

# **Effects of conservation interventions on bats: a protocol for subject-wide evidence synthesis (2021 edition)**

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## Abstract

Bats are under pressure from multiple threats, including habitat loss and modification, disease, hunting, persecution and climate change, and many species are declining in number. There is therefore an increasing need for evidence-based conservation of bat populations. Reviewing the evidence can be a time-consuming and costly exercise. In general, the assessment of the evidence-base is approached on a case-by-case basis and different stakeholders independently conduct evidence reviews relative to their specific application or enquiry. This approach is counter to the philosophy of ‘produce once and use many times over’ and is a highly inefficient use of resources. In 2014, we used a subject-wide evidence synthesis approach to produce the Bat Conservation Synopsis, which summarised the available evidence for the effectiveness of the wide range of conservation interventions for bats. We updated the synopsis in 2019 and 2020 to incorporate new research, and we aim to publish a fourth edition in early 2021 to ensure that decision-makers have access to the most recent evidence. This protocol outlines the methods that will be used to synthesize evidence and update the existing Bat Conservation Synopsis.

**Key Words:** subject-wide evidence synthesis, bats, conservation, intervention, management

## Background

Bats represent approximately one fifth of all mammal species with over 1,400 bat species currently known to science (Simmons & Cirranello 2019). They are also the most widely distributed order of terrestrial mammals occupying all areas of the world except the Arctic and Antarctica, although the greatest bat diversity is found in the tropics. Bats provide vital ecosystem services with ecological and economic benefits, such as pest suppression, pollination and seed dispersal (e.g. Boyles et al. 2011, Kunz et al. 2011). However, the life history of bats (typically low fecundity) makes them particularly vulnerable to extinction, and widespread population declines have been documented over the last few decades (e.g. Frick et al. 2019). Many bat species are threatened, particularly by anthropogenic impacts such as logging and deforestation, agriculture, urban and industrial development, pollution, hunting and persecution (e.g. see Voigt & Kingston 2016, Frick et al. 2019). Climate change and extreme weather events, such as heat waves and tropical storms, are also a threat to bats (e.g. Sherwin et al. 2013).

Five bat species are listed as extinct by the International Union of Conservation for Nature (IUCN) and almost one-fifth of bat species (18%) assessed by the IUCN are considered threatened (Frick et al. 2019). However, the actual number may be far greater given that insufficient data are available to assess the conservation status for a further 15% of bat species listed by the IUCN and many newly discovered species are not yet classified or included on the IUCN red list. Conservation efforts have been successful in reversing population declines for some species, and even preventing species extinctions. For example,

the lesser long-nosed bat was recently removed from endangered species lists in both the USA and Mexico after populations recovered following bat-friendly farming initiatives, education programs and roost protection (US Fish & Wildlife Service 2016).

Evidence-based knowledge is key for planning successful conservation strategies and for the cost-effective allocation of scarce conservation resources. Targeted reviews may be carried out to collate evidence on the effects of a particular conservation intervention, but this approach is labour-intensive, expensive and ill-suited for areas where the data are scarce and patchy. There is a paucity of evidence within the literature for the effectiveness of conservation interventions aimed at bats. As a result, very few targeted reviews exist, and those that do exist are inconclusive or limited in scope.

In 2014, we published the Bat Conservation Synopsis to collate evidence for bat conservation on a global scale (Berthinussen et al. 2014). We used a subject-wide evidence synthesis approach (Sutherland et al. 2019, Sutherland & Wordley 2018) to simultaneously summarize the evidence for the wide range of interventions dedicated to the conservation of bats. By simultaneously targeting all potential interventions for bats, we were able to review the evidence for each intervention cost-effectively and efficiently. The synopsis is freely available at [www.conservationevidence.com](http://www.conservationevidence.com) and, alongside the *Conservation Evidence* online database, provides a valuable asset to the toolkit of practitioners and policy makers seeking sound information to support bat conservation. We aim to periodically update the synopsis to incorporate new research and ensure that the most recent evidence is available to decision-makers. Updates were published in 2019 (Berthinussen et al. 2019) and 2020 (Berthinussen et al. 2020), and a third update is planned for early 2021. This protocol outlines the methods that will be used to update the existing Bat Conservation Synopsis.

## Scope of the review

### 1. Review subject

This synthesis focuses on updating the evidence for the effectiveness of global interventions for the conservation of bats. New evidence will be added to the existing Bat Conservation Synopsis (Berthinussen et al. 2020), which was produced using a subject-wide evidence synthesis approach. This is defined as a systematic method of evidence synthesis that covers entire subjects at once, including all closed review topics within that subject at a fine scale and analysing results through study summary and expert assessment, or through meta-analysis; the term can also refer to any product arising from this process (Sutherland et al. 2019).

This synthesis covers evidence for the effects of conservation interventions for wild bats (i.e. not in captivity). We will not include evidence from the literature on husbandry of commercially reared bats or those kept in zoos. However, where these interventions are relevant to the conservation of wild declining or threatened species, they will be included,

e.g. captive breeding for the purpose of reintroductions. For this synthesis, conservation interventions will include management measures that aim to conserve wild bat populations and ameliorate the deleterious effects of threats. The output of the project will be an authoritative, freely accessible evidence-base that will support bat conservation objectives with the latest evidence and help to achieve conservation outcomes.

## **2. Advisory board**

An advisory board made up of international conservationists and academics with expertise in bat conservation has been formed. These experts will input into the synopsis update at three key stages: a) reviewing the protocol including identifying key sources of evidence, b) updating the comprehensive list of conservation interventions for review, and c) reviewing the updated draft evidence synthesis. The advisory board is listed above, although additional experts may be added during the production of the synopsis update. The final list will be published in the synopsis document and online (<https://www.conservationevidence.com/site/page?view=methods>).

## **3. Creating the list of interventions**

For the existing Bat Conservation Synopsis (Berthinussen et al. 2020), a comprehensive list of interventions was developed by searching the literature and in partnership with the advisory board. The list was also checked by Conservation Evidence to ensure that it followed the standard structure. This list will be reviewed for the synopsis update, and edited or additional interventions added if relevant. The aim is to include all interventions that have been carried out or advised to support populations or communities of wild bats, whether evidence for the effectiveness of an intervention is available or not. During the update process further interventions may also be discovered, which will be integrated into the synopsis structure. The list of interventions will be organized into categories based on the IUCN classifications of direct threats (<http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme>) and conservation actions (<http://www.iucnredlist.org/technical-documents/classification-schemes/conservation-actions-classification-scheme-ver2>).

# **Methods**

Any new evidence found during the synopsis update will be summarised and added to the existing Bat Conservation Synopsis (Berthinussen et al. 2020). Methods for this update will follow those used for the existing Bat Conservation Synopsis as described below.

## **1. Literature searches**

Literature will be obtained from the Conservation Evidence discipline-wide literature database, and from searches of additional subject specific literature sources. The Conservation Evidence discipline-wide literature database is compiled using systematic searches of journals (all titles and abstracts) and report series ('grey literature'); relevant

publications describing studies of conservation interventions for all species groups and habitats are saved from each and are added to the database.

**a) *Global evidence***

Evidence from all around the world will be included.

**b) *Languages included***

The following non-English journals published in Spanish and Portuguese were searched for the existing Bat Conservation Synopsis (Berthinussen et al. 2020) and relevant papers extracted. Due to project constraints, update searches of these journals will not be carried out on this occasion. However, we will aim to update them periodically in the future.

- *Therya* Vol. 1, Issue 1 (2010) – Vol. 8, Issue 3 (2018)
- *Galemys* Vol. 1 (2011) – Vol. 7 (2017)
- *Boletim da Sociedade Brasileira de Mastozoologia* Vol. 66 (2013) – Vol. 78 (2017)
- *Mastozoologia Neotropical* Vol. 1, Issue 1 (1994) – Vol. 24, Issue 1 (2017)
- *Chiroptera Neotropical* Vol. 1, Issue 1 (1995) – Vol. 21, Issue 2 (2015)
- *Mammalogy Notes* Vol. 1, Issue 1 (2014) – Vol. 4, Issue 1 (2017)
- *Revista Mexicana de Mastozoología* Vol. 1 (1995) – Vol. 7, Issue 2 (2017)

Since the last update, over 140 additional journals published in Spanish, Portuguese, German, Russian, Japanese and Persian have also been searched by other authors and relevant papers added to the Conservation Evidence discipline-wide literature database (see below).

All other journals searched are published in English (see below).

**c) *Journals searched***

All journals (and years) listed in Appendix 1 (English journals) and Appendix 2 (non-English journals) have been searched and relevant papers added to the Conservation Evidence discipline-wide literature database. Those published up until the end of 2018 were included in the existing Bat Conservation Synopsis (Berthinussen et al. 2020). More recent relevant papers will be included in this update. An asterisk indicates the journals most relevant to this synopsis. Others are less likely to have included relevant papers, but if they did, they have previously been or will be summarised.

For this update, additional searches up to the end of 2019 will be undertaken for journals likely to yield studies for bats (marked with an asterisk in Appendix 1). No new journal searches will be undertaken as the specialist journals most likely to yield studies relevant to bat conservation are already included.

**d) Reports from specialist websites searched**

**i) From Conservation Evidence discipline-wide literature database**

All report series (and years) below have already been searched for the Conservation Evidence project and relevant studies were included in the existing Bat Conservation Synopsis (Berthinussen et al. 2020). An asterisk indicates the report series most relevant to this synopsis. Others are less likely to have included reports relevant to this synopsis, but if they did they have been summarised.

- |  |           |                 |
|--|-----------|-----------------|
| • Amphibian Survival Alliance            | 1994–2012 | Vol 9 – Vol 104 |
| • British Trust for Ornithology          | 1981–2016 | Report 1–687    |
| • IUCN Invasive Species Specialist Group | 1995–2013 | Vol 1 – Vol 33  |
| • Scottish Natural Heritage              | 2004–2018 | Reports 1–945   |

**ii) Specific searches for the Bat Conservation Synopsis**

The following specialist reports/websites relevant to bat conservation have already been searched for the existing Bat Conservation Synopsis (Berthinussen et al. 2020). Searches were carried out either by searching every report title and abstract or summary within each report series or relevant category, or using key words, and any relevant reports were added to the project database. For this update, all specialist reports/websites listed below will be searched up to the end of 2019.

- Bat Conservation International ([www.batcon.org](http://www.batcon.org), resources searched)
- Bat Conservation Trust, UK ([www.bats.org.uk](http://www.bats.org.uk), resources searched)
- Rufford Foundation, UK ([www.rufford.org](http://www.rufford.org), report titles searched for category ‘Bats’)
- The Vincent Wildlife Trust, UK ([www.vwt.org.uk](http://www.vwt.org.uk), report titles searched for category ‘Bats’)
- Scottish Natural Heritage, UK ([www.nature.scot/information-library-data-and-research/information-library](http://www.nature.scot/information-library-data-and-research/information-library), database of report titles searched using key word ‘bat\*’)
- Natural England, UK ([publications.naturalengland.org.uk](http://publications.naturalengland.org.uk), database of report titles searched for category ‘Species – Mammals – Bats’)
- Department for Food, Environment and Rural Affairs (Defra) Science and Research projects, UK ([sciencesearch.defra.gov.uk](http://sciencesearch.defra.gov.uk), database of report titles searched using key word ‘bats’)

**e) Other literature searches**

The online database ([www.conservationevidence.com](http://www.conservationevidence.com)) will be searched for relevant publications that have already been summarised.

Where a systematic review is found for an intervention, if the intervention has a small literature (<20 papers), all publications including the systematic review will be summarised. If the intervention has a large literature (≥20 papers), then only the systematic review and any publications published since the review will be summarised. Where a non-systematic review

(or editorial, synthesis, preface, introduction etc.) is found for an intervention, all relevant publications referenced within it will be included, but the review itself will not be summarised. However, if the review also provides new/collective data, then the review itself will also be included/summarised (indicating which other summarized publications it includes). Relevant publications cited in other publications summarised for the synopsis will not be included (due to time restrictions).

***f) Supplementary literature identified by advisory board or relevant stakeholders***

Additional journal or specialist website searches, and relevant papers or reports suggested by the advisory board or relevant stakeholders will also be included, where time permits.

Additional searches may be added during the production of the synopsis update. The final list of evidence sources searched for this synopsis will be published in the synopsis document (including a summary using Appendix 3), and the full list of journals and report series searched published online ([www.conservationevidence.com/journalsearcher/synopsis](http://www.conservationevidence.com/journalsearcher/synopsis)).

***g) Search record database***

A database will be created of all relevant publications found during searches. Reasons for exclusion will be recorded for all those included during screening that are not summarised for the synopsis.

## **2. Publication screening and inclusion criteria**

A summary of the total number of evidence sources and papers/reports screened will be published in the updated synopsis using the diagram in Appendix 3.

***a) Screening***

To ensure consistency/accuracy when screening publications for inclusion in the literature database, an initial test using the Conservation Evidence inclusion criteria (provided below) and a consistent set of references was carried out by authors, compared with the decisions of the experienced core Conservation Evidence team. Results were analysed using Cohen's Kappa test (Cohen 1960). Where initial results did not show 'substantial' ( $K = 0.61-0.8$ ) or 'almost perfect' agreement ( $K = 0.81-1.0$ ), authors were given further training. A second Kappa test will be used to assess the consistency/accuracy of article screening for the first two years of the first journal searched by each author. Again, where results do not show 'substantial' ( $K = 0.61-0.8$ ) or 'almost perfect' agreement ( $K = 0.81-1.0$ ), authors will receive further training before carrying out further searches.

Authors of other synopses who have searched journals and added relevant publications to the Conservation Evidence literature database since 2018, and all other searchers since 2017 have undertaken the initial paper inclusion test described above; searchers prior to that have not. Kappa tests of the first two years searched have been carried out for all new searchers who have contributed to the Conservation Evidence literature database since July 2018.



We acknowledge that the literature search and screening method used by Conservation Evidence, as with any method, will result in gaps in the evidence. The Conservation Evidence literature database currently includes relevant papers from over 300 English language journals as well as over 140 non-English journals. Additional journals are frequently added to those searched, and years searched are often updated. It is possible that searchers will have missed relevant papers from those journals searched. Publication bias will not be taken into account, and it is likely that additional biases will result from the evidence that is available, for example there are often geographic biases in study locations.

### ***b) Inclusion criteria***

The following Conservation Evidence inclusion criteria will be used.

#### **Criteria A: Conservation Evidence includes studies that measure the effect of an intervention that might be done to conserve biodiversity**

1. Does this study measure the effect of an intervention that is or was under the control of humans, on wild taxa (including captives), habitats, or invasive/problem taxa? If yes, go to 3. If no, go to 2.
2. Does this study measure the effect of an intervention that is or was under the control of humans, on human behaviour that is relevant to conserving biodiversity? If yes, go to Criteria B. If no, the study will be excluded.
3. Could the intervention be put in place by a conservationist/decision maker to protect, manage, restore or reduce impacts of threats to wild taxa or habitats, or control or mitigate the impact of the invasive/problem taxon on wild taxa or habitats? If yes, the study will be included. If no, the study will be excluded.

Explanation:

1. a. Study must have a measured outcome on wild taxa, habitats or invasive species: excludes studies on domestic/agricultural species, theoretical modelling or opinion pieces. See Criteria B for interventions that have a measured outcome on human behaviour only.
1. b. Intervention must be carried out by people: excludes impacts from natural processes (e.g. tree falls, natural fires), impacts from background variation (e.g. soil type, vegetation, climate change), correlations with habitat types, where there is no test of a specific intervention by humans, or pure ecology (e.g. movement, distribution of species).
2. Study must test an intervention that could be put in place for conservation. This excludes assessing impacts of threats (interventions which remove threats would be included), unless the threat acts as an appropriate control for an intervention. For example, a woodland that has been cut down/degraded could be compared with woodland that has been left intact to test the intervention 'Retain native woodland'. The test may involve comparisons between sites/factors not originally put in place or modified for conservation but which could be (e.g.

mown vs unmown field margins, fenced vs unfenced cave entrances – where the mowing/fencing is as you would do for conservation, even if that was not the original intention in the study).

If the title and/or abstract are suggestive of fulfilling our criteria, but there is not sufficient information to judge whether the intervention was under human control, the intervention could be applied by a conservationist/decision maker or whether there are data quantifying the outcome, then the study will be included. If the article has no abstract, but the title is suggestive, then a study will be included.

We sort articles into folders by which taxon/habitat they have an outcome on. If the title/abstract does not specify which species/taxa/habitats are impacted, then the full article will be searched and then assigned to folders accordingly.

The outcome for wild taxa/habitats can be negative, neutral or positive, does not have to be statistically significant but must be quantified (if hard to judge from abstract, then it will be included for closer inspection by the synopsis authors). It could be any outcome that has implications for the health of individuals, populations, species, communities or habitats, including, but not limited to the following:

- Individual health, condition or behaviour, including in captivity: e.g. growth, size, weight, stress, disease levels or immune function, movement, use of natural/artificial habitat/structure, range, predatory or nuisance behaviour that could lead to retaliatory action by humans.
- Breeding: egg/sperm production, sperm motility/viability after freezing, artificial fertilization success, mating success, birth rate, pup condition/survival, ‘overall recruitment’.
- Genetics: genetic diversity, genetic suitability (e.g. adaptation to local conditions, use of flyways for migratory species etc.).
- Life history: age/size at maturity, survival, mortality.
- Population measures: number, abundance, density, presence/absence, biomass, movement, cover, age-structure, species distributions (only in response to a human action), disease prevalence, sex ratio.
- Community/habitat measures: species richness, diversity measures (including trait/functional diversity), community composition, community structure (e.g. trophic structure), area covered (e.g. by different habitat types), physical habitat structure (e.g. rugosity, height, basal area).

**Interventions** within the scope of Conservation Evidence include:

- Clear management interventions, e.g. closing a cave to tourism, prescribed burning, mowing, controlling invasive species, creating or restoring habitats
- International or national policies
- Reintroductions or management of wild species in captivity

Protocol registered on 23-07-2020: <https://osf.io/643jy>

- Interventions that reduce human-wildlife conflict
- Interventions that change human behaviour, resulting in an impact on wild taxa or habitats

See <https://www.conservationevidence.com/data/index> for more examples of interventions.

Note on study types:

Literature reviews, systematic reviews, meta-analyses or short notes that review studies that fulfil these criteria will be included.

Theoretical modelling studies will be excluded, as no intervention has been taken. However, studies that use models to analyse real-world data, or compare models to real-world situations will be included (if they otherwise fulfil these criteria).

**Criteria B: Conservation Evidence includes studies that measure the effect of an intervention that might be done to change human behaviour for the benefit of biodiversity**

1. Does this study measure the effect of an intervention that is or was under human control on human behaviour (actual or intentional) which is likely to protect, manage, restore or reduce threats to wild taxa or habitats? If yes, go to 2. If no, the study will be excluded.
2. Could the intervention be put in place by a conservationist, manager or decision maker to change human behaviour? If yes, the study will be included. If no, the study will be excluded.

Explanation:

1. a. Study must have a measured outcome on actual or intentional human behaviour including self-reported behaviours: excludes outcomes on human psychology (tolerance, knowledge, awareness, attitude, perceptions or beliefs)

1. b. change in human behaviour must be linked to outcomes for wild taxa and habitats, excludes changes in behaviour linked to outcomes for human benefit, even if these occurred under a conservation program (e.g. we would exclude a study demonstrating increased school attendance in villages under a community based conservation program)

1. c. Intervention must be under human control: excludes impacts from climatic or other natural events.

2. Study must test an intervention that could be put in place for conservation: excludes studies with no intervention, e.g. correlating human personality traits with likelihood of conservation-related behaviours.

The human behaviour outcome of the study can be negative, neutral or positive, does not have to be statistically significant but must be quantified (if hard to judge from abstract, then

it will be included). It could be any behaviour that is likely to have an outcome on wild taxa and habitats (including mitigating the impact of invasive/problem taxon on wild taxa or habitats). Interventions include, but are not limited to the following:

- Change in adverse behaviours (which directly threaten biodiversity), e.g. unsustainable hunting, burning, grazing, urban encroachment, creating noise, entering sensitive areas, polluting or dumping waste, clearing or habitat destruction, introducing invasive species.
- Change in positive behaviours, e.g. uptake of alternative/sustainable livelihoods, number of households adopting sustainable practices, donations.
- Change in policy or conservation methods, e.g. placement of protected areas, protection of key habitats/species.
- Change in consumer or market behaviour, e.g. purchasing, consuming, buying, willingness to pay, selling, illegal trading, advertising, consumer fraud.
- Behavioural intentions to do any of the above.

**Interventions** which are particularly likely to have a behaviour change outcome include, but are not limited to the following:

- Enforcement: hunting restrictions, market inspections, increase number of rangers, patrols or frequency of patrols in, around or within protected areas, improve fencing/physical barriers, improve signage.
- Behaviour change: promote alternative/sustainable livelihoods, payment for ecosystem services, ecotourism, poverty reduction, increased appreciation or knowledge, debunking misinformation, altering or re-enforcing local taboos, financial incentives.
- Governance: protect or reward whistle-blowers, increase government transparency, ensure independence of judiciary, provide legal aid.
- Market regulation: trade bans, taxation, supply chain transparency laws.
- Consumer demand reduction: increase awareness or knowledge, fear appeals (negative association with undesirable product), benefit appeal (positive association with desirable behaviour), worldview framing, moral framing, employing decision defaults, providing decision support tools, simplifying advice to consumers, promoting desirable social norms, legislative prohibition.
- Sustainable Alternatives: certification schemes, artificial alternatives, sustainable alternatives.
- New policies for conservation/protection.

We allocate studies to folders by their outcome. All studies under Criteria B go in the 'Behaviour change' folder. They are additionally duplicated into a taxon/habitat folder if there is a specific intended final outcome of the behaviour change (if none mentioned, they will be filed only in Behaviour change).

***c) Relevant subject***

Studies relevant to the synopsis subject will include those focused on the conservation of wild, native bats.

***d) Relevant types of intervention***

An intervention has to be one that could be put in place by a manager, conservationist, policy maker, advisor or consultant to protect, manage, restore or reduce the impacts of threats to wild, native bats. Alternatively, interventions may aim to change human behaviour (actual or intentional), which is likely to protect, manage, restore or reduce threats to bat populations. See inclusion criteria above for further details.

If the following two criteria are met, a combined intervention will be created within the synopsis, rather than repeating evidence under all the separate interventions: a) there are five or more publications that use the same well-defined combination of interventions, with very clear description of what they were, without separating the effects of each individual intervention, and b) the combined set of interventions is a commonly used conservation strategy.

***e) Relevant types of comparator***

To determine the effectiveness of interventions, studies must include a comparison, i.e. monitoring change over time (typically before and after the intervention was implemented), or for example at treatment and control sites. Alternatively, a study could compare one specific intervention (or implementation method) against another. For example, this could be comparing the abundance of a bat species before and after woodland is restored, or the reduction in bat mortality at wind turbines with different rotor designs.

Exceptions, which may not have a control but will still be included, are for example the effectiveness of captive breeding or rehabilitation programmes.

***f) Relevant types of outcome***

Below we provide a list of anticipated metrics; others will be included if reported within relevant studies.

- Community response
  - Community composition
  - Richness/diversity
- Population response
  - Abundance: bat activity, number, density, presence/absence, biomass, movement, age-structure, sex ratio
  - Reproductive success: egg/sperm production, artificial fertilization success, mating success, birth rate, pup condition, overall recruitment, age/size at maturity
  - Survival: survival, mortality

- Condition: growth, size, weight, condition factors, biochemical ratios, stress, disease levels or immune function
- Behaviour
  - Uptake
  - Use
  - Behaviour change: movement, use of natural/artificial habitat/structure, range, predatory or nuisance behaviour that could lead to retaliatory action by humans
  - Change in human behaviour
- Other
  - Impact on roost sites

***g) Relevant types of study design***

The table below lists the study designs included. The strongest evidence comes from randomized, replicated, controlled trials with paired-sites and before and after monitoring.

Table 1. Study designs

<b>Term</b>	<b>Meaning</b>
Replicated	The intervention was repeated on more than one individual or site. In conservation and ecology, the number of replicates is much smaller than it would be for medical trials (when thousands of individuals are often tested). If the replicates are sites, pragmatism dictates that between five and ten replicates is a reasonable amount of replication, although more would be preferable. We provide the number of replicates wherever possible. Replicates should reflect the number of times an intervention has been independently carried out, from the perspective of the study subject. For example, 10 plots within a mown field might be independent replicates from the perspective of plants with limited dispersal, but not independent replicates for larger motile animals such as birds. In the case of translocations/release of captive bred animals, replicates should be sites, not individuals.
Randomized	The intervention was allocated randomly to individuals or sites. This means that the initial condition of those given the intervention is less likely to bias the outcome.
Paired sites	Sites are considered in pairs, within which one was treated with the intervention and the other was not. Pairs, or blocks, of sites are selected with similar environmental conditions, such as soil type or surrounding landscape. This approach aims to reduce environmental variation and make it easier to detect a true effect of the intervention.
Controlled*	Individuals or sites treated with the intervention are compared with control individuals or sites not treated with the intervention. (The treatment is usually allocated by the investigators (randomly or not), such that the treatment or control groups/sites could have received the treatment).
Before-and-after	Monitoring of effects was carried out before and after the intervention was imposed.

Site comparison*	A study that considers the effects of interventions by comparing sites that historically had different interventions (e.g. intervention vs no intervention) or levels of intervention. Unlike controlled studies, it is not clear how the interventions were allocated to sites (i.e. the investigators did not allocate the treatment to some of the sites).
Review	A conventional review of literature. Generally, these have not used an agreed search protocol or quantitative assessments of the evidence.
Systematic review	A systematic review follows an agreed set of methods for identifying studies and carrying out a formal 'meta-analysis'. It will weight or evaluate studies according to the strength of evidence they offer, based on the size of each study and the rigour of its design. All environmental systematic reviews are available at: <a href="http://www.environmentalevidence.org/index.htm">www.environmentalevidence.org/index.htm</a>
Study	If none of the above apply, for example a study looking at the number of people that were engaged in an awareness raising project. Or a study measuring change over time in only one site and only after an intervention.

\* Note that "controlled" is mutually exclusive from "site comparison". A comparison cannot be both controlled and a site comparison. However, one study might contain both controlled and site comparison aspects e.g. study of fertilized grassland, compared to unfertilized plots (controlled) and natural, target grassland (site comparison).

### 3. Study quality assessment & critical appraisal

We will not quantitatively assess the evidence from each publication or weight it according to quality. However, to allow interpretation of the evidence, we make the size and design of each study we report clear.

We will critically appraise each potentially relevant study and will exclude those that do not provide data for a comparison to the treatment, do not statistically analyse the results (or if included this will be stated in the summary paragraph) or have obvious errors in their design or analysis. A record of the reason for excluding any of the publications included during screening will be kept within the synopsis database.

### 4. Data extraction

Data on the effectiveness of the relevant intervention (e.g. mean species abundance inside or outside a protected area; reduction in mortality after operational changes to wind turbines) will be extracted from, and summarised for, publications that include the relevant subject, types of intervention, comparator and outcomes outlined above. A summary of the total number of evidence sources and papers/reports searched and the total number of publications included following data extraction will be published in the updated synopsis using the diagram in Appendix 3.



At the start of each month, authors will swap three summaries with another author to ensure that the correct type of data has been extracted and that the summary follows the Conservation Evidence standard format.

## 5. Evidence synthesis

### a) Summary protocol

Each publication will usually have just one paragraph for each intervention it tests describing the study in (usually) no more than 150 words using plain English. Each summary will be in the following format:

A [TYPE OF STUDY] in [YEARS X-Y] in [HOW MANY SITES] in/of [HABITAT] in [REGION and COUNTRY] [REFERENCE] found that [INTERVENTION] [SUMMARY OF ALL KEY RESULTS] for [SPECIES/HABITAT TYPE]. [DETAILS OF KEY RESULTS, INCLUDING DATA]. In addition, [EXTRA RESULTS, IMPLEMENTATION OPTIONS, CONFLICTING RESULTS]. The [DETAILS OF EXPERIMENTAL DESIGN, INTERVENTION METHODS and KEY DETAILS OF SITE CONTEXT]. Data was collected in [DETAILS OF SAMPLING METHODS].

*Type of study - use terms and order in Table 1.*

*Site context - for the sake of brevity, only nuances essential to the interpretation of the results are included. The reader is always encouraged to read the original source to get a full understanding of the study site (e.g. history of management, physical conditions).*

### For example:

A replicated study in 1999–2004 in a wetland on an island in Catalonia, Spain (1) found that all 69 bat boxes of two different designs were used by soprano pipistrelles *Pipistrellus pygmaeus* with an average occupancy rate of 71%. During at least one of the four breeding seasons recorded, 96% of boxes were occupied and occupation rates by females with pups increased from 15% in 2000 to 53% in 2003. Bat box preferences were detected in the breeding season only, with higher abundance in east-facing bat boxes (average 22 bats/box) compared to west-facing boxes (12 bats/box), boxes with double compartments (average 25 bats/box) compared to single compartments (12 bats/box) and boxes placed on posts (average 18 bats/box) and houses (average 12 bats/box). Abundance was low in bat boxes on trees (average 2 bats/box). A total of 69 wooden bat boxes (10 cm deep x 19 cm wide x 20 cm high) of two types (44 single and 25 double compartment) were placed on three supports (10 trees, 29 buildings and 30 electricity posts) facing east and west. From July 2000 to February 2004, the boxes were checked on 16 occasions. Bats were counted in boxes or upon emergence when numbers were too numerous to count within the box.

(1) Flaquer C., Torre I. & Ruiz-Jarillo R. (2006) The value of bat-boxes in the conservation of *Pipistrellus pygmaeus* in wetland rice paddies. *Biological Conservation*, 128, 223–230.

A replicated, randomized, controlled, before-and-after study in 1993–1999 of five harvested hardwood forests in Virginia, USA (2) found that harvesting trees in groups did not result in higher salamander abundances than clearcutting. Abundance was similar between treatments (group cut: 3;



clearcut: 1/30 m<sup>2</sup>). Abundance was significantly lower compared to unharvested plots (6/30 m<sup>2</sup>). Species composition differed before and three years after harvest. There were five sites with 2 ha plots with each treatment: group harvesting (2–3 small area group harvests with selective harvesting between), clearcutting and an unharvested control. Salamanders were monitored on 9–15 transects (2 x 15 m)/plot at night in April–October. One or two years of pre-harvest and 1–4 years of post-harvest data were collected.

- (2) Knapp S.M., Haas C.A., Harpole D.N. & Kirkpatrick R.L. (2003) Initial effects of clearcutting and alternative silvicultural practices on terrestrial salamander abundance. *Conservation Biology*, 17, 752–762.

### ***b) Terminology used to describe the evidence***

Unless specifically stated otherwise, results will reflect statistical tests performed on the data, i.e. we will only state that there was a difference if it was a significant difference or will state that there was no difference if it was not significant. Table 1 above defines the terms used to describe the study designs.

### ***c) Dealing with multiple interventions within a publication***

When separate results are provided for the effects of each of the different interventions tested, separate summaries will be written under each intervention heading. However, when several interventions were carried out at the same time and only the combined effect reported, the result will be described with a similar paragraph under all relevant interventions. The first sentence will make it clear that there was a combination of interventions carried out, i.e. ‘.....(REF) found that [x intervention], along with [y] and [z interventions] resulted in [describe effects]’. Within the results section we will also add a sentence such as: ‘It is not clear whether these effects were a direct result of [x], [y] or [z] interventions’, or ‘The study does not distinguish between the effects of [x], and other interventions carried out at the same time: [y] and [z].’

### ***d) Dealing with multiple publications reporting the same results and reviews***

If two publications describe results from the same intervention implemented in the same space and at the same time, we will only include the most stringently peer-reviewed publication (i.e. journal of the highest impact factor). If one includes initial results (e.g. after year one) of another (e.g. after 1-3 years), we will only include the publication covering the longest time span. If two publications describe at least partially different results, we will include both but make clear they are from the same project in the paragraph, e.g. ‘A controlled study... (Gallagher et al. 1999; same experimental set-up as Oasis et al. 2001)...’.

Basic (i.e. not systematic) reviews will only be summarised if they provide new/collective data; the individual publications will also be summarised to provide full details of each study. Publications identified in all other basic reviews will be obtained and summarised individually (where time allows). Where there is a systematic review of an intervention with a large associated literature ( $\geq 20$  papers), the systematic review will be summarised along

with any papers/reports published since the systematic review. If the intervention has a small literature (<20 papers), all publications including the systematic review will be summarised.

#### ***e) Taxonomy***

Taxonomy will not be updated but will follow that used in the original publication. Where possible, common names and Latin names will both be given the first time each species is mentioned within each summary.

#### ***f) Key messages***

Each intervention for which evidence is found will have a set of concise, bulleted key messages at the top, written once all the literature has been summarised. These will include information such as the number, design and location of studies included.

The first bullet point will describe the total number of studies that tested the intervention and the locations of the studies, followed by key information on the relevant metrics presented under the headings and sub-headings shown below (with number of relevant studies in parentheses for each).

- **X studies** examined the effects of [INTERVENTION] on [TARGET POPULATION]. Y studies were in [LOCATION 1]<sup>1,2</sup> and Z studies were in [LOCATION 2]<sup>3,4</sup>. *Locations will usually be countries, ordered based on chronological order of studies rather than alphabetically, i.e. USA<sup>1</sup>, Australia<sup>2</sup> not Australia<sup>2</sup>, USA<sup>1</sup>. However, when more than 4-5 separate countries, they may be grouped into regions to make it clearer e.g. Europe, North America. The distribution of studies amongst habitat types may also be added here if relevant.*

#### **COMMUNITY RESPONSE (x STUDIES)**

- **Community composition (x studies):**
- **Richness/diversity (x studies):**

#### **POPULATION RESPONSE (x STUDIES)**

- **Abundance (x studies):**
- **Reproductive success (x studies):**
- **Survival (x studies):**
- **Condition (x studies):**

#### **BEHAVIOUR (x STUDIES)**

- **Uptake (x studies):**
- **Use (x studies):**
- **Behaviour change (x studies):**

**OTHER (x STUDIES)** (*Included only for interventions/chapters where relevant*)

- [Sub-heading(s) for the metric(s) reported will be created] (x studies):

If no evidence is found for an intervention, the following text will be added in place of the key messages above:

- We found no studies that evaluated the effects of [INTERVENTION] on [TARGET POPULATION].

*'We found no studies' means that we have not yet found any studies that have directly evaluated this intervention during our systematic journal and report searches. Therefore we have no evidence to indicate whether or not the intervention has any desirable or harmful effects.*

## **6. Dissemination/communication of evidence synthesis**

The information from this synopsis update will be available in three ways:

- An updated synopsis pdf, downloadable from [www.conservationevidence.com](http://www.conservationevidence.com), will contain the study summaries, key messages and background information on each intervention.
- The searchable database at [www.conservationevidence.com](http://www.conservationevidence.com) will contain all the summarized information from the synopsis update, along with expert assessment scores.
- A chapter in *What Works in Conservation*, available as a pdf to download and a book from [www.conservationevidence.com/content/page/79](http://www.conservationevidence.com/content/page/79) will contain the key messages from the synopsis as well as expert assessment scores on the effectiveness and certainty of the synopsis, with links to the online database.

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## APPENDIX 1. English journals (and years) searched

English journals (and years) searched and for which relevant papers have been added to the Conservation Evidence discipline-wide literature database. An asterisk indicates the journals most relevant to this synopsis.

<b>Journal</b>	<b>Years searched</b>	<b>Topic</b>
Acrocephalus	2009–2018	All biodiversity
Acta Chiropterologica*	1999–2018	All biodiversity
Acta Herpetologica	2006–2018	All biodiversity
Acta Oecologica	1990–2018	All biodiversity
Acta Theriologica	1977–2014	All biodiversity
African Bird Club Bulletin	1994–2017	All biodiversity
African Journal of Ecology	1963–2016	All biodiversity
African Journal of Herpetology	1990–2018	All biodiversity
African Journal of Marine Science	1983–2018	All biodiversity
African Primates	1995–2012	All biodiversity
African Sea Turtle Newsletter	2014–2018	All biodiversity
African Zoology	1979–2013	All biodiversity
Agriculture, Ecosystems and Environment*	1983–2019	All biodiversity
Ambio	1972–2011	All biodiversity
American Journal of Primatology	1981–2019	All biodiversity
American Naturalist*	1867–2018	All biodiversity
Amphibia-Reptilia	1980–2018	All biodiversity
Amphibian & Reptile Conservation	1996–2018	All biodiversity
Animal Biology	2003–2013	All biodiversity
Animal Conservation*	1998–2019	All biodiversity
Animal Nutrition	2015–2019	All biodiversity
Animal Welfare	1992–2019	All biodiversity
Animals	2011–2019	All biodiversity
Annales Zoologici Fennici	1964–2013	All biodiversity
Annales Zoologici Societatis Zoologicae Botanicae Fennicae Vanamo	1932–1963	All biodiversity
Annual Review Ecology and Systematics*	1970–2019	All biodiversity
Antarctic Science	1980–2018	All biodiversity
Anthrozoos	1987–2019	All biodiversity
Apidologie	1958–2009	All biodiversity
Applied Animal Behaviour Science	1984–2019	All biodiversity
Applied Herpetology	2003–2009	All biodiversity
Applied Vegetation Science	1998–2017	All biodiversity
Aquaculture Research	1972–2008	All biodiversity
Aquarium Sciences and Conservation	1997–2001	All biodiversity
Aquatic Biology	2007–2018	All biodiversity
Aquatic Botany	1975–2017	All biodiversity
Aquatic Conservation: Marine and Freshwater Ecosystems	1991–2018	All biodiversity

Aquatic Ecology	1968–2018	All biodiversity
Aquatic Ecosystem Health & Management	1998–2018	All biodiversity
Aquatic Invasions	2006–2016	All biodiversity
Aquatic Living Resources	1988–2018	All biodiversity
Aquatic Mammals	1972–2018	All biodiversity
Arid Land Research and Management	1987–2013	All biodiversity
Asian Herpetological Research	2010–2018	All biodiversity
Asian Primates	2008–2012	All biodiversity
Asiatic Herpetological Research	1993–2008	All biodiversity
Auk	1980–2016	All biodiversity
Austral Ecology*	1977–2018	All biodiversity
Australasian Journal of Herpetology	2009–2012	All biodiversity
Australian Mammalogy*	2000–2018	All biodiversity
Avian Conservation and Ecology	2005–2016	All biodiversity
Basic & Applied Herpetology	2011–2018	All biodiversity
Basic and Applied Ecology*	2000–2019	All biodiversity
Behavior	1948–2013	All biodiversity
Behavior Ecology	1990–2013	All biodiversity
Biawak	2001–2017	All biodiversity
Bibliotheca Herpetologica	1999–2017	All biodiversity
Biocontrol	1956–2016	All biodiversity
Biocontrol Science and Technology	1991–1996	All biodiversity
Biodiversity	2000–2018	All biodiversity
Biodiversity and Conservation*	1994–2019	All biodiversity
Biological Conservation*	1981–2019	All biodiversity
Biological Control	1991–2017	All biodiversity
Biological Invasions	1999–2017	All biodiversity
Biology and Environment: Proceedings of the Royal Irish Academy	1993–2017	All biodiversity
Biology Letters	2005–2018	All biodiversity
Biotropica*	1990–2018	All biodiversity
Bird Conservation International	1991–2016	All biodiversity
Bird Study	1980–2016	All biodiversity
Boreal Environment Research	1996–2014	All biodiversity
Bulletin of the Chicago Herpetological Society	1990–2018	All biodiversity
Bulletin of the Herpetological Society of Japan	1999–2008	All biodiversity
Bulletin of the Maryland Herpetological Society	1980–2015	All biodiversity
Canadian Field Naturalist	1987–2018	All biodiversity
Canadian Journal of Fisheries and Aquatic Sciences	1901–2018	All biodiversity
Canadian Journal of Forest Research	1971–2018	All biodiversity
Caribbean Herpetology	2010–2018	All biodiversity
Caribbean Journal of Science	1961–2013	All biodiversity
CCAMLR Science	1985–2016	All biodiversity
Chelonian Conservation and Biology	1993–2018	All biodiversity
Chelonian Research Monographs	1996–2017	All biodiversity

Coastal Engineering	2000–2018	All biodiversity
Collinsorum	2012–2016	All biodiversity
Community Ecology	2000–2012	All biodiversity
Conservation Biology*	1987–2019	All biodiversity
Conservation Evidence*	2004–2019	All biodiversity
Conservation Genetics	2000–2013	All biodiversity
Conservation Letters*	2008–2019	All biodiversity
Contemporary Herpetology	1998–2009	All biodiversity
Contributions to Primatology	1974–1991	All biodiversity
Copeia	1910–2018	All biodiversity
Copeia	2004–2016	Reptile Conservation
Cunninghamia	1981–2016	All biodiversity
Current Herpetology	1964–2018	All biodiversity
Dodo	1977–2001	All biodiversity
Ecological and Environmental Anthropology	2005–2008	All biodiversity
Ecological Applications*	1991–2019	All biodiversity
Ecological Entomology	1985–2018	All biodiversity
Ecological Indicators	2001–2007	All biodiversity
Ecological Management & Restoration*	2000–2018	All biodiversity
Ecological Restoration*	1981–2019	All biodiversity
Ecology*	1936–2019	All biodiversity
Ecology Letters	1998–2019	All biodiversity
Écoscience	1994–2019	All biodiversity
Ecosystems	1998–2013	All biodiversity
Emu	1980–2016	All biodiversity
Endangered Species Bulletin	1966–2003	All biodiversity
Endangered Species Research	2004–2019	All biodiversity
Entomologia Experimentalis et Applicata	2015–2018	All biodiversity
Environmental Conservation*	1974–2019	All biodiversity
Environmental Entomology	1990–2018	All biodiversity
Environmental Evidence*	2012–2019	All biodiversity
Environmental Management*	1977–2019	All biodiversity
Environmentalist	1981–1988	All biodiversity
Estuaries and Coasts	2013–2017	All biodiversity
Ethology Ecology & Evolution	1989–2014	All biodiversity
European Journal of Soil Science	1950–2012	Soil Fertility
European Journal of Wildlife Research*	2004–2019	All biodiversity
Evolutionary Anthropology	1992–2014	All biodiversity
Evolutionary Ecology	1987–2014	All biodiversity
Evolutionary Ecology Research	1999–2014	All biodiversity
Fire Ecology	2005–2016	All biodiversity
Fish and Fisheries	2000–2018	All biodiversity
Fisheries	2017–2018	All biodiversity
Fisheries Management and Ecology	1990–2018	All biodiversity



Fisheries Oceanography	1992–2018	All biodiversity
Fisheries Research	1990–2018	All biodiversity
Flora	1991–2017	All biodiversity
Folia Primatologica	1963–2014	All biodiversity
Folia Zoologica	1959–2013	All biodiversity
Forest Ecology and Management*	1976–2018	All biodiversity
Freshwater Biology	1975–2016	All biodiversity
Freshwater Science	1982–2018	All biodiversity
Frontiers in Marine Science	2017–2018	All biodiversity
Frontiers in Psychology	2019	All biodiversity
Functional Ecology	1987–2013	All biodiversity
Genetics and Molecular Research	2002–2013	All biodiversity
Geoderma	1967–2012	Soil Fertility
Gibbon Journal	2005–2011	All biodiversity
Global Change Biology	1995–2017	All biodiversity
Global Ecology and Biogeography	1991–2014	All biodiversity
Global Ecology and Conservation	2014–2018	All biodiversity
Grass and Forage Science	1980–2017	All biodiversity
Herpetofauna	2003–2007	All biodiversity
Herpetologica	1936–2018	All biodiversity
Herpetologica	2013–2016	Reptile Conservation
Herpetological Bulletin	1980–2003	Amphibian Conservation
Herpetological Bulletin	2003–2013	Reptile Conservation
Herpetological Bulletin	2014–2016	All biodiversity
Herpetological Conservation and Biology	2006–2012	Amphibian Conservation
Herpetological Conservation and Biology	2006–2012	Reptile Conservation
Herpetological Conservation and Biology	2006–2018	All biodiversity
Herpetological Journal	1985–2014	All biodiversity
Herpetological Monographs	1982–2018	All biodiversity
Herpetological Review	1967–2018	All biodiversity
Herpetology Notes	2008–2018	All biodiversity
Herpetozoa	1988–2018	All biodiversity
Human Wildlife Interactions*	2007–2019	All biodiversity
Hydrobiologia	2000–2018	All biodiversity
Hystrix, the Italian Journal of Mammalogy*	1986–2018	All biodiversity
Ibis	1980–2016	All biodiversity
ICES Journal of Marine Science	1990–2018	All biodiversity
iForest	2008–2016	All biodiversity
Insect Conservation and Diversity	2008–2018	All biodiversity
Integrative Zoology	2006–2013	All biodiversity
International Journal of Pest Management (formerly PANS Pest Articles & News Summaries 1969 -	1969–1979	All biodiversity

1975, PANS 1976-1979 & Tropical Pest Management 1980-1992)		
International Journal of Primatology	1980–2019	All biodiversity
International Journal of the Commons	2007–2016	All biodiversity
International Journal of Wildland Fire	1991–2016	All biodiversity
International Wader Studies	1970–1972	All biodiversity
International Zoo Yearbook	1960–2019	All biodiversity
Invasive Plant Science and Management	2008–2016	All biodiversity
Israel Journal of Ecology & Evolution	1963–2013	All biodiversity
Italian Journal of Zoology	1978–2013	All biodiversity
Journal for Nature Conservation*	2002–2018	All biodiversity
Journal of Animal Ecology*	1932–2019	All biodiversity
Journal of Apicultural Research	1962–2009	All biodiversity
Journal of Applied Animal Nutrition	2012–2019	All biodiversity
Journal of Applied Animal Welfare Science	1998–2019	All biodiversity
Journal of Applied Ecology*	1964–2019	All biodiversity
Journal of Aquatic Plant Management	1962–2016	All biodiversity
Journal of Arid Environments	1993–2017	All biodiversity
Journal of Avian Biology	1980–2016	All biodiversity
Journal of Bat Research & Conservation (formerly Barbastella)*	2000–2018	All biodiversity
Journal of Cetacean Research and Management	1999–2018	All biodiversity
Journal of Coastal Research	2015–2018	All biodiversity
Journal of Ecology*	1933–2019	All biodiversity
Journal of Ecology & Natural Resources	2017–2019	All biodiversity
Journal of Environmental Management*	1973–2019	All biodiversity
Journal of Experimental Marine Biology and Ecology	2000–2018	All biodiversity
Journal of Field Ornithology	1980–2016	All biodiversity
Journal of Forest Research*	1996–2018	All biodiversity
Journal of Great Lakes Research	1975–2017	All biodiversity
Journal of Herpetological Medicine and Surgery	2009–2018	All biodiversity
Journal of Herpetology	1968–2016	All biodiversity
Journal of Insect Conservation	1997–2018	All biodiversity
Journal of Insect Science	2003–2018	All biodiversity
Journal of Kansas Herpetology	2002–2011	All biodiversity
Journal of Mammalian Evolution	1993–2014	All biodiversity
Journal of Mammalogy*	1919–2018	All biodiversity
Journal of Mountain Science	2004–2016	All biodiversity
Journal of Negative Results: Ecology & Evolutionary Biology	2004–2016	All biodiversity
Journal of North American Herpetology	2014–2017	All biodiversity
Journal of Ornithology	2004–2018	All biodiversity
Journal of Primatology	2012–2013	All biodiversity
Journal of Raptor Research	1966–2016	All biodiversity

Journal of Sea Research	1961–2018	All biodiversity
Journal of the Japanese Institute of Landscape Architecture	1934–2017	All biodiversity
Journal of the Marine Biological Association of the United Kingdom	1887–2018	All biodiversity
Journal of Tropical Ecology*	1986–2019	All biodiversity
Journal of Vegetation Science	1990–2017	All biodiversity
Journal of Wetlands Ecology	2008–2012	All biodiversity
Journal of Wetlands Environmental Management	2012–2016	All biodiversity
Journal of Wildlife Diseases	1965–2012	All biodiversity
Journal of Wildlife Management*	1945–2019	All biodiversity
Journal of Zoo and Aquarium Research	2013–2019	All biodiversity
Journal of Zoo and Wildlife Medicine	1970–2019	All biodiversity
Journal of Zoology*	1966–2019	All biodiversity
Jurnal Primatologi Indonesia	2009	All biodiversity
Kansas Herpetological Society Newsletter	1974–2001	All biodiversity
Knowledge and Management of Aquatic Ecosystems (formerly Bulletin Français de la Pêche et de la Pisciculture)	1986–2018	All biodiversity
Lake and Reservoir Management	1984 –2016	All biodiversity
Land Degradation and Development	1989–2016	All biodiversity
Land Use Policy	1984–2012	Soil Fertility
Latin American Journal of Aquatic Mammals	2002–2018	All biodiversity
Lemur News	1993–2012	All biodiversity
Limnologica - Ecology and Management of Inland Waters	1999–2018	All biodiversity
Mammal Research*	2001–2018	All biodiversity
Mammal Review*	1970–2018	All biodiversity
Mammal Study*	2005–2018	All biodiversity
Mammalia*	1937–2018	All biodiversity
Mammalian Biology*	2002–2018	All biodiversity
Mammalian Genome	1991–2013	All biodiversity
Management of Biological Invasions	2010–2016	All biodiversity
Mangroves and Salt Marshes	1996–1999	All biodiversity
Marine and Freshwater Research	1980–2018	All biodiversity
Marine Ecology	1980–2018	All biodiversity
Marine Ecology Progress Series	2000–2018	All biodiversity
Marine Environmental Research	1978–2018	All biodiversity
Marine Mammal Science	1985–2019	All biodiversity
Marine Pollution Bulletin	2010–2018	All biodiversity
Marine Turtle Newsletter	1976–2018	All biodiversity
Mesoamerican Herpetology	2014–2017	All biodiversity
Mires and Peat	2006–2016	All biodiversity
Natural Areas Journal	1992–2017	All biodiversity
Nature Conservation	2012–2019	All biodiversity

Neobiota	2011–2017	All biodiversity
Neotropical Entomology	2004–2018	All biodiversity
Neotropical Primates	1993–2012	All biodiversity
New Journal of Botany	2011–2013	All biodiversity
New Zealand Journal of Marine and Freshwater Research	1967–2018	All biodiversity
New Zealand Journal of Zoology*	1974–2019	All biodiversity
New Zealand Plant Protection	2000–2016	All biodiversity
Northwest Science	2007–2016	All biodiversity
Oecologia*	1969–2019	All biodiversity
Oikos*	1949–2019	All biodiversity
Ornitologia Neotropical	1990–2018	All biodiversity
Oryx*	1950–2019	All biodiversity
Ostrich	1980–2016	All biodiversity
Pacific Conservation Biology*	1993–2019	All biodiversity
Pakistan Journal of Zoology	2004–2013	All biodiversity
Phyllomedusa	2002–2018	All biodiversity
Plant Ecology	1948–2007	All biodiversity
Plant Protection Quarterly	2008–2016	All biodiversity
PLOS*	1980–2018	Key word: ‘bat*’
Polish Journal of Ecology	2002–2013	All biodiversity
Population Ecology	1952–2013	All biodiversity
Preslia	1973–2017	All biodiversity
Primate Conservation	1981–2014	All biodiversity
Primates	1957–2013	All biodiversity
Rangeland Ecology & Management (previously Journal of Range Management 1948-2004)	1948–2016	All biodiversity
Raptors Conservation	2005–2016	All biodiversity
Regional Studies in Marine Science	2015–2018	All biodiversity
Reptile Rap - Newsletter of the South Asian Reptile Network (SARN)	1999–2016	All biodiversity
Restoration Ecology*	1993–2019	All biodiversity
Riparian Ecology and Conservation	2013–2017	All biodiversity
River Research and Applications	1987–2016	All biodiversity
Russian Journal of Herpetology	1994–2018	All biodiversity
Slovak Raptor Journal	2007–2016	All biodiversity
Small Ruminant Research	1988–2017	All biodiversity
Soil Biology & Biochemistry	1969–2012	Soil Fertility
South African Journal of Botany	1982–2016	All biodiversity
South African Journal of Wildlife Research	1971–2014	All biodiversity
South American Journal of Herpetology	2006–2018	All biodiversity
Southern Forests: a journal of Forest Science	2008–2013	All biodiversity
Systematic Reviews Centre for Evidence-Based Conservation*	2004–2016	All biodiversity
Testudo	1978–2017	All biodiversity

The Condor	1980–2009	All biodiversity
The Open Ornithology Journal	2008–2016	All biodiversity
The Rangeland Journal	1976–2016	All biodiversity
The Southwestern Naturalist	1956–2018	All biodiversity
Trends in Ecology and Evolution*	1986–2019	All biodiversity
Tropical Conservation Science	2008–2018	All biodiversity
Tropical Ecology	1960–2018	All biodiversity
Tropical Grasslands	1967–2010	All biodiversity
Tropical Zoology	1988–2018	All biodiversity
Turkish Journal of Zoology	1996–2014	All biodiversity
Ursus	1968–2019	All biodiversity
Vietnamese Journal of Primatology	2007–2009	All biodiversity
Wader Study Group Bulletin	1970–1977	All biodiversity
Waterbirds	1983–2016	All biodiversity
Weed Biology and Management	2001–2016	All biodiversity
Weed Research	1961–2017	All biodiversity
West African Journal of Applied Ecology	2000–2016	All biodiversity
Western North American Naturalist	2000–2017	All biodiversity
Wetlands	1981–2016	All biodiversity
Wetlands Ecology and Management	1989–2016	All biodiversity
Wildfowl	1948–2018	All biodiversity
Wildlife Biology*	1995–2013	All biodiversity
Wildlife Monographs	1958–2013	All biodiversity
Wildlife Research*	1956–2012 1974–2018	Bat Conservation All biodiversity
Wildlife Society Bulletin*	1973–2018	All biodiversity
Wilson Journal of Ornithology	1980–2016	All biodiversity
Zeitschrift für Jagdwissenschaft	1955–2003	All biodiversity
Zhurnal Obshchei Biologii	1972–2013	All biodiversity
Zoo Biology	1982–2019	All biodiversity
ZooKeys	2008–2013	All biodiversity
Zoologica Scripta	1971–2014	All biodiversity
Zoological Journal of the Linnean Society	1856–2013	All biodiversity
Zootaxa	2004–2014	All biodiversity

## APPENDIX 2. Non-English journals (and years) searched

Non-English journals (and years) searched and for which relevant papers have been added to the Conservation Evidence discipline-wide literature database. An asterisk indicates the journals most relevant to this synopsis.

Journal	Years searched	Topic	Language
Mertensiella	1988–2017	All biodiversity	German
Salamandra	1965–2018	All biodiversity	German
Der Zoologische Garten: Zeitschrift für die gesamte Tiergärtnerei (Neue Folge) The Zoological Garden	2007–2017	All biodiversity	German
Insecta	1992–2014	All biodiversity	German
Tuexenia	1981–2016	All biodiversity	German
Libellula	1982–2016	All biodiversity	German
Forstarchiv Forestry Archive	2007–2017	All biodiversity	German
Zeitschrift für Feldherpetologie Journal for Field Herpetology	1994–2017	All biodiversity	German
Arachnologische Mitteilungen Arachnological Letters	1991–2017	All biodiversity	German
Fachzeitschrift für Waldökologie, Landschaftsforschung und Naturschutz Journal for Forest Ecology, Landscape Research and Nature Conservation	2004–2016	All biodiversity	German
Silva Fera: Wissenschaftliche Nachrichten aus dem Wildnisgebiet Dürrenstein Silva Fera: Scientific News from the Dürrenstein Wilderness Area	2012–2017	All biodiversity	German
Inatura Forschung Online Inatura Research Online	1996–2007	All biodiversity	German
ABU-Info (Arbeitsgemeinschaft Biologischer Umweltschutz im Kreis Soest e.V.) ABU-Info (Working Group for Biological Environmental Protection in Soest District)	2006–2017	All biodiversity	German
ANLiegen Natur: 'Zeitschrift für Naturschutz, Pflege der Kulturlandschaft und Nachhaltige Entwicklung Concerning Nature: Journal for Nature Conservation and Applied Landscape Ecology	2006–2017	All biodiversity	German
Natur und Landschaft Nature and Landscape	1990–2017	All biodiversity	German
Pulsatilla	2000–2007	All biodiversity	German
Ornithologische Beobachter Ornithological Observer	1950–2017	All biodiversity	German

Die Orchidee The Orchid	1949–2016	All biodiversity	German
Naturschutz und Landschaftsplanung Conservation and Landscape Planning	2003–2017	All biodiversity	German
Hercynia	1963–2017	All biodiversity	German
Allgemeine Forst und Jagdzeitung German Journal of Forest Research	2000–2016	All biodiversity	German
Nyctalus* International Bat Journal	2005–2017	All biodiversity	German
Ornithologischer Anzeiger Ornithological Journal	1951–2017	All biodiversity	German
Archiv für Forstwesen und Landschaftsökologie Archive for Forestry and Landscape Ecology	2013	All biodiversity	German
Botanik und Naturschutz in Hessen Botany and Nature Conservation in Hessen	1987–2018	All biodiversity	German
The Bird Fauna Die Vogelwelt	2005–2017	All biodiversity	German
Biodiversität und Naturschutz in Ostösterreich Biodiversity and Conservation in Eastern Austria	2015–2018	All biodiversity	German
Journal für Ornithologie Journal of Ornithology	1959–2003	All biodiversity	German
Mitteilungen des Badischen Landesvereins für Naturkunde und Naturschutz Communications of the Baden Association for Natural History and Nature Conservation	1953–2015	All biodiversity	German
Freiberg Online Geoscience - FOG	1998–2017	All biodiversity	German
Gesunde Pflanzen: Pflanzenschutz, Verbraucherschutz, Umweltschutz Healthy Plants: Crop Protection, Consumer Protection, Environment Protection	2002–2017	All biodiversity	German
Vogelwarte The Bird Observatory	2005–2017	All biodiversity	German
Die Bodenkultur: Journal of Land Management, Food and Environment The Soil Culture: Journal for Land Management, Food and Environment	2016–2017	All biodiversity	German
RANA - Mitteilungen für Feldherpetologie und Ichthyofaunistik RANA - Communications for Field Herpetology and Ichthyofauna	1983–2016	All biodiversity	German
Die Erde The Earth	1952–2004	All biodiversity	German
Auenmagazin Floodplains Journal	2010–2017	All biodiversity	German



Bulletin de la Société des Naturalistes Luxembourgeois Bulletin of the Luxemburgian Naturalist Society	1950–2017	All biodiversity	German and French
Mammalian Science* 哺乳類科学	1961–2016	All biodiversity	Japanese
The Journal of the Japanese Landscape Architectural Society 造園学雑誌	1925–1927	All biodiversity	Japanese
Landscape Ecology and Management 景観生態学	2005–2016	All biodiversity	Japanese
Japanese Journal of Ecology 日本生態学会誌	1954–2017	All biodiversity	Japanese
Doubutsugaku zasshi 動物学雑誌	1888–1983	All biodiversity	Japanese
Bulletin of the Herpetological Society of Japan 爬虫両棲類学会報	1999–2008	All biodiversity	Japanese
Journal of the Japanese Forest Society 日本森林学会誌	2005–2017	All biodiversity	Japanese
Wildlife and Human Society 野生生物と社会	2013–2017	All biodiversity	Japanese
Ecology and Civil Engineering 応用生態工学	1998–2017	All biodiversity	Japanese
Japanese Journal of Conservation Ecology 保全生態学研究	1996–2016	All biodiversity	Japanese
Journal of Mammalogical Society of Japan* 哺乳動物学雑誌	1959–1986	All biodiversity	Japanese
Landscape Research Japan Online ランドスケープ研究(オンライン論文集)	2008–2017	All biodiversity	Japanese
Bulletin of the International Association for Landscape Ecology-Japan 国際景観生態学会日本支部会報	2002–2003	All biodiversity	Japanese
Strix ストリクス	1982–2017	All biodiversity	Japanese
Journal of the Japanese Forestry Society 日本林学会誌	1985–2004	All biodiversity	Japanese
Japanese Journal of Ornithology 日本鳥学会誌	1917–2015	All biodiversity	Japanese
Wildlife Conservation Japan 野生生物保護	1995–2013	All biodiversity	Japanese
Journal of Natural Environment نشریه محیط زیست طبیعی	2010–2017	All biodiversity	Persian



Experimental Animal Biology زیست شناسی جانوری تجربی	2012–2017	All biodiversity	Persian
Journal of Environmental Sciences علوم محیطی و محیطی	2004–2017	All biodiversity	Persian
Journal of Animal Environment فصلنامه محیط زیست جانوری	2014–2017	All biodiversity	Persian
Journal of Environmental Studies محیط شناسی	1975–2017	All biodiversity	Persian
Environmental Researches پژوهش های محیط زیست	2010–2017	All biodiversity	Persian
Iranian Journal of Applied Ecology بوم شناسی کاربردی	2012–2017	All biodiversity	Persian
Iranian Journal of Natural Resources مجله منابع طبیعی ایران	2002–2009	All biodiversity	Persian
Journal of Animal Researches پژوهش های جانوری	2013–2017	All biodiversity	Persian
Iheringia Série Zoologia	2000–2018	All biodiversity	Portuguese
Revista Bioikos	1987–2016	All biodiversity	Portuguese
Brazilian Journal of Ecology Revista Brasileira de Ecologia	1997–2009	All biodiversity	Portuguese
Biota Neotropica	2001–2011	All biodiversity	Portuguese
Floresta	1969–2017	All biodiversity	Portuguese
Boletim da Sociedade Brasileira de Mastozoologi*	1985–2017	All biodiversity	Portuguese
Biodiversidade Brasileira	2011–2016	All biodiversity	Portuguese
Revista Brasileira de Gestão Ambiental e Sustentabilidade	2014–2017	All biodiversity	Portuguese
MG Biota	2008–2016	All biodiversity	Portuguese
Chiroptera Neotropical*	1995–2015	All biodiversity	Portuguese
Evolução e Conservação da Biodiversidade	2010–2011	All biodiversity	Portuguese
Megadiversidade	2005–2009	All biodiversity	Portuguese
Revista CEPISUL - Biodiversidade e Conservação Marinha	2010–2017	All biodiversity	Portuguese
Brazilian Journal for Nature Conservation Natureza & Conservação	2003–2009	All biodiversity	Portuguese
Neotropical Biology and Conservation	2006–2017	All biodiversity	Portuguese
Russian Journal of Ornithology Русский орнитологический журнал	1993–2017	All biodiversity	Russian
Herald of Game Management Вестник охотоведения	2007–2016	All biodiversity	Russian
Bulletin of Moscow Society of Naturalists. Biological series Бюллетень МОИП, серия биологическая	1935–2016	All biodiversity	Russian
Russian Journal of Ecology Экология	1993–2017	All biodiversity	Russian

Povolzhsky Journal of Ecology Поволжский экологический журнал	2002–2016	All biodiversity	Russian
Current Studies in Herpetology Современная герпетология	2000–2016	All biodiversity	Russian
Biology Bulletin Известия РАН, серия биологическая	1957–2017	All biodiversity	Russian
Russian Journal of Zoology Зоологический журнал	1939–2017	All biodiversity	Russian
Steppe Bulletin Степной бюллетень	1998–2016	All biodiversity	Russian
Journal of Ichthyology Вопросы ихтиологии	1961–2017	All biodiversity	Russian
Contemporary Problems of Ecology Сибирский экологический журнал	1994–2017	All biodiversity	Russian
Mammalogy Notes*	2014–2017	All biodiversity	Spanish
Mastozoología Neotropical* Neotropical Mastozoology	1994–2017	All biodiversity	Spanish
Edentata	1994–2018	All biodiversity	Spanish
Ecología Austral Austral Ecology	2001–2018	All biodiversity	Spanish
Revista Catalana de Ornitologia Catalan Journal of Ornithology	2002–2018	All biodiversity	Spanish
Ardeola	1954–2019	All biodiversity	Spanish
Hidrobiológica Hydrobiology	1991–2018	All biodiversity	Spanish
Gestión Ambiental	1999–2017	All biodiversity	Spanish
Ocelotlán	2003–2012	All biodiversity	Spanish
A Carriza: Sociedad Gallega de Ornitologia	2001–2009	All biodiversity	Spanish
Revista Chilena de Ornitología Chilean Journal of Ornithology	2016–2018	All biodiversity	Spanish
Novitates Caribaea	1999–2019	All biodiversity	Spanish
Madera y Bosques Wood and Forests	1995–2018	All biodiversity	Spanish
Revista Nicaragüense de Biodiversidad Nicaraguan Journal of Biodiversity	2015–2019	All biodiversity	Spanish
Revista Mexicana de Biodiversidad Mexican Journal of Biodiversity	2005–2018	All biodiversity	Spanish
Mediterránea Mediterranean	1982–2015	All biodiversity	Spanish
Semiárida	2013–2018	All biodiversity	Spanish
Boletín de la Real Sociedad Española de Historia Natural Bulletin of the Royal Spanish Society of Natural History	2003–2017	All biodiversity	Spanish

Bosques Latitud Cero Forests Latitude Zero	2014–2018	All biodiversity	Spanish
Anales de Biología	1984–2019	All biodiversity	Spanish
Revista Peruana de Biología Peruvian Journal of Biology	1974–2019	All biodiversity	Spanish
Boletín Científico Centro de Museos Bulletin of the Museum Scientific Center	1996–2019	All biodiversity	Spanish
Revista de Biología Tropical Journal of Tropical Biology	1976–2018	All biodiversity	Spanish
Revista Chilena de Historia Natural Chilean Journal of Natural History	1897–2018	All biodiversity	Spanish
Therya*	2010–2018	All biodiversity	Spanish
Cuadernos de Herpetología Herpetology notes	2010–2018	All biodiversity	Spanish
Boletín de la Sociedad Argentina de Botánica Bulletin of the Argentinean Society of Botany	2013–2018	All biodiversity	Spanish
Butlletí del Grup Català d'Anellament Bulletin of the Catalan Ring Group	1981–2001	All biodiversity	Spanish
Orinoquia	2003–2018	All biodiversity	Spanish
Acta Zoológica Mexicana Mexican Zoological Journal	1984–2019	All biodiversity	Spanish
Biodiversity and Natural History	2015–2017	All biodiversity	Spanish
Galemys*	1997–2017	All biodiversity	Spanish
Boletín Chileno de Ornitología Chilean Ornithology Bulletin	1994–2015	All biodiversity	Spanish
Zoologica Baetica	1990–2015	All biodiversity	Spanish
Centros: Revista Científica Universitaria Centros: Scientific Journal of the University	2012–2018	All biodiversity	Spanish
Huitzil: Revista Mexicana de Ornitología Journal of Mexican Ornithology	2000–2018	All biodiversity	Spanish
Bioma (El Salvador)	2012–2016	All biodiversity	Spanish
Quebracho	2008–2018	All biodiversity	Spanish
Etología Ethology	1989–2003	All biodiversity	Spanish
Historia Natural Natural History	2011–2018	All biodiversity	Spanish
Arxius of Miscel·lània Zoològica	2003–2019	All biodiversity	Spanish
Agrociencia Uruguay Agroscience Uruguay	1997–2017	All biodiversity	Spanish
Ecología Aplicada Applied Ecology	2002–2018	All biodiversity	Spanish
Boletín de la Asociación Herpetológica Española Bulletin of the Spanish Herpetological Association	2004–2018	All biodiversity	Spanish
El Hornero: Revista de Ornitología Neotropical	2003–2017	All biodiversity	Spanish

Revista Española de Herpetología Spanish Journal of Herpetology	2003–2007	All biodiversity	Spanish
Revista Internacional de Contaminación Ambiental International Journal of Pollution	1985–2018	All biodiversity	Spanish
Colombia Forestal	2000–2018	All biodiversity	Spanish
Revista Mexicana de Mastozoología*	1995–2017	All biodiversity	Spanish
Revista Mexicana de Ciencias Forestales Mexican Journal of Forestry Sciences	2010–2018	All biodiversity	Spanish
Boletín de Biodiversidad de Chile Bulletin of Biodiversity of Chile	2009–2014	All biodiversity	Spanish
Studia Oecológica	1981–1995	All biodiversity	Spanish
Grupo Jaragua	1997–2011	All biodiversity	Spanish
Ecosistemas y Recursos Agropecuarios Ecosystems and Agropecuary Resources	1994–2018	All biodiversity	Spanish
BioScriba	2008–2017	All biodiversity	Spanish
Ecosistemas Ecosystems Journal	2001–2018	All biodiversity	Spanish
Cedamaz	2014–2018	All biodiversity	Spanish
Animal Biodiversity and Conservation	2001–2019	All biodiversity	Spanish
Folia Amazónica	1988–2018	All biodiversity	Spanish
Notulas Faunísticas	2008–2018	All biodiversity	Spanish
Caldasia	1940–2019	All biodiversity	Spanish

### APPENDIX 3. Literature reviewed for the Bat Conservation Synopsis

The diagram below (from Berthinussen et al. 2020) will be updated and included in the synopsis document to show the numbers of journals and report series searched for the updated synopsis, the total number of publications searched (title and abstract) within those, and the number of publications that were summarized from each source of literature.

