motivations of guns involved in shooting in the UK (but see Hillyard 2016) or of users of the countryside not involved in or opposed to such recreational shooting. This is in strong contrast to a literature documenting and quantifying the attitudes and behaviours of similar stakeholders in Europe and North America including both the hunters (e.g. Kaltenborn et al. 2012, Ghasemi & Kyle 2022), land managers (e.g. Delibes-Mateos et al. 2021) and the non-hunting public (e.g. Gamborg et al. 2016, Gamborg & Jensen 2017). Our ignorance of the socio-ecological aspects of gamebird release within the UK is also in stark contrast to our knowledge of similar questions regarding shooting of native wild gamebirds (red grouse *Lagopus lagopus* and grey partridge *Perdix perdix*) (e.g. Sotherton et al. 2009, Dunlop & Smith 2010, Potts 2012) despite these activities occurring over much smaller areas and involving fewer people. This knowledge gap was repeatedly highlighted in the RSPB submission. Several other submissions presented data or highlighted other studies on socio-economic or social health aspects of gamebird release, management and shooting. These were not considered in this review because they did not focus directly on ecological effects.

D) Conditions Specific to Wales

In the RSPB submission, the authors argue that Wales differs from the rest of the UK in the land types over which shooting occurs and the motivations for land management. Specifically, they point out that the area of arable farming in Wales is small (2.4-3%) and thus the benefits of game management associated with farmland that have been reported in the previous reviews may not apply and that a smaller percentage of the woodland in Wales is managed for shooting compared to the rest of the UK. Further, they suggest that fox control in Wales is to a large extent a consequence of livestock (sheep) farming rather than game management and thus the part that game management plays in fox control in Wales is currently difficult to determine.

It is not clear exactly how different gamebird release and management in Wales is from that in other areas of the UK. Madden (2023) concluded that shoots in Wales were generally similar in release sizes and distribution of shoot sizes to those in England and Scotland, although they released relatively fewer partridges and had a higher mean, but not median release size, suggesting that in Wales there may be relatively more very large and very small shoots. Future work could explore how the habitats on shoots in Wales

matches or differs from that seen on shoots in the rest of the UK. This would indicate whether the ecosystems or species are likely to match those about which we have more evidence and thus whether the effects that we currently understand are likely to apply in Wales. Future work could also investigate whether the motivations and behaviours of Welsh landowners, game keepers and guns differs from their broader UK counterparts.

Of the 82 effects that could be based on highly relevant literature in Madden & Sage 2020, ten (12.2%) included data from Welsh sites (Amar et al. 2006, Corke 1989, Devlin 2021, Duckworth et al. 2003, Firbank et al. 1999, Madden et al. in prep, Porteus 2015 – 2 effects, Pringle et al. 2019), although only one of these (Devlin 2021) was solely focused on Welsh data with the others all taking nationwide survey approaches which included sites in Wales. If only UK studies are considered (n = 67) then these percentages increase to 14.9% of studies. While this presents a very limited Welsh-specific dataset on which to draw conclusions, it should be noted that it may not indicate an underrepresentation of work in the nation, given that 3.4-6.9% of lowland gamebird releases and shooting in the UK likely occurs in Wales (Madden 2023). Of the publications arising since Madden & Sage 2020, (see see section 3), 11 of which related to specific ecological effects, two papers (Hughes et al. 2022, Devlin et al. 2021) are specific to Wales.

E) Summary of Planned Future Work

The Three 2020 Reviews all highlighted a series of key knowledge gaps (see see section 2B and Table 3) and in response to these, a number of pieces of work have been started. The submissions to NRW reveal that there is a large and broad body of work that is highly relevant to this topic which is underway (Table 4). Some of this has been commissioned by DEFRA with a particular focus on effects on European Sites in England, while other work has been commissioned by interested organisation and charities (RSPB, BASC, GWCT, ARC), or is being conducted with or by university researchers. This work will greatly increase our knowledge about the scale and extent and ecological effects or gamebird release and management and allow us to more accurately predict net ecological effects arising in future scenarios, permitting more robust and reliable conclusions to be drawn. Although little if any of the work is solely or specifically focussed on Wales, the findings are likely to be highly applicable and relevant to any future decision making.

Topic of Study	Researcher	Expected date of completion	Source
The scale of releasing on and around European Sites in England	APHA	?	DEFRA announcement
The dispersal behaviour of gamebirds released on and around European Sites	Likely University of Exeter, APHA, BASC, GWCT	2024	DEFRA announcement
The impact of gamebird releasing on soil nutrients and ground flora on and around European Sites	NE	Early 2025	DEFRA announcement
The extent of gamebird's predation on reptiles, amphibians and invertebrates	PhD study. University of Kent, RSPB, ARC	2025	DEFRA announcement
Interactions between released gamebirds, wildlife within European Sites and pathogens/parasites	APHA	?	DEFRA announcement
The influence of released gamebirds on local predator populations	GWCT?	?	DEFRA announcement
Questionnaire survey of managers of protected areas	RSPB	End 2022	RSPB submission p8
Investigation of the extent of spatial association between raptor persecution and gamebird abundance across the UK	RSPB	End 2022	RSPB submission p8
Gamebirds and fox study. Do release sites have more fox activity than other sites across the year	GWCT	Early 2024	GWCT submission p4
Released gamebird distribution	GWCT	Late 2023	GWCT submission p4

Review paper covering releasing and invertebrates	GWCT	Early 2023	GWCT submission p4
Exmoor game cover/hedgerow bird study	GWCT	Late 2022	GWCT submission p4
Relationships between releasing and other wildlife including foxes based on NBN data	University of Exeter	Mid 2023	GWCT submission p4
PhD on ticks, *Borellia* and game management	University of Exeter	2025	GWCT submission p4
New Value of Shooting Report	BASC and other shooting organisations	Mid 2023	BASC submission p23
Collection of new data on released gamebird distribution in relation to release points	GWCT	2024	BASC submission p15
An analysis of the economics of late season shooting and how this affects release numbers	GWCT	End 2023	BASC submission p15

Table 4. Ongoing research relevant to the understanding of the ecological effects of gamebird release and management. Submission refers to evidence received as part of the NRW call for evidence.

8. SUMMARY AND CONCLUSIONS

This review updated the evidence base about the ecological effects of release and management of gamebirds for recreational shooting that had been collated and explored in three reviews from 2020 (Madden & Sage 2020, Mason et al. 2020, Sage et al. 2020). It found 11 pieces that had been published in the last two years (although the key results from three of these had been included in earlier reviews as PhD or MSc theses), as well as four publications detailing the scale and extent of releases in the UK and three reviews that consider what is known about ecological effects while adding little if any new material. It also examined eight institutional submissions made to NRW in response to their call for evidence about this activity in Wales which included 3 further new pieces of relevant evidence and a series of anecdotes. This new data was classified as to its relevance, direction of effects and spatial scale of the effects using methods deployed in the earlier reviews such that the new evidence could be integrated with the existing evidence. I followed the classification of ecological effects used by Madden & Sage (2020), meaning that I considered 22 separate effects arising from the release of pheasants and partridges,

broadly separated into Direct Effects (those arising from the activities of the released gamebird's themselves), Associated Effects (those arising from the management actions of land owners, gamekeepers and guns that accompany the release of gamebirds), and Indirect Effects (those effects occurring to habitats or wildlife because of the actions of the birds or game managers). I encountered 224 pieces of evidence (there may be multiple pieces of evidence per paper or publication) of which 80 were highly relevant, 75 moderately relevant and 69 weakly relevant.

I found reasonable evidence to support our understanding of six ecological effects including:

- Direct effects of diseases on small vertebrates;
- Direct effect of carcass availability on predators;
- Associated effect of land management on woody plants;
- Associated effect of predator control on predators;
- Indirect effects of planting and management of woody plants on small vertebrates and;
- Direct effect of foraging on invertebrates.

I found moderate evidence to support our understanding of seven ecological effects including:

- Associated effects of supplementary feeding on small vertebrates;
- Direct effects of bird actions on soil, water and air;
- Indirect effects of planting and management of woody plants on invertebrates;
- Associated effects of land management on non-woody plants;
- Direct effects of bird action on woody/non-woody plants;
- Direct effects of foraging on small vertebrates and;
- Indirect effects of planting and management of non-woody plants on small vertebrates.

There was only weak evidence for the other 9 effects.

A) Summary of Results

Despite the welcome new evidence that has accrued over the past two years, the general conclusions from the three 2020 reviews remain relatively unchanged. The broadly agreed position is that: a) the management actions motivated by the release of gamebirds, including habitat creation and maintenance, legal predator control and supplementary feeding generally have ecological effects that are considered beneficial and which may affect habitats, flora and non-game wildlife over a landscape scale; b) the direct actions of the released birds, including the changes that they cause to nutrient levels, floral and invertebrate communities, their role as disease vectors and the additional food their carcasses provide for predators and scavengers generally have effects that are considered negative with many of these operating at a local or patch scale, but some having wider consequences; c) these management actions and the actions of the birds occur within a complex socio-ecological network and in order to understand the net ecological effects of this activity it is important to understand the indirect effects that arise from the interactions between the birds, wildlife, habitats and the land owners, gamekeepers and guns who participate in the activity.

B) Focus on Wales

There is currently rather little data that is exclusively focussed on gamebird release and management in Wales. However, it appears that the size distributions and scales of release seen in Wales are similar to those seen in the rest of the UK, so it may be feasible to use data gathered in the rest of the UK to make informed decisions about the activity in Wales. This equivalence may be difficult if the habitats where shoots operate in Wales differ markedly from those typical in the rest of the UK, for example not operating in arable areas or being predominantly on uplands. A visual inspection of the known distributions of shoots in Wales shows that they mainly occur in the east of the country on the English border, but a formal analysis of habitats occupied by shoots in Wales and the UK would confirm whether they need to be treated differently in any formal analysis or modelling of ecological effects. Given the extensive investments of time, money and effort necessary to run the kind of large-scale, long-term field studies that might be needed to just replicate existing studies from the rest of the UK, careful consideration should be given to the cost-benefit trade-off of requiring additional work specific to Wales.

Areas where we might expect to find the greatest difference between Wales and the rest of the UK in the activity include: a) the agricultural and environmental financial incentives and legislation that govern the land where releases and shooting occur, and how these may shape the motivations and actions of landowners and gamekeepers; b) the greater reliance on pheasants over partridge as released quarry and hence both the differences in habitats where each species is typically released (pheasants = woodland, partridges = arable ground) and whether there are marked differences in the habitats where releases occur in Wales compared with the rest of the UK; c) the general differences in agricultural land use in Wales compared to the rest of the UK and whether this provides a different set of incentives and motivations for landowners to engage in activities such as habitat management or predator control and whether it produces a different set of ecological communities to those seen in the rest of the UK which might respond differently to the release and management of gamebirds.

C) Knowledge Gaps

The three 2020 Reviews commonly identified a series of knowledge gaps in the evidence required to assess the current ecological effects of gamebird release and management, and which are necessary to robustly model and predict the ecological effects of future scenarios arising from either legislative changes or large-scale societal or ecological changes (e.g. COVID, HPAI, climate change). These have stimulated some new published work (see see section 3) and an ongoing collection of studies that promise to make an important and exciting addition to this evidence base (Table 4). Several have been carefully designed as large-scale field experiments across replicated sites, essential for untangling the various interlinked ecological pathways that may explain and confound the relationships between releases, management and ecological effects. Incorporating these anticipated findings that address known knowledge gaps with the existing evidence base will likely markedly improve our understanding of net ecological effects. Even with this forthcoming work, there are still likely to be gaps in our knowledge about the size, direction and ubiquity of (some) individual effects, a deeper understanding of the human motivations underlying release and management, some quantification of how effects scale with the numbers of birds being released and managed, and how the activity may change in the near future due to changes in public opinion, legislation or unexpected factors such as COVID and HPAI. These knowledge gaps demand rapid and concerted attention. Further, much of the established body of work that is currently available is over a decade old and collected under social, legislative, agricultural and environmental circumstances rather different to those encountered today or likely to pertain in the future. An updating of our knowledge of effects under current circumstances is highly desirable. This will provide a robust and current evidence base upon which to devise and update advice and legislation relating to gamebird releases, facilitating a balance of public and private interests with the protection and enhancement of natural capital, ecosystem services and biodiversity preservation.

D) Conclusion

Our understanding of the ecological effects of the release and management of pheasants and partridges for recreational shooting in the UK is growing. It is encouraging to see 18 new publications since the three 2020 Reviews were published, comprising an almost 17% increase in the available literature in two years. It is also encouraging to see the large number of studies that have started since 2020 with the explicit intention of addressing the knowledge gaps identified in those reviews, and to hear of other datasets mentioned in the evidence submissions to NRW that sound relevant. This new material will improve our understanding of the net ecological effects that arise from the actions of the released birds themselves, the actions of people involved in their management and hunting, and the resulting indirect effects that these actions have via a wider socio-ecological network. Understanding these effects is imperative, given that they involve the annual release of some tens of millions of birds, and reportedly influence the management of two-thirds of lowland rural UK, and from a social perspective provides economic stimulation of perhaps many millions of pounds especially in rural areas (PACEC 2014). Within Wales, these values are smaller, but still constitute an important influence on the habitats and wildlife of the nation. By combining the existing, established body of work on the ecological effects of gamebird release and management with the recently published and forthcoming evidence, our ability to understand current ecological effects and predict the ecological

consequences of changes in future scenarios with changed legislative, social or environmental conditions can be greatly improved. By using this enhanced understanding to inform management advice, legislation and policy there is a greater chance of achieving net positive ecological outcomes for the habitats and wildlife influenced by the release and management of gamebirds in Wales, and the UK more broadly.

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