Identifying and prioritising conflicts between human and wildlife interests in Great Britain

Kate L. Palphramand[1]*, Dave Cowan[1], Daniel A. Warren[1] & Graham C. Smith[1]

[1] Animal and Plant Health Agency, York, YO41 1LZ, UK

*Corresponding author

E-mail: kate.palphramand@apha.gov.uk (KP)

© Crown Copyright 2025

Abstract

We reviewed the scientific literature to identify human-wildlife conflicts associated with British terrestrial mammals to summarise their magnitude and, where possible, costs. Conflicts were classified as either economic, health, environmental or social, further divided into 32 subcategories. We applied a Generic Impact Scoring System (GISS), whereby individual conflicts were scored on a scale of 1-5 (minimal to highest known impact); these were used to determine the potential impact (sum of all conflicts) and actual impact (sum of all conflicts corrected for geographical distribution) of individual mammals so they could be ranked on their level of impact. Forty-eight mammals were involved in a total of 200 separate conflicts. The highest ranked conflicts (scoring 5) were all measurable on an economic scale (involving rabbit, badger, brown rat and grey squirrel). We estimated a conservative annual economic cost of human-wildlife conflicts in excess of £0.5 billion, which could exceed £1 billion if health and environmental conflicts could be monetarised. The most common conflicts were health related (reservoir of disease and zoonotic disease), although generally, health conflicts were scored low (mostly 1 or 2). Overall, there was no statistical difference in impact score depending on status (native or non-native); however, when considered by subcategory, non-native species scored higher in relation to damage to woodland, agricultural interests and property, and reservoir of zoonotic disease, whilst native species caused more conflict with construction and development, and predation of livestock. Non-native species had a higher potential impact score compared to native species, but not actual impact. However, actual impact was predicted to increase, relative to population size, at a higher rate for non-native species compared to native, highlighting the need for surveillance and monitoring. Where mammals represent a cost to some, they may provide a benefit to others, e.g. fox predation of rabbits, and

© Crown Copyright 2025

as such may require a holistic approach to management. We concluded that a GISS approach is a useful tool for identifying conflict species and could form part of a package of measures to ensure a balance between the need to conserve and enhance biodiversity, whilst also considering the interests of those directly affected by human-wildlife conflict, is achieved.

Introduction

Co-habitation between humans and wildlife occurs on more than half of the earth's surface [1] and consequently human-wildlife interactions form an integral part of many ecosystems worldwide. Interactions between people and wildlife are often varied and complex and whilst the presence of wildlife may have beneficial impacts on human interests, there is a continued focus on conflict narratives that dominates how human-wildlife interactions are viewed [2].

Human-wildlife conflict is commonly described as conflict occurring between people and wildlife [3], presence and/or actions of humans or wildlife that have an adverse effect on the other [4] or threats posed by wildlife to economic activities, human life, recreation [5] or ecosystem services. Factors such as the intensification of agriculture and increasing human population have had major impacts on ecosystems worldwide [6]. Agricultural growth is expected to accelerate, resulting in an increase in farmland and subsequent decrease in the available habitat for wildlife [7]. Wildlife damage to crops is often cited as a major global conflict [3, 8, 9], which will continue to worsen as habitat loss precipitates an increase in human-wildlife encounters. Population growth and habitat encroachment may also increase the risk of disease transmission, which is of particular concern where wildlife pose zoonotic risks. For example, the first human cases of severe acute respiratory syndrome coronavirus (SARS-CoV) in Guangdong province, China, in 2002, were linked to wildlife found at a live animal market [10, 11]. Subsequent serological surveys from residents living close to bat caves in Yunnan, China,

© Crown Copyright 2025

which is geographically disparate to Guangdong, were found to be positive for SARS-related coronavirus (SARSr-CoV), indicating that spillover events may have occurred in zoonotic CoVs [12].

Conflict issues can arise with several types of problematic species, including native pests, invasive native species and invasive non-native species [13]. These often induce debates on how or whether humans and wildlife can co-exist [7], and may involve complex decisions where the conservation status of a species conflicts with its impacts on humans [3]. Addressing and categorising the adverse effects of human-wildlife conflicts is recognised as a challenging issue for conservation and development efforts [14]. There is a general consensus that the negative effects created by some wildlife species, particularly invasive non-native species, have to be reduced [15]. Where conflicts arise between wildlife and human interests, there is often the need to intervene to reduce or mitigate the impacts and therefore identifying what conflicts are occurring and what their impacts are is essential for informing decision-making and resource allocation [16]. In 2022, the UK agreed to a global policy framework at the Conference of Parties (COP15) to the Convention on Biological Diversity that created a package of international measures to address the loss of global biodiversity and to restore natural ecosystems. One of the targets identified for reducing threats to biodiversity was managing human-wildlife conflicts, which in turn would feed into other elements of the framework, such as enhancing sustainability in agriculture, fisheries and forestry [17]. However, identifying which species are causing conflict and subsequently which should be targeted first can be challenging and controversial [15].

Invasive non-native species are a major threat to biodiversity worldwide, severely impacting areas of high endemism [18], whilst also posing a serious threat to public health and

© Crown Copyright 2025

economic activities. As of 2019, 3,224 plants and animals had been introduced to Great Britain, costing the UK economy almost £4 billion annually [16]; 10-15% of these are considered invasive with an estimated 188 invasive non-native animals recorded in 2020 [19]. Tackling invasive non-native species is a key part of achieving the UK government's aims under its 25-year Environment plan [20] as well as the UK's obligation as a signatory of the Convention on Biological Diversity (https://www.cbd.int/convention/text/). However, even managing conflict caused by invasive non-native species can be controversial, resulting in debates on achievability, efficiency, social fairness and ethical implications [21]. For example, the removal of hedgehogs from South Uist, where they were introduced to control garden pests but consequently contributed significantly to the decline of wading shorebirds [22] resulted in widespread criticism and opposition, given that hedgehogs are a popular icon of British wildlife and are thought to be declining nationally [21].

Much of the available literature on wildlife conflicts in the UK, both in terms of economic and biodiversity impacts, focuses on invasive non-native species [e.g. 16, 23]. However, there is evidence to suggest that the most invasive non-native species are not necessarily the most damaging [24, 25], therefore there is the need to consider also the impacts of native species, some of which can cause considerable human-wildlife conflict. For example, badgers are a known reservoir host of *Mycobacterium bovis*, the causative agent of bovine tuberculosis, which poses a risk to livestock health and is a serious economic problem for the UK cattle industry [26]. Issues such as this highlight the challenge of conflict resolution for iconic British species, which can be both controversial and associated with complex legislative considerations. It is necessary, however, to consider all problematic species to address the UK's commitments to improving biodiversity as part of government plans or global policy frameworks.

© Crown Copyright 2025

Whilst policy frameworks are essential for providing goals and targets to reverse biodiversity loss, they do not necessarily incorporate a process by which these targets, such as managing human-wildlife conflict, can be identified in the first place, nor which should be prioritised. Assessing conflicts between species is further complicated by the fact that impacts are context dependent [27], which requires that the measure of impact is standardised to quantify and compare differences between species, taxonomic groups and localities [28]. When addressing the biodiversity impacts of invasive non-native species, Nentwig et al. [15] suggested prioritising actions against the alien species with a high impact potential of becoming established or spreading, using a method to quantify impacts in a way that could be compared among alien species within a taxonomic group. They devised a generic impact scoring system (GISS) to compare relevant impact categories that had been reported in the scientific literature, applying a scoring system to quantify impacts within the categories and rank species according to their impact scores. The GISS has since been modified and applied to a variety of classifications including alien fish [29], terrestrial arthropods [30], aquatic invertebrates [31], plants [32, 33] and alien birds [34].

The main aim of this paper was to identify and categorise human-wildlife conflicts associated with British mammals in order to summarise their magnitude and, where possible, their costs. The research augmented a review of human-wildlife conflicts produced over a decade ago (APHA, unpublished data) in response to a now withdrawn Defra policy framework on Wildlife Management in England [35]. Only terrestrial mammals (including bats) were assessed as they involve some of the most controversial and sensitive issues as well as complex legislative considerations. To determine whether the available evidence reflected the level of risk to human interests, or the welfare or conservation status of an affected species, a modified GISS was applied to all conflicts so that mammals could be ranked according to their

© Crown Copyright 2025

level of impact. Identifying species with the highest impact scores has the potential to assist policy development by enabling prioritisation of the most damaging species. In addition, the compilation of a comprehensive audit of British wildlife conflicts highlights where further areas of research might be required and identifies the early emergence of potential issues.

Materials and methods

Literature searches and screening

Searches were undertaken using Scopus (an abstract and citation database of peer-reviewed scientific literature) for literature published up until and including 2024. Additional searches were conducted using Google Scholar limited to the first 200 returns [36] to provide additional evidence where required. Separate searches were carried out for each of the 66 terrestrial mammals incorporating a combination of unique species terms and common keywords within the title, abstract and keywords of the scientific literature. The following search terms were applied to each species: [{common name} AND {Latin name}] AND [{England} OR {Scotland} OR {Wales} OR {Great Britain} OR] AND [{conflict} OR {pest} OR {damage} OR {impact} OR {management} OR {disease} OR {zoono*} OR {animal health} OR {health} OR {conservation} OR {predat*}]. The minimum requirements for a literature resource to be included in the analysis were the presence of an accessible abstract and that the conflict occurred in Great Britain. Only articles written in English were included.

All articles returned during an individual search were subjected to a number of screening processes. A rapid first screening of the title assessed documents for any likely relevance to the species concerned and its potential conflicts. All potentially relevant articles or ambiguous titles were screened further by examining the abstracts in more detail or the full article, if

© Crown Copyright 2025

necessary, resulting in a definitive list of conflicts for each species. In many cases, single articles were applicable to multiple conflicts and/or more than one species and therefore may have been added retrospectively to a species reference catalogue.

Categorising and scoring conflicts

Conflicts were categorised depending on whether they were an economic, health, environmental or social impact. Within these four main categories, conflicts were further assigned to 32 subcategories (economic=15, health=6, environmental=7, social=4). Subcategories were not weighted, therefore all subcategories were considered as of equal importance. Some species were involved in multiple conflicts within multiple categories, which were all captured as distinct entities. A comprehensive report was compiled for all species identified as being involved in human-wildlife conflict. An impact scale scoring system modified from Nentwig et al. [15] was applied to estimate the magnitude of each conflict at the national level for Great Britain, rated independently by three reviewers (KP, DC, GS). The level of impact was quantified on a scale of 1 (minimal impact known) to 5 (the highest possible impact: Table 1), with a value of confidence (low=1, medium=2 or high=3: Table 2) also assigned to each conflict (taken from Hawkins et al. [37]). Mammals for which no data were available, no impacts were known or impacts were not detectable were excluded from the analysis. The median of the three independent assignments of impact scale and confidence rating are reported for each conflict.

© Crown Copyright 2025

Table 1. Criteria used to describe the scale of impacts in each of the four categories of conflict.

Scale of impact	A. Economic impact	B. Health impact	C. Environmental impact	D. Social impact
1	<£10K / yr	Local mild, short-term, reversible effects to individuals	Local, short-term, population loss, no significant ecosystem effect	Minimal social disruption
2	£10K – 100K / yr	Mild short-term, reversible effects to identifiable groups, localised	Some ecosystem impact, reversible changes, localised	Significant concern expressed at local level
3	£100K – 1M / yr	Minor irreversible effects and/or larger numbers covered by reversible effects, localised	Measurable long-term damage to populations and ecosystem, but little spread, no extinction	Temporary changes to normal activities at local level
4	£1M – 10M / yr	Significant irreversible effects locally or reversible effects over a large area	Long-term irreversible ecosystem change, spreading beyond local area	Some permanent change of activity locally, concern over a wider area
5	>£10M / yr	Widespread, severe, long-term, irreversible health effects	Widespread, long-term population loss or extinction, affecting several species with serious ecosystem effects	Long-term social change, significant loss of employment, migration from area

Table 2. Criteria used for the confidence ratings of the impact scale assignments.

Confidence level	Example evidence
High (3) (approx. 90% chance of impact scale assignment being correct)	There is direct relevant observational evidence to support the assessment; **and** Impacts are recorded at the typical spatial scale over which the conflict can be characterised; **and** There are reliable / good quality data sources on the impacts of the conflict; **and** The interpretation of the data / information is straightforward; **and** Data / information is not controversial or contradictory
Medium (2) (approx. 65-75% chance of impact scale assignment being correct)	There is some direct observational evidence to support the assessment but some information is inferred; **and/or** Impacts are recorded at a spatial scale, which may not be relevant to the scale over which conflict can be characterized, but extrapolation or downscaling of the data to relevant scales is considered reliable, or to embrace little uncertainty; **and/or** The interpretation of the data is to some extent ambiguous or contradictory
Low (1) (approx. 35% chance of impact scale assignment being correct)	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; **and/or** Impacts are recorded at a spatial scale, which is unlikely to be relevant to the scale over which conflict can be characterized; extrapolation or downscaling of the data to relevant scales is considered unreliable potentially leading to significant uncertainties; **and/or** Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous; **and/or** The information sources are considered to be of low quality or contain information that is unreliable

© Crown Copyright 2025

Various species characteristics were also included in the analyses to determine whether they were associated with a conflict impact (modified from Nentwig et al. [15]). Impact scores were considered as the maximum impact for a particular species in Great Britain and did not account for their current distribution. Overall impacts were compared between species by summing the median scores of all conflicts and within each category ("potential impact"). To consider the distribution of a species, potential impact values were multiplied by the proportion of hectads (10 kilometre square resolution) each species occupies in Great Britain (derived from Crawley et al. [38]). The potential impact scores, corrected for the area occupied can be considered as the "actual impact" a species causes in Great Britain. Estimated population sizes were derived mostly from Mathews et al. [39], typical body weights were taken mostly from Harris & Yalden [40]. Where information was missing, relevant online sources were used (see S2 Table). The overall biomass for each species was calculated by multiplying population estimates and body mass. Population estimates and/or distribution data could not be reliably established for three species (feral cat, feral ferret, greater white-toothed shrew), therefore they were excluded from some of the statistical analyses.

Statistical analysis

All statistical analyses were performed using the R statistical programme version 4.2.2 [41] and the RStudio Integrated Development Environment (IDE: version 2022.12.0, Posit Software, PBC). Given the nature of the response variables, initial analyses (to assess whether impact/confidence scores assigned by the three reviewers differed overall and in relation to the conflict species assessed) were performed using an ordinal logistic regression model fitted using the *ordinal::clm* function version 2023.12-4. [42]. Species were aggregated based on status (native/non-native/feral) and taxonomic order, with an interaction term between each

© Crown Copyright 2025

aggregate type and reviewer ID included. Additional analyses were performed to assess whether impact scores assigned by the reviewers differed across impact categories (i.e. economic, environmental, health and social), across subcategories, between native/non-native species and between taxonomic orders, including interaction terms. (N.B. feral species were removed from further analyses due to their low number of conflicts). Data were expanded to account for the disparity in the number of subcategories described for each species from the literature, so that for each species, a total of 32 subcategories were present, with an impact and confidence score of zero (0), representing no available data, assigned to absent subcategories.

Differences in potential and actual impact scores were analysed using generalised linear models (GLM), using the *glmmTMB* package version 1.1.10 [43]. Diagnostic testing of these analyses was performed using the *DHARMa* package version 0.4.7 [44]. Prior to analysis, data were modified to account for species whereby an actual impact score could not be reliably established, with a score of zero (0) assigned to indicate insufficient evidence of impact. Feral ferret was subsequently excluded from the analyses, given a lack of data regarding population size and geographic distribution. Analyses assessed whether estimates of total impact (actual or potential) differed in relation to native/non-native status and taxonomic order, when modelled independently. Several covariate predictors were also specified independently in each model, including population size, body mass (kg) and biomass (kg). Models consisted of GLMs, fitted with a gaussian error distribution and “identity” link function, selected given that model residuals conformed to key assumptions (i.e. linearity, normality, homogeneity of variance), when total impact estimates were logarithmically transformed [log(n+1)]. For each model, a two-way interaction term was specified between species aggregation type (either native/non-native status or taxonomic order) and each covariate predictor (population size,

© Crown Copyright 2025

body mass, biomass). Due to issues with model performance, population size, body mass and biomass were also log-transformed [log(n+1)].

Additional analyses examined how estimates of impact (actual or potential) might differ across the main impact categories (economic, health, environment, social); these were performed using a GLM fitted with a Tweedie distribution, which is appropriate when analysing a continuous response variable consisting of a combination of zeroes and positive values. These models compared impact across categories in relation to native/non-native status and order, as well as population size, body mass and biomass. Interaction terms involving impact category, species aggregation type and each covariate predictor were included with respect to native/non-native species only. Analyses of impact, in relation to impact categories and order and covariate predictors, were limited to main order effects only, due to persistent issues with model performance (i.e. failure of models to converge), when considering any possible interaction between both predictor variables. This is likely due to the complexity of the models (impact category=4 levels; taxonomic order=6 levels; total number of factorial combinations=24) when considering interaction terms and the complete separation of certain impact categories across certain taxonomic orders, caused by the presence of absolute zeroes (e.g. social impact and Rodentia).

Results

General literature searches

A total of 13,148 articles were returned for potential human-wildlife conflicts involving the 66 terrestrial mammals in the UK. Further screening identified 405 useful articles for 48 mammals belonging to seven taxonomic groups (Rodentia: n=15; Carnivora: n=11; Artiodactyla: n=8;

© Crown Copyright 2025

Chiroptera: n=6; Eulipotyphla: n=4; Lagomorpha: n=3; Perissodactyla: n=1). The first available record was from 1947 and the latest was from 2024. The majority of articles (n=367, 91%) were published within the last three decades (2014-2024: n=176, 44%; 2004-2013: n=110, 27%; 1994-2003: n=81, 20%).

A detailed description of all of the conflicts is in S1 File. A summary of characteristics (native/non-native/feral status, population size, body mass, biomass) and conflicts for each species is in S2 Table. The periods during which conflicts were reported in the scientific literature (i.e. identified during the original review only ("pre-2014"), during the original and current review ("pre-2014 and 2014 to present") and during the current review only ("2014 to present") are also shown. The median impact scores and confidence ratings are shown after each conflict in parentheses.

Overview of conflicts

Conflicts and status

Twenty-nine of the 48 mammals (61%) are native to the British Isles, 17 (35%) are non-native (which includes 10 that have been introduced in recent times and seven that are considered naturalised) and two (4%) are feral (species that are considered wild but are either managed or may have human dependence). Of the 48 mammals, 40 (83%) caused at least one economic conflict, 36 (75%) caused at least one health conflict, 23 (48%) caused at least one environmental conflict and eight (17%) caused at least one social conflict (Fig 1). When compared by status, 86% (25/29) of native mammals caused economic conflict, 66% (19/29) caused health conflict and 35% (10/29) caused environmental conflict. In comparison, 82% (14/17) of non-native mammals caused economic conflict, 88% (15/17) caused health conflict

© Crown Copyright 2025

and 71% (12/17) caused environmental conflict. Social conflicts accounted for approximately 17% for both native (5/29) and non-native (3/17) species. The proportion of feral mammals causing conflict was either 50% (economic and environment) or 100% (health), although this was attributable to only two species (feral cat, Dartmoor/Exmoor pony).

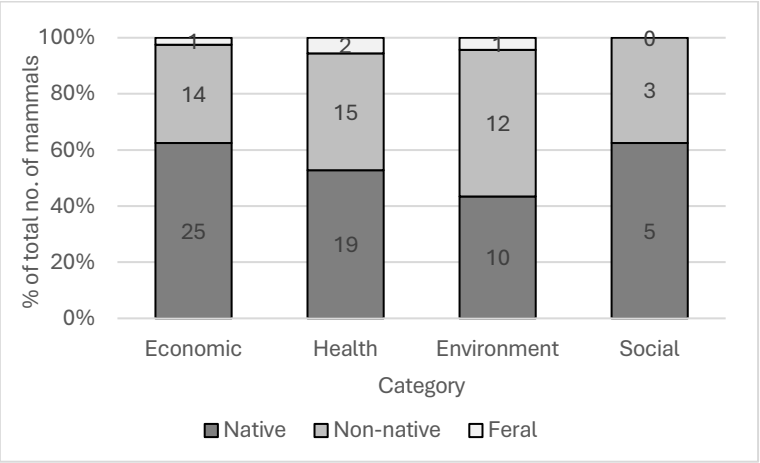

Fig 1. Percentage of mammals within each status causing conflict within the four main categories. Data labels denote the number of mammals within each status.

Frequency of conflicts

In total, 200 separate conflicts were identified, with 103 attributable to native mammals (52%), 92 to non-native mammals (46%) and five to feral mammals (3%). Ninety-one of the 200 conflicts (45%) were economic impacts (Appendix 1a), 71 (35%) were health impacts (Appendix 1b), 29 (15%) were environmental impacts (Appendix 1c) and nine (5%) were social impacts (Appendix 1d). A similar proportion of conflicts were recorded for both native and non-native species within all four categories (Fig 2). For native mammals, economic impacts accounted for 47% (48/103), health impacts accounted for 36% (37/103), environmental impacts accounted for 11% (12/103) and social impacts accounted for 6% (6/103). For non-

© Crown Copyright 2025

native mammals, economic impacts accounted for 45% (42/92), health impacts accounted for 36% (32/92), environmental impacts accounted for 16% (15/92) and social impacts accounted for 3% (3/92). Feral mammals were involved in considerably less conflicts, mostly attributable to health and environmental impacts.

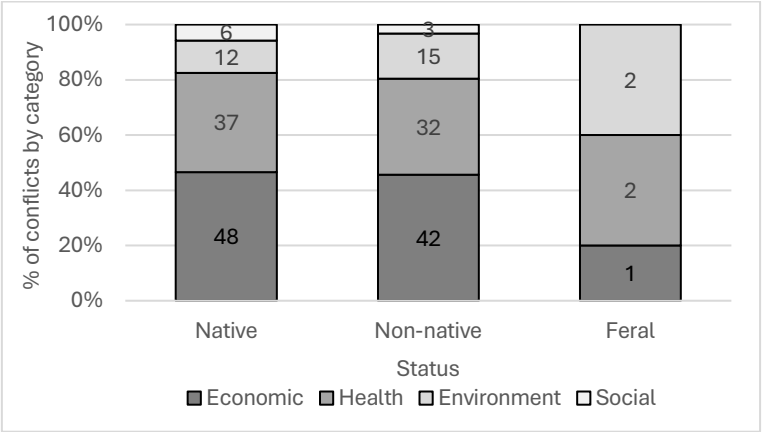

Fig 2. The percentage of conflicts within each category depending on status. Data labels denote the number of conflicts within each category. Native mammals: n=103; non-native mammals: n=92; feral mammals: n=5.

The total number of mammals causing conflict within a particular subcategory ranged from one to 30 (Appendix 1a-1d). Two of the four most common conflicts were health related (reservoir of zoonotic disease, n=30; reservoir of disease, n=22) followed by two economic conflicts (damage to agricultural interests, n=19; damage to forestry, n=15), with a similar number of native and non-native mammals causing conflict in these subcategories. However, when these data were analysed separately according to status, non-native mammals accounted proportionately more than native mammals in all four subcategories (Fig 3).

© Crown Copyright 2025

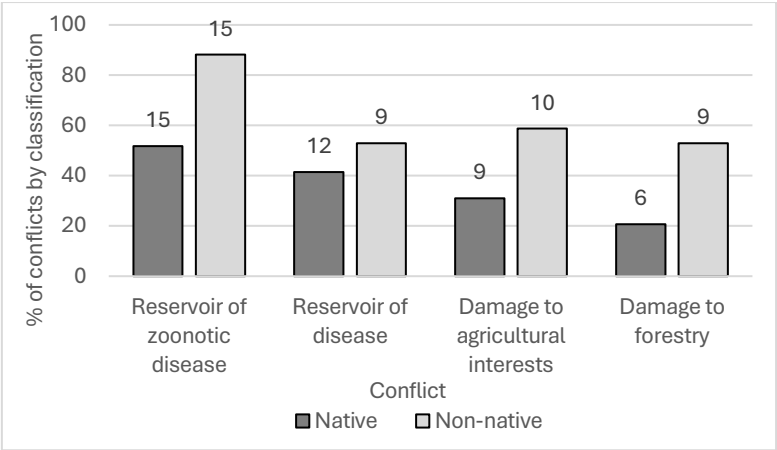

Fig 3. The percentage of native and non-native mammals causing conflict within the four most common conflict subcategories. Data labels denote the number of mammals. Native: n=29; non-native: n=17.

Impact scores and ranking of conflicts

Reproducibility of the scoring

Of the 200 conflicts, the three reviewers agreed on the impact score in 92 cases (46%); there was a maximum deviation of one score in 89 cases (44%), a maximum deviation of two scores in 18 cases (9%) and a maximum deviation of three scores in 1 case (1%). Overall, there was no statistically significant difference between the independently assigned impact scores ($\chi^2(2)=3.057$, $p=0.217$). However, confidence scores were found to differ statistically between reviewers ($\chi^2(2)=144.54$, $p<0.001$); all three agreed in 33 of the 200 conflicts (17%), two agreed in 131 cases (65%), with a deviation of one or two assigned by the third reviewer, and all three assigned a different confidence score in 36 cases (18%). This suggests that the reviewers were largely consistent in their impact scoring of British mammals but not necessarily in the confidence of the assignments.

Conflict scoring and ranking

© Crown Copyright 2025

Using the median impact scores across the three reviewers, seven of the 200 conflicts (4%) were assessed as impact score 5, 20 (10%) as impact score 4, 30 (15%) as impact score 3, 88 (44%) as impact score 2 and 55 (27%) as impact score 1 (Table 4a-4d). Six of the seven conflicts assessed as having the highest impact score of 5 (all with confidence rating of high) were economic and one was a health conflict. These were (in order of highest approximate economic cost): (1) rabbit damage to agricultural interests (£120 million), (2) badger involvement in the transmission of bTB to cattle (>£100 million), (3) brown rat damage to agricultural interests (£54 million), (4) rabbit damage to forestry (£43 million) (5) badger damage to agricultural interests (£39 million) (6) grey squirrel damage to forestry (£28 million, not including carbon capture estimates) and (7) brown rat damage to property (£14 million, based on local authority costs only). In all four categories, the majority of conflicts were scored as impact 2 (economic: 35% (32/91); health: 46% (33/71); environmental: 55% (16/29); social: 78% (7/9)). Despite two health conflicts being the most common amongst all mammals, generally, health conflicts were scored low, with over 90% (64/71) scoring either a 1 or 2.

© Crown Copyright 2025

Table 4a. Total number of mammals causing conflict within the 15 economic subcategories and their median impact score. Status categories: Na=native; NN=non-native; Fe=feral.

	Mammal impact scores within each subcategory					Total per status
Conflict (total mammals)	**Impact 5**	**Impact 4**	**Impact 3**	**Impact 2**	**Impact 1**	
Damage to forestry (15)	Grey squirrel, rabbit	Roe deer, red deer, fallow deer	Japanese sika, brown hare, edible dormouse, field vole	Muntjac, feral goat, mountain hare, beaver, bank vole	Chinese water deer	**Na - 6** **NN - 9**
Damage to agricultural interests (19)	Badger, rabbit, brown rat	Roe deer, fallow deer, mole, house mouse	Red deer	Japanese sika, Chinese water deer, muntjac, wild boar, brown hare, mountain hare, grey squirrel, beaver, wood mouse	Edible dormouse, field vole	**Na - 9** **NN - 10**
Damage to vehicles (RTAs) (9)	-	Roe deer, fallow deer, badger	Red deer, muntjac	Japanese sika, Chinese water deer, wild boar, Exmoor/Dartmoor pony	-	**Na - 4** **NN - 4** **Fe - 1**
Competition with livestock (3)	-	-	-	-	Red deer, Japanese sika, feral goat	**Na - 1** **NN - 2**
Predation of game species (11)	-	Red fox	-	Stoat, badger, American mink, hedgehog, brown rat	Wild cat, pine marten, feral ferret, weasel, polecat	**Na - 8** **NN - 3**
Predation/impact on commercial fisheries (3)	-	-	-	Otter, American mink	Beaver	**Na - 2** **NN - 1**
Predation of poultry (4)	-	-	-	American mink	Pine marten, feral ferret, polecat	**Na - 2** **NN - 2**
Damage to property (6)	Brown rat	Badger, grey squirrel, house mouse	Edible dormouse	Natterer's bat	-	**Na - 2** **NN - 4**
Damage to amenities and domestic grassland (4)	-	Rabbit	American mink, mole	Badger	-	**Na - 2** **NN=2**
Conflicts with construction, infrastructure and development (9)	-	Badger	Natterer's, serotine, common pipistrelle, soprano pipistrelle, brown long-eared bat	Beaver, hazel dormouse, water vole	-	**Na - 9**
Predation of livestock (1)	-	Red fox	-	-	-	**Na - 1**
Conflicts with transport (2)	-	-	Rabbit, brown rat	-	-	**NN - 2**
Sustaining predators harmful to game (2)	-	-	-	-	Field vole, Orkney vole	**Na - 1** **NN - 1**
Damage to property as a result of poaching (2)				Brown hare	Mountain hare	**Na - 1** **NN - 1**
Conflicts with utilities (1)	-	Brown rat	-	-	-	**NN - 1**
Total per impact score	**6**	**18**	**17**	**32**	**18**	**91**

© Crown Copyright 2025

Table 4b. Total number of mammals causing conflict within the six health subcategories and their median impact score. Status categories: Na=native; NN=non-native; F=feral.

	Mammal impact scores within each subcategory					Total per status
Conflict (total mammals)	**Impact 5**	**Impact 4**	**Impact 3**	**Impact 2**	**Impact 1**	
Health risks from RTAs (9)	-	-	Roe deer, wild boar	Red deer, Japanese sika, fallow deer, muntjac, badger	Chinese water deer, Exmoor/Dartmoor pony	**Na - 4** **NN - 4** **Fe - 1**
Reservoir of disease (22)	-	-	Rabbit, grey squirrel	Roe deer, red deer, fallow deer, muntjac, wild boar, feral cat, badger, red fox, field vole, wood mouse, house mouse	Japanese sika, Chinese water deer, feral goat, stoat, Daubenton's, hedgehog, brown hare, red squirrel, beaver	**Na - 12** **NN - 9** **Fe - 1**
bTB transmission (8)	Badger	-	-	Fallow deer, muntjac, wild boar	Roe deer, red deer, Japanese sika, red fox	**Na - 5** **NN - 3**
Reservoir of zoonotic disease (30)	-	Brown rat	House mouse	Roe deer, red deer, fallow deer, muntjac, American mink, red fox, Daubenton's, serotine, hedgehog, rabbit, bank vole, field vole, wood mouse	Japanese sika, Chinese water deer, feral goat, polecat, common shrew, greater white-toothed shrew, brown hare, mountain hare, red squirrel, grey squirrel, beaver, edible dormouse, yellow-necked mouse, Skomer vole, black rat	**Na - 15** **NN - 15**
Threat to livestock where ground is undermined (1)	-	-	-	Mole	-	**Na - 1**
Threats of branches falling (1)	-	-	-	-	Grey squirrel	**NN - 1**
Total per impact score	**1**	**1**	**5**	**33**	**31**	**71**

© Crown Copyright 2025

Table 4c. Total number of mammals causing conflict within the seven environmental subcategories and their median impact score. Status categories: Na=native; NN=non-native; F=feral.

	Mammal impact scores within each subcategory					Total per status
Conflict (total mammals)	**Impact 5**	**Impact 4**	**Impact 3**	**Impact 2**	**Impact 1**	
Damage to conservation habitats (9)	-	-	Roe dee, red deer	Japanese sika, fallow deer, muntjac, feral goat	Chinese water deer, wild boar, bank vole	**Na - 4** **NN - 5**
Threat to biodiversity (6)	-	Grey squirrel	-	Roe deer, red deer, Japanese sika, fallow deer, greater white-toothed shrew	-	**Na - 2** **NN - 4**
Threat to genetic integrity (3)	-	-	Feral cat	Japanese sika, feral ferret	-	**NN - 2** **Fe - 1**
Competition with or predation of wildlife (including protected or conservation species) (7)	-	-	Badger, American mink, red fox	Feral cat, otter, pine marten, stoat	-	**Na - 5** **NN - 1** **Fe - 1**
Predation of important ground-nesting birds and island ecosystem damage (2)	-	-	Hedgehog, brown rat	-	-	**Na - 1** **NN - 1**
Sustaining predators harmful to important conservation species (1)				Rabbit	-	**NN - 1**
Damage to island ecosystems (1)	-	-	-	-	Black rat	**NN - 1**
Total per impact score	**0**	**1**	**8**	**16**	**4**	**29**

Table 4d. Total number of mammals causing conflict within the four social subcategories and their median impact score. Status categories: Na=native; NN=non-native; F=feral.

	Mammal impact scores within each subcategory					Total per status
Conflict (total mammals)	**Impact 5**	**Impact 4**	**Impact 3**	**Impact 2**	**Impact 1**	
Public nuisance (4)	-	-	-	Muntjac, feral goat, rabbit	Wild boar	**Na - 1** **NN - 3**
Domestic nuisance (2)	-	-	-	Pine marten	Red fox	**Na - 2**
Predation of domestic pets (1)	-	-	-	Red fox	-	**Na - 1**
Domestic nuisance & hygiene (2)	-	-	-	Natterer's, serotine	-	**Na - 2**
Total per impact score	**0**	**0**	**0**	**7**	**2**	**9**

© Crown Copyright 2025

Analysis of impact scores in relation to native/non-native status and conflict category, found a statistically significant effect of category, when considered as a main order effect ($\chi^2(3)=62.90$, $p<0.001$) but not status ($\chi^2(1)=0.421$, $p=0.516$). Reviewers assigned a greater score in relation to economic impacts, followed by environmental, health and then social impacts (Fig 4). When conflict category was considered in relation to status, there was no statistically significant interaction term between the two ($\chi^2(3)=4.839$, $p=0.184$).

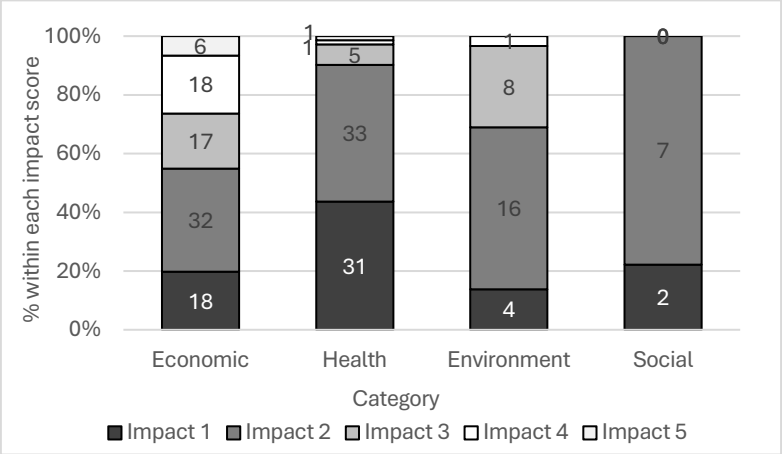

Fig 4. The proportion of conflicts depending on impact score (1-5) within the four categories. Data labels denote to total number of conflicts within each impact score. Economic: n=91, health: n=71, health: n=29, social: n=9.

Analysis of impact scores, in relation to native/non-native status and conflict subcategories, showed both as having a statistically significant effect ($\chi^2(1)=33.63$, $p<0.001$; $\chi^2(31)=640.18$, $p<0.001$, respectively), with a significant two-way interaction term also identified ($\chi^2(31)=155.56$, $p<0.001$). Across all economic impacts, non-native species received a statistically significantly greater impact score than natives in relation to damage to woodland, damage to agricultural interests, damage to property, conflict with transport and conflict with utilities (all $p<0.05$). Conversely, native species received a significantly higher score due to

© Crown Copyright 2025

conflicts with construction and development and the predation of livestock (both $p<0.001$). Across health impacts, the model predicted a statistically greater impact score for non-native species as reservoirs of zoonotic diseases only ($p=0.008$). With regards to the environment, non-native species received a statistically significant greater impact score for damage to conservation habitats and their threat to biodiversity and genetic integrity (all $p<0.05$). In terms of social impacts, non-native species received a greater impact than natives with respect to public nuisance only ($p<0.01$).

Potential impact

The number of separate conflicts per species ranged from one to eleven (Table 5), with sika deer involved in the most conflicts. Species scoring highest in potential total impact (i.e. the sum of all median conflict scores for a particular species) were badger, rabbit, roe deer, fallow deer and red deer. Generally, these species also scored highly within the separate categories (except for social conflicts), with badgers scoring highest in both potential economic and health impacts. The highest potential environmental impact was produced by sika deer, followed by roe deer, red deer and feral cat. The highest potential social impact was observed in the red fox, followed by rabbit, wild boar, pine marten, Natterer's and serotine bat.

© Crown Copyright 2025

Table 5. Distribution (i.e. the proportion of Great Britain each mammal is found, based on presence in 10x10km squares), total number of conflicts and impact scores (potential and actual) in total and within each of the four categories (economic, health, environmental, social) for all conflict mammals. Mammals are listed in order of highest total actual impact. – denotes missing data.

Species	Distribution	No. conflicts	Potential impact					Actual impact				
			Total potential impact	Economic	Health	Environment	Social	Total actual impact	Economic	Health	Environment	Social
Badger	0.746	10	33	21	9	3	0	24.624	15.670	6.716	2.239	0
Rabbit	0.833	8	26	17	5	2	2	21.649	14.155	4.163	1.665	1.665
Roe deer	0.726	9	25	12	8	5	0	18.151	8.713	5.808	3.630	0
Red fox	0.800	8	19	8	5	3	3	15.207	6.403	4.002	2.401	2.401
Grey squirrel	0.583	7	20	11	5	4	0	11.653	6.409	2.913	2.331	0
Brown rat	0.529	7	21	14	4	3	0	11.105	7.403	2.115	1.586	0
Red deer	0.412	10	23	11	7	5	0	9.480	4.534	2.885	2.061	0
Fallow deer	0.347	9	24	12	8	4	0	8.317	4.158	2.772	1.386	0
American mink	0.533	6	14	9	2	3	0	7.457	4.794	1.065	1.598	0
Mole	0.807	3	9	7	2	0	0	7.266	5.651	1.615	0	0
Hedgehog	0.824	4	8	2	3	3	0	6.592	1.648	2.472	2.472	0
Brown hare	0.680	5	9	7	2	0	0	6.119	4.759	1.360	0	0
Muntjac	0.334	9	17	7	8	2	0	5.673	2.336	2.669	0.667	0
Field vole	0.564	5	9	5	4	0	0	5.075	2.819	2.256	0	0
Wood mouse	0.560	3	6	2	4	0	0	3.360	1.120	2.240	0	0
Otter	0.782	2	4	2	0	2	0	3.126	1.563	0	1.563	0
House mouse	0.235	4	13	8	5	0	0	3.060	1.883	1.177	0	0
Stoat	0.597	3	5	2	1	2	0	2.983	1.193	0.597	1.193	0
Natterer's	0.411	3	7	5	0	0	2	2.880	2.057	0	0	0.823
Sika deer	0.134	11	19	8	5	6	0	2.540	1.069	0.668	0.802	0
Bank vole	0.446	3	5	2	2	1	0	2.229	0.892	0.892	0.446	0
Common pipistrelle	0.674	1	3	3	0	0	0	2.021	2.021	0	0	0
Soprano pipistrelle	0.619	1	3	3	0	0	0	1.858	1.858	0	0	0
Brown long-eared bat	0.600	1	3	3	0	0	0	1.799	1.799	0	0	0
Serotine	0.246	3	7	3	2	0	2	1.721	0.738	0.492	0	0.492
Daubenton's	0.491	2	3	0	3	0	0	1.472	0	1.472	0	0
Pine marten	0.171	4	6	2	0	2	2	1.025	0.342	0	0.342	0.342

© Crown Copyright 2025

Table 5 cont.

			Potential impact					Actual impact				
Species	**Distribution**	**No. conflicts**	**Total potential impact**	**Economic**	**Health**	**Environment**	**Social**	**Total actual impact**	**Economic**	**Health**	**Environment**	**Social**
Mountain hare	0.162	4	6	5	1	0	0	0.973	0.811	0.162	0	0
Water vole	0.425	1	2	2	0	0	0	0.850	0.850	0	0	0
Polecat	0.269	3	3	2	1	0	0	0.807	0.538	0.269	0	0
Weasel	0.530	1	1	1	0	0	0	0.530	0.530	0	0	0
Common shrew	0.502	1	1	0	1	0	0	0.502	0	0.502	0	0
Red squirrel	0.247	2	2	0	2	0	0	0.494	0	0.494	0	0
Feral goat	0.023	6	13	4	7	1	1	0.209	0.070	0.047	0.047	0.047
Hazel dormouse	0.199	1	2	2	0	0	0	0.397	0.397	0	0	0
Chinese water deer	0.042	7	9	5	3	1	0	0.375	0.208	0.125	0.042	0
Wild boar	0.031	7	9	3	2	2	2	0.402	0.124	0.216	0.03	0.031
Beaver	0.018	6	9	7	2	0	0	0.166	0.129	0.037	0	0
Yellow-necked mouse	0.129	1	1	0	1	0	0	0.129	0	0.129	0	0
Edible dormouse	0.008	4	8	7	1	0	0	0.064	0.056	0.008	0	0
Wildcat	0.039	1	1	1	0	0	0	0.039	0.039	0	0	0
Exmoor/Dartmoor pony	0.005	2	3	2	1	0	0	0.016	0.011	0.005	0	0
Black rat	0.006	2	2	0	1	1	0	0.011	0	0.006	0.006	0
Skomer vole	0.004	1	1	0	1	0	0	0.004	0	0.004	0	0
Orkney vole	0.003	1	1	1	0	0	0	0.003	0.003	0	0	0
Feral cat	-	3	7	0	2	5	0	-	-	-	-	-
Feral ferret	-	3	4	2	0	2	0	-	-	-	-	-
Greater white-toothed shrew	-	2	3	0	1	2	0	-	-	-	-	-

© Crown Copyright 2025

Analyses identified a statistically significant difference between native/non-native species ($\chi^2(1)=4.235$, $p=0.040$), with the latter predicted as having a higher potential impact overall ($\beta=0.513$, z ratio=2.058, $p=0.046$). When specified as main order effects, total potential impact was found to increase as a function of body mass ($\beta=0.335$, t ratio=3.598, $p<0.001$) and biomass ($\beta=0.184$, t ratio=4.706, $p<0.001$) but not population size ($\beta=0.040$, t ratio=1.012, $p=0.311$). However, no statistically significant interaction term was identified ($p>0.05$), suggesting that differences in the rate of change for total potential impact were comparable between native and non-native species, relative to changes in population size, body mass and biomass.

There was a statistically significant difference between taxonomic orders ($\chi^2(5)=18.468$, $p=0.002$), with Artiodactyla having a higher potential impact compared to Chiroptera ($\beta=1.129$, t ratio=3.661, $p=0.009$) and Rodentia ($\beta=1.231$, t ratio=3.236, $p=0.028$), whilst all other taxonomic comparisons were non-significant (Fig 5). Inclusion of covariate predictors as main order effects, revealed a statistically significant effect of population size ($\chi^2(1)=7.259$, $p=0.007$) and biomass ($\chi^2(1)=39.467$, $p<0.001$), with total potential impact predicted to increase as a function of each (population size: $\beta=0.096$, t ratio=2.499, $p<0.001$; biomass: $\beta=0.199$, t ratio=5.641, $p<0.001$).

© Crown Copyright 2025

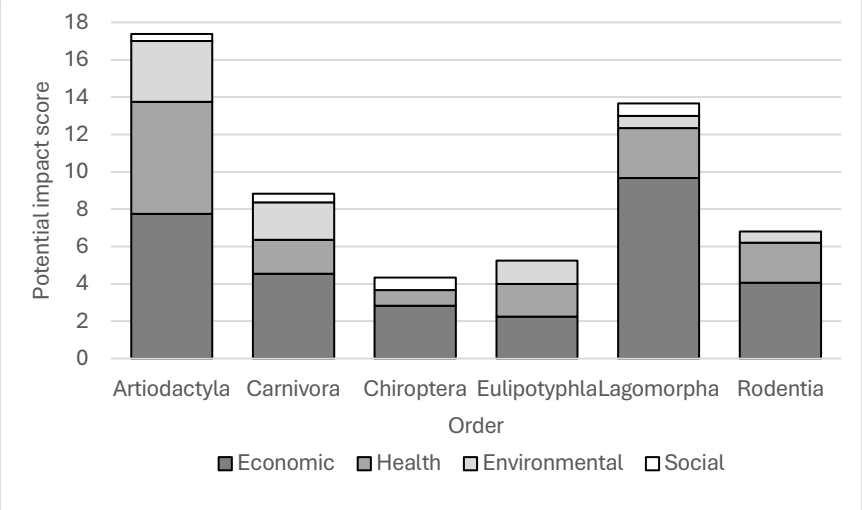

Figure 5. Average potential impacts within the four categories across orders (excluding Perissodactyla).

Actual impact

Species scoring the highest actual impact were badger, rabbit, roe deer and red fox (Table 5). Generally, these species also scored highly within the separate categories, with badgers scoring highest in both actual economic and health impacts. Roe deer scored the highest actual environmental impact, followed by hedgehog, red fox, grey squirrel, badger and red deer. The highest potential social impact was observed in the red fox, followed by rabbit and Natterer's bat.

Analysis of actual impact estimates showed no statistically significant difference between native/non-native species ($\chi^2(1)=0.056$, $p=0.813$). When considered as main order effects, total actual impact was predicted to increase significantly in relation to population size ($\beta=0.094$ t ratio=1.980, $p=0.048$) and biomass ($\beta=0.215$, t ratio=4.691, $p<0.001$). When considered in relation to status, there was no statistically significant interaction for biomass ($\chi^2(1)=0.298$, $p=0.585$) suggesting that the rate of increase was comparable across native and

© Crown Copyright 2025

non-native species. Body mass was found to have no statistically significant effect on total actual impact when considered as a main order effect ($\chi^2(1)=1.741$, $p=0.187$) or through interaction with status ($\chi^2(1)=0.088$, $p=0.767$). A statistically significant interaction term was identified between status and population size, with total actual impact predicted to increase, relative to population size, at a significantly higher rate for non-native species when compared to natives ($\beta=0.179$, t ratio=2.120, $p=0.034$).

There was no statistical difference, in relation to actual impact scores, between the taxonomic orders ($\chi^2(5)=5.622$, $p=0.345$: Fig 6).

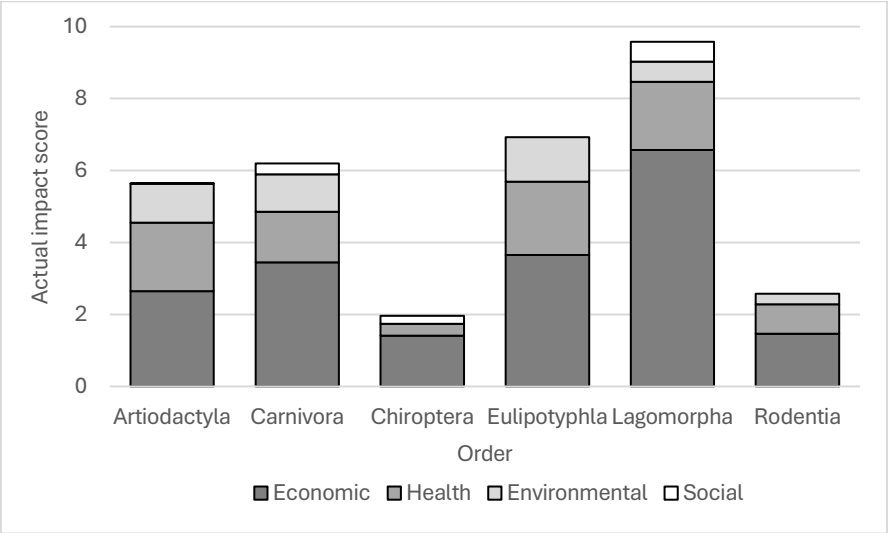

Figure 6. Average actual impacts within the four categories across orders (excluding Perissodactyla).

Conflict change over time

For many mammals, a conflict occurring before 2014 was still being reported in the scientific literature within the last decade (S2 Table). Twenty-seven of the 46 (59%) conflicts reported

© Crown Copyright 2025

only before 2014 were economic, followed by 10 (22%) health, 5 environment (11%) and 4 social (8%). In contrast, 25 of the 45 (55%) conflicts reported from 2014 to 2024 were health (55%), mostly attributable to reservoir of disease or reservoir of zoonotic disease, followed by 9 environment (20%), 8 economic (18%) and 3 social (7%).

Discussion

Negative interactions between people and wildlife are more often than not viewed as human–wildlife conflict, with socio-economic factors cited amongst the issues influencing people's perception of wildlife [45]. In this paper, we estimated a conservative total annual economic cost of human-wildlife conflicts in Great Britain (as reported in S1 File) in excess of £0.5 billion, which would likely exceed £1 billion if health and environmental conflicts could be monetarised. All but one of the seven conflicts assessed as having the highest impact score of 5 involved economic conflicts. The one health conflict scored as impact 5 (the involvement of badgers in the transmission of bTB), was also measurable on an economic scale, suggesting that conflicts associated with a monetary value are inherently easier to quantify compared with those that are not. To account for potential bias associated with individual conflicts, we applied a prioritisation approach (generic impact scoring system (GISS)) to evaluate the overall impact of conflict mammals. In some cases, mammals causing the greatest economic damage, such as rabbit and badger, were ranked highest overall for their actual impact. However, this approach also identified species that did not necessarily cause the highest individual impacts; for example, roe deer and red fox were ranked third and fourth overall, respectively, for actual impact despite neither receiving the highest impact score of 5 for any of their identified conflicts.

The emphasis of legislation associated with wildlife in the UK has moved from protecting human economic interests (e.g. Prevention of Damage by Pests Act 1949 and Pests Act 1954),

© Crown Copyright 2025

468 to promoting animal welfare (e.g. Wildlife and Countryside Act 1981 and Animal Welfare Act
469 2006) and protecting biodiversity (e.g. Habitats Directive 1992, Environment Act 2021). There
470 is likely to be an increasing trend for conflicts arising between promoting biodiversity and human
471 economic interests, as human activities continue to expand into existing wildlife habitats. Four
472 of the five mammals identified as causing the greatest actual economic and health impact
473 (badger, rabbit, roe deer), environmental impact (roe deer, hedgehog, red fox), and social impact
474 (red fox, rabbit) are native, which leads to increasing conflict where specific legislation applies
475 to a protected species. For example, badgers are protected under the Protection of Badgers Act
476 1992 but are the focus of ongoing controversy regarding management options for controlling the
477 spread of *Mycobacterium bovis* to cattle in the UK, which is estimated to cost the taxpayer over
478 £100 million annually [46]. Likewise, some bat species are widely distributed throughout Great
479 Britain and often associated with conflicts with buildings or construction; as bats and their
480 roosts are legally protected under the Wildlife and Countryside Act 1981 and the Conservation
481 of Habitats and Species Regulations 2010, this can lead to potentially complex and costly
482 resolution.

483 Although native mammals were ranked amongst the highest scoring impacts in all four
484 categories, overall, there was no statistical difference in the impact scores between native and
485 non-native species. However, there was a disproportionate amount of conflict in specific areas,
486 with non-native species perceived as causing significantly more damage to woodlands,
487 conservation habitats and agricultural interests, and a greater reservoir of zoonotic disease
488 compared to native species. Rabbits caused the highest economic conflict compared to all
489 other mammals with their impact on agriculture, and ranked second overall for total actual
490 impact. As such, this may highlight rabbits as a priority species for human-wildlife resolution.
491 However, rabbit populations have declined significantly in the UK in recent years, with severe

© Crown Copyright 2025

492 local population reductions reported [47], which have led to concerns regarding the impact of
493 such population reductions on other species, such as carnivores, that rely on them as a food
494 source [48]. In contrast, grey squirrel abundance and distribution has expanded rapidly since
495 they were introduced to Great Britain in the late 19th century [49]. They are considered a pest
496 species in the UK and as such are afforded no protection under the Wildlife and Countryside
497 Act 1981. As part of its 25-year Environment plan [20], the government has committed to
498 managing grey squirrels to protect woodlands and red squirrel populations in the UK. While the
499 general consensus is that grey squirrels must be managed to protect biodiversity within the UK,
500 removing healthy wildlife can be controversial and may face opposition from pressure groups,
501 which can be key to the success or failure of an eradication project [50].

502 Although the majority of reported conflicts were economic, the two most common
503 conflicts were health related (reservoir of zoonotic disease and reservoir of disease). More than
504 60% of human pathogens are zoonotic in origin [51] with urbanisation and anthropogenic
505 factors, amongst others, thought to have greatly influenced the emergence and distribution of
506 zoonoses [52]. Generally, though, the impact score of health conflicts were deemed low
507 (mostly 1 or 2), therefore we assumed that most health impacts were likely local, mild, short-
508 to mid-term and with reversible effects (see Table 1). This highlights the importance of
509 surveillance, which is crucial to preventing and controlling the spread of disease, in particular
510 zoonotic disease [52]. This is also pertinent to exotic diseases, which are not reported here as
511 only current diseases causing conflict in Britian were assessed. Whilst there is extensive
512 research on the pathology and epidemiology of disease in a wide range of British mammals, as
513 reported in S1 File, it is evident that for some mammals, there is an inference of disease
514 presence and/or zoonotic potential or a general lack of information (e.g. some hantaviruses [53]
515 and Ljungan virus [54] in rodents; *Babesia* spp. in deer [55] and badgers [56]), which suggests

© Crown Copyright 2025

516 further research may be warranted. Understanding disease dynamics in British wildlife is
517 intrinsically linked to biodiversity conservation, as anthropogenic activities such as urbanisation
518 and habitat destruction, are likely to lead to increased interaction between humans and wildlife
519 [57].

520 In many cases, mammals that caused the most conflict were amongst the most widely
521 distributed throughout the British Isles, e.g. badger, rabbit, roe deer and red fox. Our analyses
522 identified that total actual impact tended to increase as a function of biomass and population
523 size, therefore a GISS approach may be particularly beneficial for monitoring recently
524 introduced species, whether native or non-native, which have the potential to expand beyond
525 their current range. Beavers were reintroduced to Great Britain around 20 years ago and are
526 considered keystone species due to their ability to alter ecosystem structure and function
527 through their engineering activities [58, 59]. Whilst beavers are generally considered as having
528 a positive impact on biodiversity, we identified six potential conflicts of interest with humans;
529 whilst they ranked 38th overall based on total actual impact, likely owing to their current limited
530 distribution, they ranked joint 12th overall based on potential impact. Whilst the reintroduction
531 of beavers across Great Britain is currently carefully managed, highlighting and monitoring
532 potential issues at this stage is essential for ensuring the status of this species remains positive
533 rather than possible future perception as a pest species.

534 The overall assessments of the conflicts reported here were made at the national level for
535 Great Britain. Local impacts may be of considerable importance for those affected, for instance
536 those injured in road traffic accidents, and thus a national score of 1 or 2 should not be taken to
537 indicate that the conflict is not important or worth mitigating at a local level. Furthermore, it is
538 important to recognise that the impacts are not necessarily uniformly distributed geographically

© Crown Copyright 2025

539 or equitably shared. For example, Artiodactyla were predicted to receive significantly higher
540 potential impact scores compared to other taxonomic orders. The total potential impact for five
541 of the six deer species were amongst the highest of all the mammals, although the actual
542 impact for some deer species may be lower depending on their distribution. For example, sika
543 deer were involved in the most conflicts of all the mammals but were ranked 20th overall for
544 actual impact, suggesting its impacts are localised given its limited distribution.

545 Human-wildlife conflict has long been associated with negative impacts on human
546 interests, although it is evident that interactions between people and wildlife are more varied
547 and complex [2]. More recently, the emphasis has shifted from conflict between humans and
548 wildlife and its mitigation, to a coexistence approach [14], or at least one that constrains
549 conflict or adapts shared spaces to mitigate conflict. Whilst there is a general consensus that
550 some species must be managed or even eradicated (e.g. invasive non-native species: Nentwig
551 et al. [15]), for others, particularly native species, a more holistic approach may be required. In
552 some cases, mammals that represent a conflict and cost to some, may also provide a benefit
553 to others. In Great Britain, the red fox has been widely persecuted due to its perceived status as
554 a pest species [60]. Their impact on agriculture has been estimated to cost £20 million annually,
555 most of which is attributable to direct and indirect effects of livestock predation [61]. However,
556 fox predation on rabbits, which have a much more significant impact on agriculture, is estimated
557 to create an indirect economic benefit to farmers of at least £11 million annually and may even
558 be approaching an economically neutral impact on agriculture [61].

559 The findings reported here must be viewed in light of several limitations. Although an
560 extensive literature search was conducted to identify conflicts associated with British wildlife,
561 it is likely that some conflicts were not identified or cost estimates were not available, and

© Crown Copyright 2025

562 therefore not reported. Whilst the conflict descriptions given in S1 File are not exhaustive and
563 based only on the searches returned, they likely represent reasonable overviews and are
564 sufficiently robust to provide an overall audit of the current national importance of conflicts
565 between human and wildlife interests in Great Britain. However, individual assignments of scale
566 may need to be revised as further information emerges. Conflicts that were identified before
567 2014 only are more than likely still occurring or may not be reported as frequently in the
568 scientific literature. Likewise, conflicts reported after 2014 only may have been occurring prior
569 to this and again, either missed in the original literature searches or less frequently reported.
570 The majority of "new" conflicts we identified were disease related, which may reflect a shift of
571 focus leading to increased reporting in this area, possibly in light of several international public
572 health emergencies of zoonotic origin within the last ten years, such as Middle East respiratory
573 syndrome (MERS), Ebola and Covid-19 pandemics [62].

574 Another limitation of our findings is the lack of data for some species. Feral species were
575 excluded from some of the analyses due to the small number of conflicts in Great Britain,
576 although their impacts can be significant. Data regarding feral cats are limited due to the
577 difficulty in differentiating between feral and domestic cats [63], the uncertainties of feral cat
578 population estimates (based mostly on urban populations) and the lack of known distribution
579 within Great Britain. Cats are one of the most ubiquitous mammals globally (see McDonald &
580 Skillings [64]) and one of the most destructive, with free-ranging cats suggested as having a
581 major impact on the mortality of several bird species in the UK [65]. They are also the biggest
582 threat to the survival of Scottish wildcats due to introgression [66]. Given their domesticated
583 origins, feral cats have no native range and their ubiquitous adverse impacts on native wildlife
584 around the world has led to them being labelled amongst the world's worst invasive species
585 [67]. From a biodiversity conservation perspective, a wealth of evidence suggests that feral cats

© Crown Copyright 2025

should be controlled and ideally removed from places where their impact is detrimental, often as an urgent priority [68].

When applying the GISS in this paper, none of the conflicts were weighted, i.e. they were all considered of equal importance. This follows Nentwig et al. [15], who stated that in the absence of objective scientific criteria to consider one impact category more important than the other, selective weights were not applied. They also stated that deciding relative impact weights is a social process rather than a scientific one. It is possible to apply individual weights to conflicts, for example, by considering stakeholder values (e.g. Kumschick et al. [69]), which will likely differ according to the relevance of a particular conflict to a particular group. The scoring system applied here is thus considered robust to the uncertainty of impact knowledge but could be adjusted with weight scores to account for specific social values, such as stakeholder interests, in the future [15].

Conclusions

The prioritisation approach we applied here is a useful tool for identifying individual conflicts for individual species but also provides a broader assessment of where human-wildlife impacts may be affecting socio-economic and biodiversity interests. It is clear that it should not be relied upon in isolation to identify priority species for mitigation purposes, and all other available evidence or opinion from conservation groups, stakeholder groups, public perception and other interested parties, should be considered. Ideally, any decision making, whether relevant to government policies or conservation organisations, should consider ensuring a balance between the need to conserve and enhance biodiversity, the interests of the general public and the interests of those directly affected [35].

© Crown Copyright 2025

Acknowledgements

We are grateful to Eloise Cunningham for her assistance with the literature searches.

Author contributions

Conceptualisation and methodology: DC, KLP. Analysed the data: KP, DW, DC, GC. Writing-original draft: KP. Writing-review & editing: KP, DC, DW, GC.

References

1. Locke H, Ellis EC, Venter O, Schuster R, Ma K, Shen X, et al. Three global conditions for biodiversity conservation and sustainable use: an implementation framework. National Science Review. 2019;6:1080-82.
2. Hill CM. Conflict is integral to human-wildlife coexistence. Frontiers in Conservation Science. 2021;2:734314.
3. Woodroffe R, Thirgood S, Rabinowitz A. People and wildlife: conflict or coexistence? Cambridge, UK: Cambridge University Press; 2005.
4. Conover MR. Resolving human-wildlife conflicts: the science of wildlife damage management: CRC Press, Boca Raton, FL; 2002.
5. Treves A, Karanth KU. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology. 2003;17:1491–99.
6. Tilman D. Global environmental impacts of agricultural expansion: the need for sustainable and efficient practices. The Proceedings of the National Academy of Sciences. 1999;96:5995–6000.

© Crown Copyright 2025

7. Nyhus PJ. Human-wildlife conflict and co-existence. Annual Review of Environment and Resources. 2016;41:143-71.

8. Pérez E, Pacheco LF. Damage by large mammals to subsistence crops within a protected area in a montane forest of Bolivia. Crop Protection. 2006;25:933-39.

9. Fang L, Hong Y, Zhou Z, Chen W. The frequency and severity of crop damage by wildlife in rural Beijing, China. Forest Policy and Economics. 2021;124:102379.

10. Drexler JF, Corman VM, Drosten C. Ecology, evolution and classification of bat coronaviruses in the aftermath of SARS. Antiviral Research. 2014;101:45-56.

11. Song Z, Xu Y, Bao L, Zhang L, Yu P, Qu Y, et al. From SARS to MERS, thrusting coronaviruses into the spotlight. Viruses. 2019;11.

12. Hao YJ, Wang YL, Wang MY, Zhou L, Shi JY, Cao JM, et al. The origins of COVID-19 pandemic: A brief overview. Transboundary and Emerging Diseases. 2022;69(6):3181-197.

13. Cassini MH. Human-wildlife conflicts: does origin matter? . Animals. 2022;12:1-10.

14. Gross EM, Jayasinghe N, Dahal S, Tenzin S, Klenzendorf S, Vannelli K, et al. C2C—conflict to coexistence: a global approach to manage human–wildlife conflict for coexistence. Conservation Science and Practice. 2024;7:e13292.

15. Nentwig W, Künel E, Bacher S. A generic impact-scoring system applied to alien mammals in Europe. Conservation Biology. 2010;24:302–11.

16. Eschen R, Kadzamira M, Stutz S, Ogunmodede A, Djeddour D, Shaw R, et al. An updated assessment of the direct costs of invasive non native species to the United Kingdom. Biological Invasions. 2023;25:3265-76.

17. The Wildlife Trust. Local to global: the Global Biodiversity Framework and what the UK needs to do to implement it. 2024; https://www.wildlifetrusts.org/sites/default/files/2024-

© Crown Copyright 2025

651 09/UK%20and%20Global%20Biodiversity%20Framework%20-
652 %20The%20Wildlife%20Trusts%202024.pdf.
653 18. Dueñas MA, Hemming DJ, Roberts A, Diaz-Soltero H. The threat of invasive species to
654 IUCN-listed critically endangered species: a systematic review. Global Ecology and
655 Conservation. 2021;26:e01476.
656 19. NNSS. GB non-native species report card 2020. 2020;
657 https://www.nonnativespecies.org/assets/NNSIP-Scorecard-2020.pdf.
658 20. HMGovernment. A green future: our 25 year plan to improve the environment. 2018;
659 https://assets.publishing.service.gov.uk/media/65fd713d65ca2f00117da89e/CD1.H_HM_Go
660 vernment_A_Green_Future_Our_25_Year_Plan_to_Improve_the_Environment.pdf; 2018.
661 21. Crowley SL, Hinchliffe S, McDonald RA. Conflict in invasive species management.
662 Frontiers in Ecology and the Environment. 2017;15:133-41.
663 22. Jackson DB, Green RE. The importance of the introduced hedgehog (*Erinaceus*
664 *europaeus*) as a predator of the eggs of waders (Charadrii) on machair in South Uist, Scotland.
665 Biological Conservation. 2000;93:333–48.
666 23. Manchester SJ, Bullock JM. The impacts of non-native species on UK biodiversity and
667 the effectiveness of control. Journal of Applied Ecology. 2000;37:845-64.
668 24. Ricciardi A, Cohen J. The invasiveness of an introduced species does not predict its
669 impact. Biological Invasions. 2007;9:309–15.
670 25. Ricciardi A, Hoopes MF, Marchetti MP, Lockwood JL. Progress toward understanding the
671 ecological impacts of nonnative species. Ecological Monographs,. 2013;83:263–82.
672 26. Swift BMC, Barron ES, Christley R, Corbetta D, Grau-Roma L, Jewell C, et al.
673 Tuberculosis in badgers where the bovine tuberculosis epidemic is expanding in cattle in
674 England. Scientific Reports. 2021;11:20995.

© Crown Copyright 2025

27. Kumschick S, Gaertner M, Vilà M, Essl F, Jeschke JM, Pyšek P, et al. Ecological impacts of alien species: quantification, scope, caveats, and recommendations. Bioscience. 2015;65:55–63.

28. Nentwig W, Bacher S, Pyšek P. The generic impact scoring system (GISS): a standardized tool to quantify the impacts of alien species. Environmental Monitoring and Assessment. 2016;188:315.

29. Van der Veer G, Nentwig W. Environmental and economic impact assessment of alien and invasive fish species in Europe using the generic impact scoring system. Ecology Freshwater Fish. 2014(4):646-56.

30. Vaes-Petignat S, Nentwig W. Environmental and economic impact of alien terrestrial arthropods in Europe. NeoBiota. 2014;22:23–42.

31. Laverty C, Nentwig W, Dick JTA, Lucy FE. Alien aquatics in Europe: assessing the relative environmental and socio-economic impacts of invasive aquatic macroinvertebrates and other taxa. Management of Biological Invasions. 2015;6:341–50.

32. Novoa A, Kumschick S, Richardson DM, Rouget M, Wilson JRU. Native range size and growth form in Cactaceae predicts invasiveness and impact. NeoBiota. 2016;30:75-90.

33. Sohrabi S, Pergl J, Pyšek P, Foxcroft LC, Gherekhloo J. Quantifying the potential impact of alien plants of Iran using the Generic Impact Scoring System (GISS) and Environmental Impact Classification for Alien Taxa (EICAT). Biological Invasions. 2021;23:2435-449.

34. Evans T, Blackburn TM, Jeschke JM, Probert AF, Bacher S. Application of the Socio-Economic Impact Classification for Alien Taxa (SEICAT) to a global assessment of alien bird impacts. NeoBiota. 2020;62:123-42.

© Crown Copyright 2025

35. Defra. Wildlife management in England: a policy making framework for resolving human-wildlife conflicts (withdrawn). 2010; https://www.thenbs.com/publicationindex/documents/details?Pub=DEFRA&DocId=295502.

36. Haddaway NR, Collins AM, Coughlin D, Kirk S. The role of Google Scholar in evidence reviews and its applicability to grey literature searching. PLOS One. 2015;7:e013823.

37. Hawkins CL, Bacher S, Essl F, Hulme PE, Jeschke JM, Kühn I, et al. Framework and guidelines for implementing the proposed IUCN Environmental Impact Classification for Alien Taxa (EICAT). Diversity and Distributions. 2015;21:1360-63.

38. Crawley D, Coomber F, Kubasiewicz L, Harrower C, Evans P, Waggitt J, et al. Atlas of the mammals of Great Britain and Northern Ireland. The Mammal Society: Pelagic Publishing, UK; 2020. 192 p.

39. Mathews F, Kubasiewicz LM, Gurnell J, Harrower CA, McDonald RA, Shore RF. A review of the population and conservation status of British mammals: technical summary. A report by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage. Peterborough: Natural England; 2018.

40. Harris S, Yalden DW. Mammals of the British Isles: handbook 4th edition. Southampton: The Mammal Society; 2008.

41. R Core Team. R: A language and environment for statistics computing. In: Computing RFfS, editor. Vienna, Austria2022.

42. Christensen R. *ordinal* - Regression Models for Ordinal Data. R package version 2023.12-4.1. 2023; https://cran.r-project.org/web/packages/ordinal/ordinal.pdf.

43. Brooks ME, Kristensen K, van Benthem KJ, Magnusson A, Berg CW, Nielsen A, et al. *glmmTMB* balances speed and flexibility among packages for zero-inflated generalised linear mixed modelling. The R Journal. 2017;9:378-400.

© Crown Copyright 2025

44. Hartig F. *DHARMa*: Residual diagnostics for hierarchical (multi-level/mixed) regression models. R package version 0.4.7. 2024; https://cran.r-project.org/web/packages/DHARMa/vignettes/DHARMa.html.

45. Bhatia S, Redpath SM, Suryawanshi K, Mishra C. Beyond conflict: exploring the spectrum of human–wildlife interactions and their underlying mechanisms. Oryx. 2020;54(5):1-8.

46. Defra. Government to end badger cull with new TB eradication strategy. 2024; https://www.gov.uk/government/news/government-to-end-badger-cull-with-new-tb-eradication-strategy#:~:text=The%20new%20strategy%20will%20mark,the%20end%20of%20this%20parliament.

47. Petrovan SO, Ward AI, P. W. Detectability counts when assessing populations for biodiversity targets. PLOS One. 2011;6:8.

48. Sainsbury KA, Shore RF, Schofield H, Croose E, Campbell RD, McDonald RA. Recent history, current status, conservation and management of native mammalian carnivore species in Great Britain. Mammal Review. 2019;49(2):171-88.

49. Gurnell J, Hare EJ. Rodents: Order Rodentia. In: Harris S, Yalden DW, editors. Mammals of the British Isles. Southampton: The Mammal Society; 2008. p. 55-199.

50. Bremner A, Park K. Public attitudes to the management of invasive non-native species in Scotland. Biological Conservation. 2007;139:306-14.

51. Taylor LH, Latham SM, Woolhouse ME. Risk factors for human disease emergence. Philosophical Transactions of the Royal Society of London Series B, Biological Sciences. 2001;356:983–89.

© Crown Copyright 2025

52. Rahman T, Sobur A, Islam S, Ievy S, Hossain J, El Zowalaty ME, et al. Zoonotic diseases: etiology, impact, and control. Microorganisms. 2020;8:1405.

53. Vapalahti O, Mustonen J, Lundkvist Å, Henttonen H, Plyusnin A, Vaheri A. Hantavirus Infections in Europe. Lancet Infectious Diseases. 2003;3:653–61.

54. Salisbury AM, Begon M, Dove W, Niklasson B, Stewart JP. Ljungan virus is endemic in rodents in the UK. Archives of Virology. 2014;159:547-51.

55. Gray A, Capewell P, Zadoks R, Taggart MA, French AS, Katzer F, et al. Wild deer in the United Kingdom are a potential reservoir for the livestock parasite *Babesia divergens*. Current Research in Parasitology & Vector-Borne Diseases. 2021;1:100019.

56. Guardone L, Ebani VV, Verin R, Nardoni S, Consolazione A, Bennett M, et al. Molecular detection of arthropod-borne pathogens in Eurasian badgers (*Meles meles*) from the United Kingdom. Animals. 2020;10:446.

57. Bedenham G, Kirk A, Luhano U, Shields A. The importance of biodiversity risks: link to zoonotic diseases. British Actuarial Journal. 2022;27(e10):1-9.

58. Puttock A, Graham HA, Cunliffe AM, Elliott M, Brazier RE. Eurasian beaver activity increases water storage, attenuates flow and mitigates diffuse pollution from intensively-managed grasslands. Science of the Total Environment. 2017;576:430-43.

59. Auster RE, Puttock A, Brazier R. Unravelling perceptions of Eurasian beaver reintroduction in Great Britain. Area. 2019;52:364-75.

60. Macdonald DW, Johnson PJ. Foxes in the landscape: hunting, control, and economics. In: Macdonald DW, Feber RE, editors. Wildlife Conservation on Farmland: Volume 2, Conflict in the Countryside. Oxford: Oxford University Press; 2015. p. 20-46.

© Crown Copyright 2025

61. Baker P, Harris S, White PCL. After the hunt: the future for foxes in Britain. London: International Fund for Animal Welfare. 2006; https://mknhs.org.uk/wp-content/uploads/2015/08/IFAW-after-the-hunt.pdf; 2006.

62. Sun ZS, Wan EY, Agbana YL, Zhao HQ, Yin JX, Jiang TG, et al. Global One Health index for zoonoses: A performance assessment in 160 countries and territories. iScience. 2024;27:109297.

63. Hand A. Estimating feral cat densities using distance sampling in an urban environment. Ecological Evolution. 2019;9:2699–705.

64. McDonald JL, Skillings E. Human influences shape the first spatially explicit national estimate of urban unowned cat abundance. Scientific Reports. 2021;11:20216.

65. Baker PJ, Molony SE, Stone E, Cuthill IC, Harris S. Cats about town: is predation by free-ranging pet cats Felis catus likely to affect urban bird populations? . Ibis. 2008;150:86-99.

66. Fredrikson A. Of wildcats and wild cats: troubling species-based conservation in the Anthropocene. Environment and Planning D: Society and Space. 2016;34(4):1-25.

67. Lowe S, Browne M, Boudjelas S. 100 of the world's worst invasive alien species: a selection from the Global Invasive Species database. Invasive Species Specialist Group (ISSG), International Union for Conservation of Nature. 2000; https://portals.iucn.org/library/sites/library/files/documents/2000-126.pdf.

68. Trouwborst A, McCormack PC, Camacho EM. Domestic cats and their impacts on biodiversity: A blind spot in the application of nature conservation law. People and Nature. 2019;2:235-50.

69. Kumschick S, Bacher S, Dawson W, Heikkila J, Sendek A, Pluess T, et al. A conceptual framework for prioritization of invasive alien species for management according to their impact. NeoBiota. 2012;15:69-100.

© Crown Copyright 2025

Supporting information

S1 File. Detailed description of all of the conflicts identified in the scientific literature for 48 mammals of the British Isles.

S2 Table. List of species causing conflict, including order, status, population size, body mass, biomass and type of conflicts recorded over time (pre-2014 only; both pre-2014 and 2014 to present; 2014 to present only). The median impact score (1=minimal known impact to 5=highest known impact) and confidence rating (1=low; 2=medium; 3=high) are shown after each conflict [x,x]. The highest impact scores are shown in bold.

© Crown Copyright 2025