

Effectiveness of animal conditioning interventions in reducing Human-wildlife conflict. A systematic map protocol

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Abstract

Background: Human-wildlife conflict (HWC) is currently one of the most pressing conservation challenges. HWC occurs when human-wildlife interactions negatively impact social, economic or cultural aspects of human life, but also when they impact conservation of wildlife populations or the environment. Conflicts often involve wild animals becoming habituated to consuming anthropogenic resources, such as crops or livestock, either out of necessity (loss of habitat and natural prey) or as consequence of opportunistic behaviour. A variety of interventions are undertaken to reduce HWC, differing in practicability, costs and social acceptance. One such non-lethal intervention is animal conditioning, a technique to reduce conflict by modifying the behaviour of ‘problem’ animals long-term. Conditioning changes associations animals have with resources or behaviours. Both via aversive (punishment of conflict behaviour) and positive (reward of alternative behaviour)

conditioning, researchers aim to make expression of conflict behaviour relatively less desirable to animals. Despite the potential, however, studies testing conditioning interventions have reported seemingly contradictory outcomes. To facilitate reduction of HWC, we thus need to better understand if and when conditioning interventions are indeed effective. With this systematic map we intend to make the global evidence base for conditioning of free-ranging vertebrates more accessible to practitioners, to identify potential evidence clusters and effect modifiers for a subsequent systematic review and to highlight evidence gaps for future research.

Methods: We will compile evidence, including grey literature, from bibliographic databases, online search engines, specialist sites and expert contacts. Where possible, a Boolean-style full search string will be used, including Intervention and Outcome search terms. Searches will be conducted in English. Search comprehensiveness will be evaluated with an a-priori list of benchmark articles. We will base inclusion of articles on presence of quantitative data, subject identity, comparator and outcome. Inclusion consistency checks will be performed with 10% of the titles and abstracts and 10% of the full texts. We will critically appraise the literature base on basis of study design (e.g. BA, BACI) and sample size. Finally, we will develop a searchable literature database and an interactive evidence atlas along with a narrative synthesis of the evidence.

Keywords: Aversive Conditioning, Conservation, Crop raiding, Depredation, Evidence synthesis, Human-wildlife conflict, Predator control, Problem animals, Systematic map, Wildlife damage

Background

“Everyone knew there were wolves in the mountains, but they seldom came near the village - the modern wolves were the offspring of ancestors that had survived because they had learned that human meat had sharp edges.”

- Terry Pratchett, Equal Rites -

Human-wildlife conflict (HWC), i.e. human-wildlife interactions negatively impacting social, economic or cultural aspects of human life, conservation of wildlife populations or the environment (WWF), is increasing. The human population and the numbers of associated livestock are growing and expanding, while at the same time natural habitat is declining [1]. As a consequence, the intensity and frequency of HWC has increased to the point of being recognized as one of the most critical conservation challenges [2–5]. Conflict with wildlife can range from Canadian geese (*Branta canadensis*) eating and defecating on golf courts, to wolves (*Canis lupus*) killing sheep, to polar bears (*Ursus maritimus*) and tigers (*Panthera tigris*) attacking and killing people. Conflicts thus cover a variety of ‘problem’ behaviours. Not only do these conflicts result in short-term costs for humans and, often as a consequence of retaliation, for animals, on the long-term it also decreases local support for wildlife conservation [3, 5, 6].

Although there has been a recent surge in urgency, especially concerning conflicts with large carnivores [2, 4, 7, 8], HWC has since long been an issue, as

illustrated by a quote from 254–184 BC: “Where there are sheep, the wolves are never very far away.” (Titus Plautus). As such, many lethal and non-lethal interventions, with the aim to reduce conflicts, have been proposed and tested, but not one type of intervention has proven to be the silver bullet [4, 5, 9–15]. Besides effectiveness, an intervention needs to fulfil a number of additional criteria, such as those based on cost-effectiveness, feasibility, sustainability and social, legal and ethical acceptance. Lethal interventions might be socially or legally undesirable even if they appear effective in some cases [14, 16–18], translocation might be too costly and risky for the animals, next to being generally ineffective for large carnivores [10, 19–21] and use of simple deterrents may be effective during the actual intervention but not on the long-term [9, 11, 13, 22–25]. Large-scale traditional fencing might be undesirable from a social ethical perspective and unfeasible when it strongly restricts movements of non-target species [10, 26–29] and while virtual fences could prevent problems for non-target species, their usefulness might be restricted to highly social species [30]. Finally, although guardian animals appear to be a promising tool, specifically for reducing livestock predation, they may not be effective against all kinds of problem species and behaviours [9–11, 31]. In summary, appropriateness and effectiveness of specific HWC intervention techniques is very much dependent on the local context. Therefore, a combination of several techniques is likely to always be necessary to effectively reduce HWC, ideally also in combination with preventive measures that reduces the problem animal’s need for anthropogenic resources, such as habitat restoration and natural prey management, direct interventions that interrupt the problem animal’s learning mechanism before a conflict can form, such as olfactory pre-exposure [32] and indirect interventions that

target the human side of the conflict, such as knowledge exchange and compensation schemes [15, 33].

A promising HWC intervention that could be part of an effective 'HWC mitigation toolbox' and which does not involve extremely invasive procedures such as killing or translocating animals, is 'animal conditioning' [34]. The key component of conditioning is associative learning. Associative learning involves memory, making it in essence effective after, not just during, the intervention, and learned associations have the potential to be generalized over locations, possibly also making the intervention effective over larger areas or from *ex situ* (captivity) to *in situ* (wild) [35]. Conditioning has therefore been flagged as a potentially useful tool for reducing HWC [36]. Conditioning interventions in HWC specifically aim to change the behaviour of an animal on the long-term. This can be achieved, for example, by pairing an attractive 'conflict' resource with a reward or punishment stimulus. For example, pairing eggs (resource) with illness (punishment) by injecting them with an illness-inducing substance, so that ravens (*Corvus corax*) learn to avoid eating those eggs [37]. Not only the resource in question, also the behaviour itself can be conditioned. Certain 'good' behaviours can be reinforced by pairing (following) them with a reward stimulus and 'bad' behaviours can be weakened by pairing them with a punishment stimulus. In HWC situations, the use of punishment is the most common conditioning stimulus applied and this method is often referred to as 'aversive conditioning'. In aversive conditioning an attempt is made to change the current positive or neutral association an animal has with a particular resource or behaviour to a negative one. In other words, aversive conditioning is used to make a problematic behaviour, such as eating crops, less desirable to the animal. It should

be noted, however, that when a behaviour is emitted to acquire a resource that is essential to an animal's health and survival, for example because no alternative natural resources are sufficiently available, making the behaviour less desirable will not extinguish the behaviour. Yet, when a resource is not (or no longer) essential to the animal and the conflict thus involves somewhat opportunistic problem behaviour [5], conditioning has the potential to be an effective, and socially acceptable, intervention.

There are, however, some practical challenges associated with applying conditioning as a HWC intervention technique. The first challenge is that to be successfully paired the stimulus should follow the behaviour quickly. With certain sporadic and elusive problem behaviours, such as livestock predation, it is very difficult to catch the animal in the act and immediately apply punishment. In those cases, the conflict resource (or a proxy for it), such as a sheep carcass, is regularly conditioned instead [38, 39], with seemingly contradictory outcomes concerning effectiveness in reducing the actual problematic attacking and killing behaviour [40–42]. This limited effectiveness might also be explained by a second challenge in animal conditioning, namely that not all types of stimuli can be effectively paired with each type of resource or behaviour. For example, wild rats were observed to avoid eating the food that made them sick, but not to avoid coming to the place that made them sick [43, 44]. In cases where illness-inducing substances are used, limited effectiveness might also be the result of the animals having associated the smell of the substance (and not the prey) with the illness [42, 45, 46]. Especially mammalian predators are quick to learn associations between (unintended) olfactory cues and following rewards or punishments, although pre-exposure to the smell might provide

a solution in this case [32]. Third, animals could learn to overcome the aversive stimulus and even start to use it as a cue for resource availability, i.e. the “dinner bell” effect [47]. Lastly, the social system of animals may limit the effectiveness of conditioning interventions, as social interactions can modify the learned aversions of individuals [48].

Unsurprisingly, there is no clear agreement on the overall effectiveness of conditioning interventions in reducing HWC. Moreover, based on field trials with livestock predating carnivores, conditioning interventions are often deemed unsuccessful [9, 10, 13]. Differences in outcomes are explained by differences in methodology, context, conditioned behaviour, species traits and individual traits. But studies have also been criticised for lacking internal validity, by using a too small sample size and not using an (appropriate) control [9, 49], and for lacking external validity, by using captive instead of wild animals or by focussing too much on one (type of) species [9, 11, 40]. To facilitate effective and minimally invasive reduction of HWC with free-ranging vertebrates, it is thus necessary to better understand if and when conditioning interventions in HWC are indeed effective. First, it should be assessed whether there is enough (high-quality) evidence available to evaluate overall effectiveness of conditioning in free-ranging vertebrates, by synthesising existing conditioning intervention studies in a systematic map [50]. If there is sufficient evidence, a systematic map can provide a global evidence base for the premise of animal conditioning as a wildlife intervention technique. Second, systematic reviews based on potential evidence clusters highlighted by this map may subsequently assess if animal conditioning is an intervention technique worth

pursuing overall, if it should be restricted for use in certain species or behaviours, or if resources might be better invested elsewhere.

Stakeholder engagement

The topic of HWC reduction using animal conditioning techniques was first identified during discussions with an international group of fellow behavioural/conservation ecologists in a joined Collaboration for Environmental Evidence (CEE) training workshop (Oct 2017). Subsequently, an Advisory Team was established (i.e. the co-authors), comprising experts in behavioural ecology, animal cognition, conservation biology, conservation planning and specifically HWC. The Advisory Team includes staff of the Institute for Conservation Research of San Diego Zoo and WWF-Netherlands. It also includes participants of the workshop, who contributed to the search strategy and will be part of the consistency checking process. All Advisory Team members contributed to the lists of search terms, inclusion/exclusion criteria, literature, specialist websites and contact persons. Moreover, the complete Advisory Team ensured that the primary question turned out to be as relevant (for practitioners) and comprehensive (for a systematic map) as practically feasible.

Objectives of the map

With the proposed map we mean to provide an extensive evidence base of existing studies on the effectiveness of animal conditioning interventions in reducing HWC with free-ranging vertebrates. The map is the first step towards a systematic review on this topic and we will use it to identify evidence clusters (appropriate

subtopics/subcategories for systematic review) and potential effect modifiers. Additionally, we aim to identify evidence gaps as a basis for recommendations for relevant future research directions. This systematic map protocol has been structured following the ROSES reporting standards [51, 52], see Appendix 1.

Primary question

Are animal conditioning techniques effective in reducing Human-Wildlife-Conflict with free-ranging vertebrates?

Secondary questions

(1) Over what **period of time** are animal conditioning techniques generally effective in reducing Human-Wildlife-Conflict?

(2) Are animal conditioning techniques more or less effective in reducing specific categories of Human-Wildlife-Conflict, such as ***crop raiding*** versus ***egg predation*** versus ***livestock predation***?

Components of the primary question

The primary question can be broken down to the following PICO components:

Population (P) All free-ranging vertebrate species, known to be involved in HWC. Subjects should be free-ranging during the quantification of the outcome.

Intervention (I) Non-lethal techniques that have conditioning of the animal as goal (e.g. aversive conditioning, positive reinforcement) or have conditioning of the animal as a potential consequence (e.g. disruptive stimuli, such as deterrents and repellents). Overall, deterrents serve to ‘hinder’, while repellents serve to ‘avert’ at the moment of intervention. However, disruptive stimuli lie on a continuum and all these stimuli may (unintentionally) lead to learned aversions. Therefore, we will include all applications of above-mentioned stimuli under the condition that the authors quantified a potential change of behaviour **after** the intervention.

Comparator (C) No intervention (as described above) in time, space or both. Alternative interventions (e.g. killing, translocation and fencing) in time, space or both.

Outcome (O) Reduction in: human-wildlife incidents (e.g. undesired close encounters, attacks and kills), livestock predation, depredation of eggs or animals with a high conservation value, damage to anthropogenic goods or food resources (e.g. crop raiding, beehive destruction and car break-ins) and visitations to specific (human-populated) areas.

Methods

Searches

Search string

A list of relevant search terms and initial HWC research and review articles was compiled by the Advisory Team. Subsequently, we used these and 'snowballed' articles to generate word frequency lists and complement the initial search term list with frequently used HWC terms. We formatted the initial search string for Web of Science following Boolean-style and structured it using derivatives of two of the four PICO elements: Intervention (e.g. Condition* = conditioned, conditioning etc) and Outcome (e.g. Depredat* = depredation, depredated etc). These search terms are combined using the Boolean operators "OR" and "AND" (Table 1). The asterix (*) is used to represent any number of additional characters, including no character, and the dollar sign (\$) to only include a maximum of one more character. Quotation marks (""") are used to allow for the search of exact phrases (including hyphenated variations). Terms combined using 'NEAR/5', allows the search of terms that occur within five words apart from each other.

Simplified search strings will be developed for databases and search engines that do not accept the elaborate search string proposed in Table 1. All adjustments and variations of the search string, together with the corresponding database and/or search engine name will be recorded. For databases, search engines and website searches, only English search strings will be used. If articles include publications from other languages, but include a relevant abstract in English, they will be recorded separately. A database will be compiled, including the references of all the returned publications. Search comprehensiveness will be evaluated with an a-priori list of 23 benchmark articles of which 20 are available in Web of Science (Appendix 2). The list was compiled via stakeholder suggestions, pilot searches on Google

Scholar and snowballing HWC review paper reference lists. The final percentage of benchmark articles retrieved via our search strategy will be reported.

With our search strategy we aim to retrieve studies published as primary literature in scientific journals, as well as those published as grey literature (e.g. PhD theses, NGO reports). We do this to be as inclusive as possible and to reduce the influence of a publication bias that is often associated with journal publications, i.e. an over-representation of articles reporting significant effects of conflict interventions [11]. The quality of the studies will be evaluated during the critical appraisal phase and will not be based on the venue of publication (e.g. High-Impact journals). If the time-span between the initial search and the target date for final submission of the systematic map were to exceed two years, literature-update searches will be conducted to check for new published studies. After the final publication, we intend to update the map approximately every five years.

Table 1. Composition of the initial Boolean-style full search string for Web of Science (WoS), leading to 11,800 search results, including 20/20 of the “benchmark” articles available in WoS.

Search string
(I) TI=("Aversive conditioning" OR "Positive conditioning") OR TS=((Banger\$ OR (Bear NEAR/3 spray) OR "Capsicum spray" OR Conditioning OR Conditioned OR CTA OR Diversionary OR Flare\$ OR Hazing OR "Illness inducing" OR "Non-lethal management" OR Pinger\$ OR "Rubber bullets" OR Collar* OR Slingshot\$ OR "Taste aversion" OR Train* OR Vexing) AND

(O) (Cattle predation OR Collision\$ OR Crop-raid* OR (Wildlife NEAR/5 Damage) OR Depredati* OR Deterr* OR Food-condition* OR Habituat* OR (Human NEAR/5 Coexistence) OR (Human NEAR/5 Conflict) OR HWC OR Human-Animal OR Human-Wildlife OR Human/Wildlife OR (Predat* NEAR/5 Livestock) OR (Predat* NEAR/5 Nest) OR (Predat* NEAR/5 Egg) OR Nuisance OR (Problem NEAR/5 Animal) OR Repell* OR Retalliat*)) **AND**

SU=("Life Sciences Biomedicine" OR "Zoology")

TI = Title, TS = Topic, SU = Research area

Bibliographic databases

We will search the following online bibliographic databases, using the institutional access provided by the host-institutes of the Advisory Team. We will search “All Databases”, however, where possible, searches will exclude articles from clearly irrelevant research fields, such as Physical Sciences and Arts, for example by adding SU = “Life Sciences Biomedicine” and “Zoology” in Web of Science. Such specifications will be documented.

1. ISI Web of Science Core Collection - Database for Scientific Literature and Data -
[<https://webofknowledge.com>]
2. Scopus - Database for Peer-Reviewed Literature - [<https://www.scopus.com>]
3. BioRxiv - The Preprint Server for Biology - [<https://www.biorxiv.org/>]
4. ProQuest - Dissertation and Theses Dissemination and Ordering - [<http://www.proquest.com/>]
5. AGRICOLA - Agriculture Research Database -
[<https://www.ebsco.com/products/research-databases/agricola>]

Search engines

We will use Google Scholar to search the internet for relevant articles. Google Scholar Search is limited to one 'phrase' (enclosed in double quotation marks), one OR substring and 256 characters. Our search string will therefore be adjusted accordingly, creating multiple search strings. All these strings and the number of hits will be recorded. The first 50 hits per search string, sorted by relevance, will be examined. Additional relevant specialist websites identified by this method will be listed. Searches will be made with cookies and browser history cleared and using private 'incognito' settings in Google Chrome.

Specialist websites and databases

The Advisory Team compiled the following list of specialist websites and databases (Appendix 3). These websites will be screened intensively and specialists will be contacted if there is evidence for (unpublished) HWC studies that might involve conditioning techniques or outcomes. This list is not final as additional relevant websites might be encountered throughout the mapping process.

Other literature sources

We will consult stakeholders within the network of our Advisory Team for relevant published and unpublished material. An open request will be made on ResearchGate, LinkedIn and Twitter for additional highly relevant material, including publications in other languages. If relevant non-English papers are identified an additional (open) request will be made for a researcher speaking the language to enter the associated metadata in English. Reference lists of literature included at the

final full text stage will be scanned for relevant missed articles and, if possible, such articles will be retrieved.

Search record log

Any adjustments of the proposed search string in Table 1 will be documented and for each search the total number of hits per unique platform/literature source will be recorded, together with the date of the search. The percentage of benchmark articles returned will be recorded for all platforms combined. Additional relevant (unpublished) material put forward by stakeholders and specialists and additional publications identified by scanning the reference lists of included articles will be reported.

Reference management and literature reference archive

References of articles will be exported per search platform to separate Zotero databases (Roy Rosenzweig Center for History and New Media, Fairfax, USA). Subsequently, when searches for all platforms are complete, the Zotero references will be exported as one RIS database per search string and platform to CADIMA version 1.7.6 (Julius Kühn-Institut, Quedlinburg, Germany), an open-access evidence synthesis tool and database [53]. CADIMA will be used to identify and remove duplicates. The resulting database will be the reference database (i.e. reference archive) for this systematic map and any subsequent systematic reviews following this map. Next, CADIMA will be used to screen for relevant titles and abstracts. Any missing full texts of articles included after abstract screening will be actively searched for and, if possible, retrieved using institutional access of the

Advisory Team and expert stakeholders or by contacting the first and final author (for publications < 10 years).

Article screening and inclusion criteria

Screening process

The retrieved literature will first be screened on basis of their title and abstract and finally the full text. Consistency of screening will be checked within CADIMA before the official screening of the titles and abstracts. Two reviewers will evaluate a random subset of 10% of the articles at each of the two stages (max 100 articles at title and abstract stage and 50 at full text stage). Consistency of article inclusion will be analysed using the Kappa score and will be deemed acceptable with a Kappa score of 0.6 or higher. Discrepancies will be discussed, irrespective of the score, but the check will be repeated with adjusted criteria definitions if the score falls below 0.6. When the score is 0.6 or higher the primary reviewer will continue with screening all the article titles and abstracts. The process will then be repeated for article full texts. Inclusion will be conservative, meaning that when we are in doubt, an article will be included to be reviewed in the next stage. Articles with relevant titles but no abstract will automatically transfer to the full text screening stage.

Inclusion criteria

Population relevance: All vertebrate species (excluding humans) involved in HWC. Animals should be free-ranging at the time of the outcome measure. This includes translocated or reintroduced animals that are known to have a high probability of becoming involved in HWC.

Intervention relevance: All methods that can consequently result in conditioning of the animal. This does not have to be a method that was intentionally designed for the purpose of conditioning. For example, a repellent, such as bear spray, is designed for immediate aversion of conflict, but could have as a consequence that the bear reduces its overall tendency to approach people.

Comparator presence: The study should include a control group, comprising before versus after treatment, treatment versus no intervention or treatment versus a clearly different intervention. Effectiveness of the conditioning intervention should be evaluated using behavioural data collected only after the intervention. Otherwise, changes in behaviour cannot conclusively be assigned to the animal conditioning or learning (i.e. forming a new association between the existing resource or behaviour and a reward or punishment).

Outcome relevance: The animals should be free-ranging at the time of the outcome measurement. Precursor behaviours, i.e. those behaviours that are essential for the 'problem behaviour' to arise (approach before attack and attack before kill), will be included.

Study design and data availability: Only when the article includes quantitative data on effectiveness it will be included, with the exception of meta-analyses. Review, opinion, comment and discussion papers will be excluded. The study should at the very least include a Before-After (BA) design or Control-Impact (CI) design

and articles reporting on purely correlative studies will not be included. Articles will be included independent of study sample size, but the sample size, together with the presence/absence of randomization and the study design, will be documented in the metadata and used for critical appraisal.

Language and date: Only studies in English will be evaluated, unless highly relevant publications in other languages are proposed by experts/stakeholders. When such publications can be reliably translated (see above) they will be included as well. No date restrictions will be applied.

All inclusion/exclusion decisions will be documented and made publicly available together with the literature reference archive and search records. When the same study is published twice, for example via a thesis and via a publication, the most recent publication will be included.

Critical appraisal of study validity

The evidence base as a whole, but not individual studies, will be critically appraised on a basic descriptive level. However, metadata for extensive critical appraisal of individual studies will be collected (Appendix 4) for use in potential subsequent systematic reviews on knowledge clusters identified by this map. These metadata include: sample size, presence of randomization and study design. Consistency of the critical appraisal scores will be checked in CADIMA by two reviewers appraising 10% of the studies (max 50 studies). We will create bar graphs visualizing the number of studies per unique research design (e.g. BA, CI, BACI) and we will create frequency histograms to visualize variation in sample size among studies. If the data

permit we will subdivide these data per species family, type of problem behaviour, conditioning technique and/or stimulus type. Additionally, we will pay special attention to the correspondence between the reported problem behaviour and the outcome measurement. For example, when the primary problem is an animal killing livestock, the quantified outcome should ideally be closely related to attack or kill behaviour, and not merely be eating behaviour. When an animal can be conditioned to stop consuming a dead sheep, it does not necessarily mean the animal will not attack and kill a live sheep. We will therefore discuss and graphically represent how many of the included studies show a potential mismatch between the problem behaviour and quantified outcome behaviour.

Data coding strategy

Metadata will be collected on a variety of aspects of the study, including bibliographical information, study year & location characteristics, population characteristics, problem behaviour characteristics, intervention & outcome characteristics, study design & comparator information and any additional remarks. See Appendix 4 for a complete overview. To evaluate consistency of data extraction a second reviewer will additionally fill in the datasheet for ten publications. Any discrepancies will be discussed before further extraction and if necessary definitions of variables will be refined and/or codes adjusted.

Data synthesis and presentation

A narrative synthesis will be made of the included studies. In this synthesis the availability of the evidence in respect to the main research question and the two

sub-questions, as well as specific metadata variables (e.g. species, social system, intervention type, study-design) will be discussed. Where useful, descriptive statistics will be provided and one or more study-frequency heat-maps will be created to visualise the potential presence of evidence clusters and gaps in the evidence base. In the narrative synthesis we aim to discuss whether the identified evidence clusters might be suitable for systematic review. Based on the included studies, we will also discuss potentially important effect modifiers to be included in a subsequent systematic review. We will pay special attention to factors already mentioned in previous studies to potentially affect effectiveness of conditioning (see Introduction), such as the social system of the subject species, the specific combination of types of unconditioned stimulus and conditioned stimulus or behaviour, frequency and duration of stimulus pairing and order and time between occurrence of conditioned stimulus or behaviour and unconditioned stimulus presentation. Finally, we will discuss any identified evidence gaps and will suggest potential relevant avenues for future research on this topic. Special attention will be paid to avoid vote-counting and discussions on the overall effectiveness of conditioning interventions. Together with the narrative synthesis, we will create an interactive geographic map of the results (i.e. evidence atlas), which will show the geographical spread of the evidence within the literature. We will also make a MS-Excel database available that includes all the extracted metadata (see Appendix 3). Finally, a flow diagram of the mapping process will be presented and all data related to search strategy, consistency checking and other intermediate steps in the mapping process (as made available by CADIMA) will be published together with the narrative.

We confirm that none of the reviewers (co-authors) has published or gathered field data themselves on the effectiveness of conditioning interventions in reducing HWC or would otherwise be biased towards the evaluation of the evidence.

Authors' contributions

L.S. specified the systematic map topic with input from F.H.. L.S. wrote the main body of the protocol. All authors contributed to the list of search terms, literature sources and inclusion criteria. All authors commented on a draft of the protocol and all agreed to its final version.

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Competing interests

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Appendix 3

List of Specialist Websites and Databases

1. Animal Damage Control (ADC, under the USDA) -
[\[https://www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/\]](https://www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/)
2. Australia Government Publications -
[\[https://www.australia.gov.au/about-government/publications\]](https://www.australia.gov.au/about-government/publications)
3. Canadian Parks and Wilderness Society - [\[http://cpaws.org/\]](http://cpaws.org/)
4. Center for Conservation and Research - [\[http://www.ccrsl.org/\]](http://www.ccrsl.org/)
5. Chester Zoo Scientific Publications and Reports -
[\[http://www.chesterzoo.org/conservation-and-science/resources\]](http://www.chesterzoo.org/conservation-and-science/resources)
6. Commonwealth Scientific and Industrial Research Organisation (CSIRO) -
[\[https://www.csiro.au/en/Publications\]](https://www.csiro.au/en/Publications)
7. Conservation Evidence [\[www.conservationevidence.com\]](http://www.conservationevidence.com)
8. Danish Centre for Environment and Energy - [\[http://dce.au.dk/en/\]](http://dce.au.dk/en/)
9. Database Carnivore Ecology and Conservation - [\[www.carnivoreconservation.org\]](http://www.carnivoreconservation.org)
10. Defenders of Wildlife - [\[https://defenders.org/publications\]](https://defenders.org/publications)
11. Department of Environmental Science, Policy and Management, University of California Berkeley - [\[https://ourevironment.berkeley.edu/\]](https://ourevironment.berkeley.edu/)
12. Department of Renewable Resources , Government of the Northwest Territories, Canada -
[\[http://www.enr.gov.nt.ca/en/resources\]](http://www.enr.gov.nt.ca/en/resources)
13. Environment and Climate Change Canada -
[\[https://www.canada.ca/en/environment-climate-change.html\]](https://www.canada.ca/en/environment-climate-change.html)
14. European Commission Joint Research Centre - [\[https://ec.europa.eu/jrc/en\]](https://ec.europa.eu/jrc/en)
15. European Environment Agency - [\[https://www.eea.europa.eu/\]](https://www.eea.europa.eu/)
16. Fauna & Flora International - [\[https://www.fauna-flora.org/documents\]](https://www.fauna-flora.org/documents)
17. Federal Office for the Environment (FOEN) Switzerland -
[\[https://www.bafu.admin.ch/bafu/en/home.html\]](https://www.bafu.admin.ch/bafu/en/home.html)

18. Finland's Environmental Administration - [<http://www.environment.fi/en-US>]
19. Food and Agriculture Organisation of the United Nations - [<http://www.fao.org/publications/en/>]
20. Get Bear Smart Society – [<http://www.bearsmart.com/>]
21. Institute for Wildlife Studies [<http://www.iws.org/>]
22. IUCN-Directory of Specialist Groups, Red List Authorities, Task Forces of the Species Survival Commission (SSC) - [<https://www.iucn.org/ssc-groups>]
23. IUCN-Human Wildlife Conflict Task Force (HWCTF) Document Library - [<http://www.hwctf.org/resources/document-library>]
24. IUCN-World Commission on Protected Areas (WCPA) [<https://www.iucn.org/theme/protected-areas/publications/>]
25. IVL Swedish Environmental Research Institute - [<https://www.ivl.se/english/startpage/pages/publications.html>]
26. Kenya Wildlife Service - [<http://www.kws.go.ke/>]
27. Little Blue Society - Human-Animal Conflict Resolution [<http://www.littlebluesociety.org>]
28. Ministry of the Environment New Zealand - [<http://www.mfe.govt.nz/>]
29. Nature Conservation Foundation - [<http://ncf-india.org/>]
30. National Wildlife Research Center - (NWRC, under the USDA) [https://www.aphis.usda.gov/aphis/ourfocus/wildlifedamage/programs/nwrc/sa_publications/ct_research_gateway]
31. Norwegian Directorate for Nature Management and the Ministry of Agriculture - [<http://www.nsd.uib.no/polsys/data/en/forvaltning/enhet/19804/litteratur>]
32. OECD iLibrary - [<http://www.oecd-ilibrary.org/>]
33. Panthera - [<https://www.panthera.org/science-center>]
34. Parks Canada - [<https://www.pc.gc.ca/en/index>]
35. Research Institute for Agriculture, Fisheries and Food - [<http://www.ilvo.vlaanderen.be/language/en-US/EN/Research.aspx#.WnRSwa7ibIU>]

36. Ruaha Carnivore Project, Iringa, Tanzania -
[<http://www.ruahacarnivoreproject.com/research/scientific-publications/>]
37. Swedish Environmental Protection Agency - [<http://www.swedishepa.se/#>]
38. The Nature Conservancy - [<https://www.nature.org/>]
39. UK Government Publications - [<https://www.gov.uk/government/publications>]
40. Umweltbundesamt (Federal Environment Agency Germany) -
[<https://www.umweltbundesamt.de/en/publications>]
41. United Nations Environment Programme - [<https://www.unenvironment.org/>]
42. US Environmental Protection Agency - [<https://www.epa.gov/>]
43. US Fish & Wildlife Service - [<https://www.fws.gov/>]
44. US Government Publications - [<https://www.science.gov/>]
45. US National Park Services - [<https://www.nps.gov/>]
46. W.A. Franke College of Forestry & Conservation, University of Montana -
[<http://www.cfc.umt.edu/research/default.php>]
47. WildCRU - [<https://www.wildcru.org/research/theme/all-projects/>]
48. Wildlife Conservation Society - [<https://library.wcs.org/>]
49. WildSmart – [<http://www.wildsmart.ca/>]
50. WWF - [<https://www.worldwildlife.org/>]
51. Yale School of Forestry and Environmental Studies - [<http://environment.yale.edu/>]
52. Zoological Society London (ZSL) -
[<https://www.zsl.org/science/publications/scientific-publications>]