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What Works in Conservation

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2. BAT CONSERVATION

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Scope of assessment: for native wild bat species across the world.

Assessed: 2020. For previous assessments and expert panels please check *What Works in Conservation 2019*.

Effectiveness measure is the median % score for effectiveness.

Certainty measure is the median % certainty of evidence for effectiveness, determined by the quantity and quality of the evidence in the synopsis.

Harm measure is the median % score for negative side-effects to the group of species of concern.

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This book is meant as a guide to the evidence available for different conservation interventions and as a starting point in assessing their effectiveness. The assessments are based on the available evidence for the target group of species for each intervention. The assessment may therefore refer to different species or habitat to the one(s) you are considering. Before making any decisions about implementing interventions it is vital that you read the more detailed accounts of the evidence in order to assess their relevance for your study species or system.

Full details of the evidence are available at
www.conservationevidence.com

There may also be significant negative side-effects on the target groups or other species or communities that have not been identified in this assessment.

A lack of evidence means that we have been unable to assess whether or not an intervention is effective or has any harmful impacts.

2.1 Threat: Residential and commercial development

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for residential and commercial development?	
Unknown effectiveness	• Change timing of building work • Create alternative bat roosts within developments • Create or restore bat foraging habitat in urban areas • Exclude bats from roosts during building work • Legally protect bats during development • Protect brownfield or ex-industrial sites • Relocate access points to bat roosts within developments • Retain existing bat roosts and access points within developments
No evidence found (no assessment)	• Educate homeowners about building and planning laws relating to bats to reduce disturbance to bat roosts • Encourage homeowners to increase semi-natural habitat within gardens • Encourage homeowners to plant gardens with night-scented flowers • Install sound-proofing insulation between bat roosts and areas occupied by humans within developments • Protect greenfield sites or undeveloped land in urban areas

Unknown effectiveness

Change timing of building work

One study evaluated the effects of changing the timing of building work on bat populations. The study was in Ireland.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One before-and-after study in Ireland found that carrying out roofing work outside of the bat maternity season, along with retaining bat access points, resulted in a similar number of brown long-eared bats continuing to use a roost within an attic.
Assessment: unknown effectiveness (effectiveness 50%; certainty 12%; harms 0%).

https://www.conservationevidence.com/actions/950

Create alternative bat roosts within developments

Eleven studies evaluated the effects of creating alternative bat roosts within developments on bat populations. Two studies were in the USA, and nine studies were in Europe.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (11 STUDIES)
Use: (11 studies): Two replicated studies in the USA and UK found that bats did not use any of the alternative roosts provided in bat houses or a purpose-built bat wall after exclusion from buildings. Three studies (two replicated) in the USA and UK and one review in the UK found that bat boxes or bat lofts/barns were used by bats at 13–74% of development sites, and bat lofts/barns were used by maternity colonies at one of 19 development sites. Three of five before-and-after studies in Portugal, Ireland, Spain and the UK found that bat colonies used purpose-built roosts in higher or similar numbers after the original roosts were destroyed. The other two studies found that bats used purpose-built roosts in lower numbers than the original roost. One review in the UK found that new bat boxes/lofts built to replace destroyed roosts were four times less likely to be used by returning bats than roosts retained during development.
Assessment: unknown effectiveness (effectiveness 45%; certainty 35%; harms 0%).

https://www.conservationevidence.com/actions/949

Create or restore bat foraging habitat in urban areas

Three studies evaluated the effects of creating or restoring bat foraging habitat in urban areas on bat populations. One study in the USA evaluated restored forest fragments, and two studies in the UK and USA evaluated green roofs.

COMMUNITY RESPONSE (1 STUDY)

Richness/diversity (1 study): One replicated, controlled, site comparison study in the USA found no difference in species richness over green roofs and conventional unvegetated roofs.

POPULATION RESPONSE (3 STUDIES)

Abundance (3 studies): One site comparison study in the USA found higher bat activity (relative abundance) in two of seven restored forest fragments in urban areas than in two unrestored forest fragments. One replicated, controlled, site comparison study in the UK found significantly greater bat activity over 'biodiverse' green roofs than conventional unvegetated roofs, but not over 'sedum' green roofs. One replicated, controlled, site comparison study in the USA found greater bat activity for three of five bat species over green roofs than over conventional unvegetated roofs.

BEHAVIOUR (0 STUDIES)

Assessment: unknown effectiveness (effectiveness 60%; certainty 36%; harms 0%).

https://www.conservationevidence.com/actions/954

Exclude bats from roosts during building work

One study evaluated the effects of excluding bats from roosts during building work on bat populations. The study was in the UK.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (1 STUDY)

Behaviour change (1 study): One replicated, before-and-after study in the UK found that excluding bats from roosts within buildings did not change roost switching frequency, core foraging areas or foraging preferences of soprano pipistrelle colonies.

Assessment: unknown effectiveness (effectiveness 45%; certainty 23%; harms 17%).

https://www.conservationevidence.com/actions/1930

Legally protect bats during development

Three studies evaluated the effects of legally protecting bats by issuing licences during development on bat populations. The three studies were in the UK.

COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (2 STUDIES)
Change in human behaviour (2 studies): One review in the UK found that the number of development licences for bats more than doubled over three years in Scotland. One review in the UK found that 81% of licensees did not carry out post-development monitoring to assess whether bats used the roost structures installed.
OTHER (2 STUDIES)
Impact on bat roost sites (2 studies): One review in the UK found that licenced activities during building developments had a negative impact on bat roosts, with 68% of roosts being destroyed. One replicated, before-and-after study in the UK found that five of 28 compensation roosts provided under licence were used, and two by similar or greater numbers of bats after development.
Assessment: unknown effectiveness (effectiveness 18%; certainty 15%; harms 2%).

https://www.conservationevidence.com/actions/1935

Protect brownfield or ex-industrial sites

One study evaluated the effects of protecting brownfield or ex-industrial sites on bat populations. The study was in the USA.
COMMUNITY RESPONSE (1 STUDY)
Richness/diversity (1 study): One study in the USA found that five bat species were recorded within a protected urban wildlife refuge on an abandoned manufacturing site.
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 40%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/953

Relocate access points to bat roosts within developments

Two studies evaluated the effects of relocating access points to bat roosts within building developments on bat populations. One study was in Ireland and one in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (2 STUDIES)
Use (2 studies): One before-and-after study in Ireland found that fewer brown long-eared bats used a roost after the access points were relocated,

and no bats were observed flying through them. One before-and-after study in the UK found that few lesser horseshoe bats used an alternative access point with a 'bend' design to re-enter a roost in a building development, but the number of bats using the roost increased after an access point with a 'straight' design was installed.
Assessment: unknown effectiveness (effectiveness 45%; certainty 32%; harms 10%).

https://www.conservationevidence.com/actions/946

Retain existing bat roosts and access points within developments

Two studies evaluated the effects of retaining existing bat roosts and access points within developments on bat populations. One study was in Ireland and one in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (2 STUDIES)
Use (2 studies): One before-and-after study in Ireland found similar numbers of brown long-eared bats roosting within an attic after existing access points were retained during renovations. One replicated, before-and-after study in the UK found that four of nine bat roosts retained within developments were used as maternity colonies, in two cases by similar or greater numbers of bats after development had taken place.
Assessment: unknown effectiveness (effectiveness 67%; certainty 27%; harms 0%).

https://www.conservationevidence.com/actions/947

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Educate homeowners about building and planning laws relating to bats to reduce disturbance to bat roosts
- Encourage homeowners to increase semi-natural habitat within gardens
- Encourage homeowners to plant gardens with night-scented flowers
- Install sound-proofing insulation between bat roosts and areas occupied by humans within developments
- Protect greenfield sites or undeveloped land in urban areas.

2.2 Threat: Agriculture

2.2.1 All farming systems

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for all farming systems?	
Likely to be beneficial	• Retain or plant native trees and shrubs amongst crops (agroforestry) • Use organic farming instead of conventional farming
Unknown effectiveness	• Create tree plantations on agricultural land to provide roosting and foraging habitat for bats • Engage farmers and landowners to manage land for bats • Introduce agri-environment schemes • Manage hedges to benefit bats • Reduce field size (or maintain small fields) • Retain riparian buffers on agricultural land • Retain unmown field margins
No evidence found (no assessment)	• Increase the proportion of semi-natural habitat in the farmed landscape • Manage ditches to benefit bats • Plant field margins with a diverse mix of plant species • Plant in-field trees • Plant new hedges • Provide or retain set-aside areas in farmland • Retain existing in-field trees • Retain remnant forest or woodland on agricultural land

Likely to be beneficial

Retain or plant native trees and shrubs amongst crops (agroforestry)

Seven studies evaluated the effects of retaining or planting native trees and shrubs amongst crops on bat populations. Two studies were in South America, four were in Mexico, and one was in Tanzania.

COMMUNITY RESPONSE (7 STUDIES)

Community composition (1 study): One replicated, site comparison study in Tanzania found different compositions of bat species in coffee plantations with different amounts and types of shade cover.

Richness/diversity (7 studies): Four of six replicated, site comparison studies in Colombia, Mexico and Costa Rica found a similar number of bat species in shaded and unshaded coffee plantations, and in coffee plantations with different amounts and types of shade cover. The two other studies found more bat species and higher bat diversity in coffee, cacao and banana plantations with varied shade cover, than in plantations with a single shade species or no shade. One replicated, site comparison study in Tanzania found more bat species in shaded coffee plantations than in traditional mixed agroforestry systems with natural forest vegetation.

POPULATION RESPONSE (5 STUDIES)

Abundance (5 studies): Two replicated, site comparison studies in Mexico captured more bats in coffee plantations with varied shade cover than in plantations with a single shade species. One replicated, site comparison study in Mexico found higher activity (relative abundance) of forest bat species in plantations with a varied shade cover than in plantations with a single shade species, but the opposite was true for open habitat bat species. One replicated, site comparison study in Costa Rica found no difference in the number of bats captured between cacao and banana shade plantations and unshaded monocultures. One replicated, site comparison study in Tanzania found greater bat occurrence in shaded coffee plantations than in traditional mixed agroforestry systems with natural forest vegetation.

BEHAVIOUR (0 STUDIES)

Assessment: likely to be beneficial (effectiveness 55%; certainty 50%; harms 0%).

https://www.conservationevidence.com/actions/963

Use organic farming instead of conventional farming

Twelve studies evaluated the effects of using organic farming instead of conventional farming on bat populations. Eight studies were in Europe, two in the USA, one in Canada and one in Chile.

COMMUNITY RESPONSE (7 STUDIES)

Community composition (1 study): One replicated, paired sites study in the USA found that the composition of bat species did not differ between organic and non-organic farms.

Richness/diversity (7 studies): Five of seven replicated, paired sites or site comparison studies in Europe, the USA, Canada and Chile found that the number of bat species did not differ between organic and non-organic farms. The other two studies found more bat species on organic farms than non-organic farms.

POPULATION RESPONSE (12 STUDIES)

Abundance (12 studies): Five of nine replicated, paired sites or site comparison studies in Europe, the USA, Canada and Chile found that overall bat activity (relative abundance) and common pipistrelle activity did not differ between organic and non-organic farms. The other four studies found higher overall bat activity, bat feeding activity, Brazilian free-tailed bat activity, and activity of four of seven bat species on organic farms than non-organic farms. Two replicated, paired sites and site comparison studies in the UK found higher activity of Myotis species over water and rivers on organic farms than non-organic farms, but no differences were found for other species or habitats. One replicated, site comparison study in France found higher activity for two of three bat species over organic fields than two of three types of conventionally managed fields.

BEHAVIOUR (0 STUDIES)

Assessment: likely to be beneficial (effectiveness 60%; certainty 60%; harms 0%).

https://www.conservationevidence.com/actions/961

Unknown effectiveness

Create tree plantations on agricultural land to provide roosting and foraging habitat for bats

Three studies evaluated the effects of creating tree plantations on agricultural land to provide roosting and foraging habitat for bats on bat populations. The three studies were in Australia.

COMMUNITY RESPONSE (3 STUDIES)
Richness/diversity (3 studies): Three replicated, site comparison studies in Australia found no difference in the number of bat species in agricultural areas with and without plantations of native trees.
POPULATION RESPONSE (3 STUDIES)
Abundance (3 studies): Two of three replicated, site comparison studies in Australia found no difference in bat activity (relative abundance) in agricultural areas with and without plantations of native trees. The other study found higher bat activity in plantations next to remnant native vegetation than in isolated plantations or over grazing land. In all three studies, bat activity was lower in plantations compared to original forest and woodland remnants.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 30%; certainty 30%; harms 0%).

https://www.conservationevidence.com/actions/958

Engage farmers and landowners to manage land for bats

One study evaluated the effects of engaging farmers and landowners to manage land for bats on bat populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One study in the UK found that during a five-year project to engage farmers and landowners to manage land for bats, the overall population of greater horseshoe bats at four maternity roosts in the area increased (but see summary below).
BEHAVIOUR (1 STUDY)
Change in human behaviour (1 study): One study in the UK found that a landowner engagement project resulted in 77 bat-related management agreements covering approximately 6,536 ha of land.
Assessment: unknown effectiveness (effectiveness 55%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1936

Introduce agri-environment schemes

Three studies evaluated the effects of agri-environment schemes on bat populations. The three studies were in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (3 STUDIES)
Abundance (3 studies): Two of three replicated, paired sites study in the UK found that total bat activity (relative abundance) and the activity of six

bat species did not differ significantly between farms managed under agri-environment schemes and those managed conventionally. The other study found significantly lower overall bat activity and activity of pipistrelle species on agri-environment scheme farms than conventional farms.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 35%; certainty 30%; harms 10%).

https://www.conservationevidence.com/actions/962

Manage hedges to benefit bats

One study evaluated the effects of managing hedges to benefit bat populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, paired sites study in the UK found that pipistrelle activity (relative abundance) did not differ between hedges managed for wildlife on agri-environment scheme farms and hedges on conventional farms.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 0%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1943

Reduce field size (or maintain small fields)

One study evaluated the effects of maintaining small fields on bat populations. The study was in Canada.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One study in Canada found that agricultural landscapes with smaller fields had higher activity (relative abundance) of six of seven bat species than landscapes with larger fields.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 60%; certainty 30%; harms 0%).

https://www.conservationevidence.com/actions/1939

Retain riparian buffers on agricultural land

One study evaluated the effects of retaining riparian buffers on agricultural land on bat populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)

Abundance (1 study): One replicated, paired sites study in the UK found that pipistrelle activity (relative abundance) did not differ along waterways with buffers of vegetation on agri-environment scheme farms and waterways on conventional farms.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 40%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/2284

Retain unmown field margins

One study evaluated the effects of retaining unmown field margins on bats populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, paired sites study in the UK found that pipistrelle activity (relative abundance) did not differ between unmown field margins managed for wildlife on agri-environment scheme farms and field margins on conventional farms.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 0%; certainty 10%; harms 0%).

https://www.conservationevidence.com/actions/1940

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Increase the proportion of semi-natural habitat in the farmed landscape
- Manage ditches to benefit bats
- Plant field margins with a diverse mix of plant species
- Plant in-field trees
- Plant new hedges
- Provide or retain set-aside areas in farmland
- Retain existing in-field trees
- Retain remnant forest or woodland on agricultural land.

2.2.2 Livestock farming

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for livestock farming?	
Unknown effectiveness	• Remove livestock modifications from water troughs
No evidence found (no assessment)	• Avoid the use of antiparasitic drugs for livestock • Manage grazing regimes to increase invertebrate prey • Replace culling of bats with non-lethal methods of preventing vampire bats from spreading rabies to livestock

Unknown effectiveness

Remove livestock modifications from water troughs

One study evaluated the effects of removing livestock modifications from water troughs on bat populations. The study was in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One replicated, paired sites study in the USA found that removing livestock modifications from water troughs resulted in bats drinking from them more frequently.
Behaviour change (1 study): One replicated, paired sites study in the USA found that when livestock modifications were removed from water troughs, bats approached troughs fewer times before successfully drinking from them.
Assessment: unknown effectiveness (effectiveness 60%; certainty 30%; harms 0%).

https://www.conservationevidence.com/actions/1951

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Avoid the use of antiparasitic drugs for livestock
- Manage grazing regimes to increase invertebrate prey

- Replace culling of bats with non-lethal methods of preventing vampire bats from spreading rabies to livestock.

2.2.3 Perennial, non-timber crops

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for perennial, non-timber crops?	
No evidence found (no assessment)	• Introduce certification for bat-friendly crop harvesting regimes • Prevent culling of bats around fruit orchards • Replace netting with non-lethal measures to prevent bats from accessing fruit in orchards • Restore and manage abandoned orchards for bats

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Introduce certification for bat-friendly crop harvesting regimes
- Prevent culling of bats around fruit orchards
- Replace netting with non-lethal measures to prevent bats from accessing fruit in orchards
- Restore and manage abandoned orchards for bats.

2.3 Threat: Energy production

2.3.1 Wind turbines

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for wind turbines?	
Beneficial	• Increase the wind speed at which turbines become operational ('cut-in speed') to reduce bat fatalities
Likely to be beneficial	• Automatically reduce turbine blade rotation when bat activity is high • Deter bats from turbines using ultrasound • Prevent turbine blades from turning at low wind speeds to reduce bat fatalities
No evidence found (no assessment)	• Apply textured coating to turbines • Close off potential access points on turbines to prevent roosting bats • Deter bats from turbines using low-level ultraviolet light • Deter bats from turbines using radar • Modify turbine placement to reduce bat fatalities • Paint turbines to reduce insect attraction • Reduce rotor diameter • Reduce turbine height • Remove turbine lighting to reduce bat and insect attraction • Retain a buffer between turbines and habitat features used by bats

Beneficial

Increase the wind speed at which turbines become operational ('cut-in speed') to reduce bat fatalities

Four studies evaluated the effects of increasing the wind speed at which turbines become operational ('cut-in speed') on bat populations. One study was in Canada and three studies were in the USA.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (4 STUDIES)

Survival (4 studies): Three randomized, replicated, controlled studies (including one before-and-after study) in Canada and the USA, and one review in the USA found that bat fatalities were significantly reduced when the wind speed at which turbines became operational ('cut-in speed') was increased.

BEHAVIOUR (0 STUDIES)

Assessment: beneficial (effectiveness 80%; certainty 70%; harms 0%).

https://www.conservationevidence.com/actions/1960

Likely to be beneficial

Automatically reduce turbine blade rotation when bat activity is high

Two studies evaluated the effects of automatically reducing turbine blade rotation when bat activity is high on bat populations. One study was in Germany, and one in the USA.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (2 STUDIES)

Survival (2 studies): Two replicated studies (one randomized, controlled and one paired sites study) in Germany and the USA found that automatically reducing the rotation speed of wind turbine blades when bat activity is predicted to be high resulted in significantly fewer bat fatalities for all bat species combined and for little brown bats.

BEHAVIOUR (0 STUDIES)

Assessment: likely to be beneficial (effectiveness 80%; certainty 55%; harms 0%).

https://www.conservationevidence.com/actions/971

Deter bats from turbines using ultrasound

Two studies evaluated the effects of deterring bats from wind turbines using ultrasound on bat populations. The two studies were in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Survival (1 study): One randomized, replicated, controlled study with a before-and-after trial in the second year in the USA found mixed results. In the first year of the study, 21-51% fewer bats were killed at turbines with an ultrasonic deterrent fitted than at control turbines, but in the second year, from 2% more to 64% fewer bats were killed at turbines with ultrasonic deterrents fitted.
BEHAVIOUR (1 STUDY)
Behaviour change (1 study): One paired sites study in the USA found significantly fewer bats flying near one of two wind turbines with an ultrasonic deterrent compared to turbines without.
Assessment: likely to be beneficial (effectiveness 40%; certainty 45%; harms 7%).

https://www.conservationevidence.com/actions/968

Prevent turbine blades from turning at low wind speeds to reduce bat fatalities

Three studies evaluated the effects of preventing turbine blades from turning at low wind speeds on bat populations. Two studies were in Canada and one review was in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (3 STUDIES)
Survival (3 studies): Two replicated, controlled before-and-after studies (including one randomized study) in Canada and one review in the USA found that bat fatalities were significantly reduced when turbine blades were prevented from turning at low wind speeds.
BEHAVIOUR (0 STUDIES)
Assessment: likely to be beneficial (effectiveness 80%; certainty 50%; harms 0%).

https://www.conservationevidence.com/actions/970

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Apply textured coating to turbines

- Close off potential access points on turbines to prevent roosting bats
- Deter bats from turbines using low-level ultraviolet light
- Deter bats from turbines using radar
- Modify turbine placement to reduce bat fatalities
- Paint turbines to reduce insect attraction
- Reduce rotor diameter
- Reduce turbine height
- Remove turbine lighting to reduce bat and insect attraction
- Retain a buffer between turbines and habitat features used by bats.

2.3.2 Mining

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for mining?	
Trade-off between benefit and harms	• Install and maintain gates at mine entrances to restrict public access
Unknown effectiveness	• Maintain microclimate in closed/abandoned mines • Restore bat foraging habitat at ex-quarry sites
No evidence found (no assessment)	• Exclude bats from roosts prior to mine reclamation • Provide artificial subterranean bat roosts to replace roosts in reclaimed mines • Relocate bats from reclaimed mines to alternative subterranean roost sites • Reopen entrances to closed mines and make suitable for roosting bats • Retain access points for bats following mine closures

Trade-off between benefit and harms

Install and maintain gates at mine entrances to restrict public access

Nine studies evaluated the effects of installing gates at mine entrances on bat populations. Eight studies were in the USA and one in Australia.
COMMUNITY RESPONSE (1 STUDY)

Richness/diversity (1 study): One replicated, before-and-after study in the USA found that fewer bat species entered mines after gates were installed.
POPULATION RESPONSE (3 STUDIES)
Abundance (3 studies): Two replicated, site comparison or before-and-after studies in the USA and Australia found fewer bats in mines or at mine entrances after gates were installed. One replicated, controlled, before-and-after study in the USA found that bat activity (relative abundance) remained stable or increased at five of seven gated mines, and decreased at two gated mines.
BEHAVIOUR (6 STUDIES)
Use (2 studies): One before-and-after study in the USA found that 43 of 47 mines continued to be used 12 years after gates were installed, however bats abandoned four mines with 'ladder' design gates. One replicated study in the USA found that gate design and time since gate installation had varied effects on the presence of four bat species.
Behaviour change (4 studies): Four replicated, before-and-after or site comparison studies in the USA and Australia found that bats at mine entrances circled more and entered mines less after gates were installed.
OTHER (2 STUDIES)
Collisions with gates (1 study): One replicated, controlled, before-and-after study in the USA found that up to 7% of bats at mine entrances collided with mine gates.
Assessment: trade-off between benefit and harms (effectiveness 50%; certainty 50%; harms 46%).

https://www.conservationevidence.com/actions/1963

Unknown effectiveness

Maintain microclimate in closed/abandoned mines

One study evaluated the effects of maintaining the microclimate in an abandoned mine on bat populations. The study was in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One before-and-after study in the USA found that modifying the microclimate of an abandoned mine by closing a man-made entrance resulted in a greater number of bats hibernating within the mine.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 45%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1964

Restore bat foraging habitat at ex-quarry sites

One study evaluated the effects of restoring bat foraging habitat at ex-quarry sites on bat populations. The study was in France.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Abundance (1 study): One replicated, site comparison study in France found that gravel-sand pits had higher overall bat activity (relative abundance) 10 years after restoration than gravel-sand pit sites before or during quarrying.

BEHAVIOUR (0 STUDIES)

Assessment: unknown effectiveness (effectiveness 50%; certainty 35%; harms 0%).

https://www.conservationevidence.com/actions/2286

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Exclude bats from roosts prior to mine reclamation
- Provide artificial subterranean bat roosts to replace roosts in reclaimed mines
- Relocate bats from reclaimed mines to alternative subterranean roost sites
- Reopen entrances to closed mines and make suitable for roosting bats
- Retain access points for bats following mine closures.

2.4 Threat: Transportation and service corridors

2.4.1 Roads

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for roads?	
Likely to be beneficial	• Install overpasses as road crossing structures for bats • Install underpasses or culverts as road crossing structures for bats
Unknown effectiveness	• Divert bats to safe crossing points with plantings or fencing • Install green bridges as road crossing structures for bats • Maintain bat roosts in road bridges and culverts
Unlikely to be beneficial	• Install bat gantries or bat bridges as road crossing structures for bats
No evidence found (no assessment)	• Avoid planting fruit trees alongside roads in areas with fruit bats • Create spaces for roosting bats in road bridges and culverts • Deter bats from roads using lighting • Deter bats from roads using ultrasound • Install hop-overs as road crossing structures for bats • Minimize road lighting to reduce insect attraction • Replace or improve habitat for bats around roads

Likely to be beneficial

Install overpasses as road crossing structures for bats

Three studies evaluated the effects of installing overpasses as road crossing structures for bats. Two studies were in Europe and one in Australia.

COMMUNITY RESPONSE (1 STUDY)

Richness/diversity (1 study): One site comparison study in Australia found that the same number of bat species were recorded at an overpass and in nearby forest and bushland.

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (2 STUDIES)

Use (2 studies): One replicated, site comparison study in Ireland found that three bat species used overpasses but up to three-quarters of bats crossed the road below at traffic height. One study in the UK found that an overpass with planters was used by two-thirds of crossing bats, and an unvegetated overpass with a paved road over it was not used by crossing bats.

Assessment: likely to be beneficial (effectiveness 45%; certainty 42%; harms 0%).

https://www.conservationevidence.com/actions/977

Install underpasses or culverts as road crossing structures for bats

Six studies evaluated the effects of installing underpasses or culverts as road crossing structures for bats. Five studies were in Europe and one in Australia.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (6 STUDIES)

Use (6 studies): Six studies (including four replicated studies) in Germany, Ireland, the UK and Australia found that bats used underpasses below roads, and crossed over the roads above them, in varying proportions. One replicated, site comparison study in Australia found that bat species adapted to cluttered habitats used small culverts and underpasses more than bat species adapted to open or edge habitats.

Assessment: likely to be beneficial (effectiveness 52%; certainty 50%; harms 0%).

https://www.conservationevidence.com/actions/976

Unknown effectiveness

Divert bats to safe crossing points with plantings or fencing

One study evaluated the effects of diverting bats using an artificial hedgerow on bat populations. The study was in Switzerland.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One controlled, before-and-after study in Switzerland found that up to one fifth of lesser horseshoe bats within a colony flew along an artificial hedgerow to commute.
Assessment: unknown effectiveness (effectiveness 10%; certainty 10%; harms 5%).

https://www.conservationevidence.com/actions/981

Install green bridges as road crossing structures for bats

One study evaluated the effects of installing green bridges as road crossing structures for bats. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One study in the UK found that a green bridge was used by 97% of bats crossing a road.
Assessment: unknown effectiveness (effectiveness 70%; certainty 27%; harms 0%).

https://www.conservationevidence.com/actions/979

Maintain bat roosts in road bridges and culverts

One study evaluated the effects of maintaining bat roosts within a bridge on bat populations. The study was in Ireland.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One before-and-after study in Ireland found that a maternity colony of Daubenton's bats continued to roost in a road bridge over a river in similar numbers after crevices were retained during repair work.
Assessment: unknown effectiveness (effectiveness 55%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1966

Unlikely to be beneficial

Install bat gantries or bat bridges as road crossing structures for bats

Two studies evaluated the effects of installing bat gantries as road crossing structures for bats. Both studies were in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (2 STUDIES)
Use (2 studies): Two replicated studies (including one site comparison) in the UK found that fewer bats used bat gantries than crossed the road below at traffic height, and one bat gantry was not used at all.
Assessment: unlikely to be beneficial (effectiveness 2%; certainty 40%; harms 0%).

https://www.conservationevidence.com/actions/978

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Avoid planting fruit trees alongside roads in areas with fruit bats
- Create spaces for roosting bats in road bridges and culverts
- Deter bats from roads using lighting
- Deter bats from roads using ultrasound
- Install hop-overs as road crossing structures for bats
- Minimize road lighting to reduce insect attraction
- Replace or improve habitat for bats around roads.

2.5 Threat: Biological resource use

2.5.1 Hunting

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for hunting?	
Unknown effectiveness	• Inform local communities about disease risks from hunting and eating bat meat to reduce killing of bats • Inform local communities about the negative impacts of bat hunting to reduce killing of bats
No evidence found (no assessment)	• Encourage online vendors to remove bat specimens for sale • Enforce regulations to prevent trafficking and trade of bats • Introduce alternative treatments to reduce the use of bats in traditional medicine • Introduce and enforce legislation to control hunting of bats • Introduce other food sources to replace bat meat • Introduce other income sources to replace bat trade • Replace culling of bats with non-lethal methods of preventing vampire bats from spreading rabies to humans • Restrict the collection of bat specimens for research • Strengthen cultural traditions that discourage bat harvesting

Unknown effectiveness

Inform local communities about disease risks from hunting and eating bat meat to reduce killing of bats

One study evaluated the effects of informing local communities about disease risks from hunting and eating bat meat to reduce killing of bats on bat populations. The study was in Ghana.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (1 STUDY)

Behaviour change (1 study): One before-and-after study in Ghana found that fewer hunters intended to hunt bats in future after they were provided with education about the risks of diseases carried by bats.

Assessment: unknown effectiveness (effectiveness 50%; certainty 25%; harms 0%).

https://www.conservationevidence.com/actions/1974

Inform local communities about the negative impacts of bat hunting to reduce killing of bats

One study evaluated the effects of informing local communities about the negative impacts of bat hunting to reduce killing of bats on bat populations. The study was in Ghana.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (1 STUDY)

Behaviour change (1 study): One before-and-after study in Ghana found that after providing education about the ecological roles of bats fewer hunters intended to hunt bats in the future.

Assessment: unknown effectiveness (effectiveness 50%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1973

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Encourage online vendors to remove bat specimens for sale
- Enforce regulations to prevent trafficking and trade of bats
- Introduce alternative treatments to reduce the use of bats in traditional medicine

- Introduce and enforce legislation to control hunting of bats
- Introduce other food sources to replace bat meat
- Introduce other income sources to replace bat trade
- Replace culling of bats with non-lethal methods of preventing vampire bats from spreading rabies to humans
- Restrict the collection of bat specimens for research
- Strengthen cultural traditions that discourage bat harvesting.

2.5.2 Guano harvesting

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for guano harvesting?	
No evidence found (no assessment)	• Introduce and enforce legislation to regulate harvesting of bat guano

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Introduce and enforce legislation to regulate harvesting of bat guano.

2.5.3 Logging and wood harvesting

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for logging and wood harvesting?	
Likely to be beneficial	• Retain forested corridors in logged areas • Thin trees within forest and woodland • Use selective or reduced impact logging instead of conventional logging
Unknown effectiveness	• Manage forest and woodland to encourage understorey growth • Retain residual tree patches in logged areas • Use shelterwood cutting instead of clearcutting

No evidence found (no assessment)	• Change timing of forestry operations • Coppice woodland • Encourage natural regeneration in former plantations • Maintain forest and woodland edges for foraging bats • Protect roost trees during forest operations • Replant native trees in logged areas • Retain buffers around roost trees in logged areas • Retain riparian buffers in logged areas • Strengthen cultural traditions such as sacred groves that prevent timber harvesting • Train arborists and forestry operatives to identify potential bat roosts

Likely to be beneficial

Retain forested corridors in logged areas

Three studies evaluated the effects of retaining forested corridors in logged areas on bat populations. The three studies were in the USA.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Abundance (1 studies): One replicated, site comparison study in the USA found that bat activity (relative abundance) was significantly higher along the edges of forested corridors than in corridor interiors or in adjacent logged stands, which had similar activity levels.

BEHAVIOUR (2 STUDIES)

Use (2 studies): One replicated, site comparison study in the USA found more Seminole bats roosting in forested corridors than logged stands or mature forest. One replicated, site comparison study in the USA found more male but fewer female evening bats roosting in forested corridors than logged stands.

Assessment: likely to be beneficial (effectiveness 55%; certainty 40%; harms 0%).

https://www.conservationevidence.com/actions/996

Thin trees within forest and woodland

Eleven studies evaluated the effects of thinning trees within forest and woodland on bat populations. Six studies were in the USA, one study was in Canada, and four were in Australia.

COMMUNITY RESPONSE (2 STUDIES)

Richness/diversity (2 studies): One replicated, site comparison study in Australia recorded the same bat species in thinned and unthinned forest, except for the chocolate wattled bat, which was not recorded in forests with unthinned regrowth. One replicated, site comparison study in Australia found that forest thinned up to 20 years previously had higher bat diversity than unthinned forest, but sites thinned more than 20 years previously did not differ.

POPULATION RESPONSE (11 STUDIES)

Abundance (11 studies): Five of six replicated, site comparison studies (including two paired sites studies and one controlled study) in the USA and Australia found higher overall bat activity (relative abundance) in thinned or thinned and burned forest than unthinned forest. The other study found similar overall bat activity in thinned and unthinned stands. One replicated, randomized, site comparison study in the USA found higher overall bat activity for three of four types of thinning and burning treatments. One replicated, site comparison study in Australia found that forest thinned up to eight years previously or more than 20 years previously had higher bat activity than unthinned forest, but sites thinned 8–20 years previously did not differ. Three replicated, controlled studies (including one site comparison and one before-and-after study) in Canada and Australia found that thinning increased the activity of some bat species but not others.

BEHAVIOUR (0 STUDIES)

Assessment: likely to be beneficial (effectiveness 60%; certainty 60%; harms 0%).

https://www.conservationevidence.com/actions/991

Use selective or reduced impact logging instead of conventional logging

Four studies evaluated the effects of using selective or reduced impact logging instead of conventional logging on bat populations. Two studies were in the Neotropics, one study was in Italy, and one in Germany.

COMMUNITY RESPONSE (1 STUDY)

Community composition (1 study): One replicated, controlled, site comparison study in Trinidad found that the composition of bat species differed between selectively logged and conventionally logged forest.
Richness/diversity (1 study): One replicated, site comparison study in Germany found similar bat diversity in selectively logged and conventionally logged forest.
POPULATION RESPONSE (3 STUDIES)
Abundance (3 studies): One replicated, site comparison study in Germany found similar overall bat activity (relative abundance) in selectively logged and conventionally logged forest. A review of 41 studies in the Neotropics found that reduced impact logging had a smaller effect on bat abundance than conventional logging. One replicated, site comparison study in Italy found greater bat activity at two of three sites that used selective logging techniques to open up the forest canopy rather than leaving the canopy intact.
BEHAVIOUR (0 STUDIES)
Assessment: likely to be beneficial (effectiveness 50%; certainty 40%; harms 0%).

https://www.conservationevidence.com/actions/989

Unknown effectiveness

Manage forest and woodland to encourage understorey growth

One study evaluated the effects of managing forest and woodland to encourage understorey growth on bat populations. The study was in Germany.
COMMUNITY RESPONSE (1 STUDY)
Richness/diversity (1 study): One paired sites study in Germany found more bat species and higher bat diversity in a forest managed to encourage understorey growth than in a managed forest without understorey growth.
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One paired sites study in Germany found higher overall bat activity (relative abundance) in a forest managed to encourage understorey growth than in a managed forest without understorey growth.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 60%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1986

Retain residual tree patches in logged areas

Three studies evaluated the effects of retaining residual tree patches in logged areas on bat populations. The three studies were in Canada.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (3 STUDIES)
Abundance (3 studies): Two replicated, site comparison studies in Canada found no difference in bat activity (relative abundance) along the edges of residual tree patches and the edges of clearcut blocks. One replicated, site comparison study in Canada found that the activity of smaller bat species was higher along the edge of residual tree patches than in the centre of clearcut blocks, but the activity of larger bat species did not differ. One replicated, controlled study in Canada found that residual tree patches had similar activity of little brown bats and northern long-eared bats and lower activity of silver-haired bats compared to clearcut forest patches.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 30%; certainty 35%; harms 0%).

https://www.conservationevidence.com/actions/995

Use shelterwood cutting instead of clearcutting

One study evaluated the effects of using shelterwood cutting instead of 'gap release' cutting on bat populations. The study was in Australia. We found no studies that evaluated the effects of shelterwood cutting instead of clearcutting.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One site comparison study in Australia found more Gould's long-eared bats roosting in remnant trees within forests that had been shelterwood harvested than in forests harvested using gap release methods. Comparisons were not made with clearcutting.
Assessment: unknown effectiveness (effectiveness 15%; certainty 10%; harms 0%).

https://www.conservationevidence.com/actions/990

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Change timing of forestry operations

- Coppice woodland
- Encourage natural regeneration in former plantations
- Maintain forest and woodland edges for foraging bats
- Protect roost trees during forest operations
- Replant native trees in logged areas
- Retain buffers around roost trees in logged areas
- Retain riparian buffers in logged areas
- Strengthen cultural traditions such as sacred groves that prevent timber harvesting
- Train arborists and forestry operatives to identify potential bat roosts.

2.6 Threat: Human intrusions and disturbance

2.6.1 Caving and tourism

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for caving and tourism?	
Likely to be beneficial	• Impose restrictions on cave visits
Trade-off between benefit and harms	• Install and maintain cave gates to restrict public access
Unknown effectiveness	• Install fencing around cave entrances to restrict public access • Minimize noise levels within caves • Restrict artificial lighting in caves and around cave entrances
No evidence found (no assessment)	• Inform the public of ways to reduce disturbance to bats in caves • Introduce guidelines for sustainable cave development and use • Minimize alterations to caves for tourism • Provide artificial subterranean bat roosts to replace roosts in disturbed caves • Restore and maintain microclimate in modified caves • Retain bat access points to caves • Train tourist guides to minimize disturbance and promote bat conservation

Likely to be beneficial

Impose restrictions on cave visits

Three studies evaluated the effects of imposing restrictions on cave visits on bat populations. One study was in the USA, one in Canada and one in Turkey.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (2 STUDIES)
Abundance (2 studies): Two before-and-after studies in Canada and Turkey found that bat populations within caves increased after restrictions on cave visitors were imposed.
BEHAVIOUR (1 STUDY)
Behaviour change (1 study): One study in the USA found that reducing the number of people within cave tour groups did not have a significant effect on the number of take-offs, landings or overall activity (bat movements) of a cave myotis colony roosting within the cave.
Assessment: likely to be beneficial (effectiveness 64%; certainty 45%; harms 0%).

https://www.conservationevidence.com/actions/1002

Trade-off between benefit and harms

Install and maintain cave gates to restrict public access

Eleven studies evaluated the effects of installing cave gates on bat populations. Five studies were in Europe and six studies were in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (7 STUDIES)
Abundance (7 studies): Three of four before-and-after studies (including one replicated study and one controlled study) in the Netherlands, the USA, Spain and Turkey found more or similar numbers of bats in caves and a bunker after gates were installed to restrict public access. The other study found fewer bats in caves after gates were installed. Two before-and-after studies in the USA and Spain found more bats within two caves after the size of the gated entrances were increased. One replicated, before-and-after study in the USA found that installing cave gates resulted in population increases or decreased rates of decline for 13 of 20 colonies of Indiana bat. One replicated, site comparison study in Spain found no difference in the population growth rates of bats roosting in caves with and without cave gates.

Condition (1 study): One site comparison study in the USA found that bats hibernating in a cave with a wall and gate over the entrance lost more body mass than bats in a nearby unmodified cave.
BEHAVIOUR (5 STUDIES)
Use (1 study): One replicated, site comparison study in Spain found no difference in the occupancy rates of bats roosting in caves with and without cave gates.
Behaviour change (4 studies): One replicated, controlled, before-and-after and site comparison study in the USA found that bats at cave entrances circled more and entered caves less after gates were installed. One replicated study in the USA found that bats flew through gates with a funnel design more frequently than gates with a round bar or angle iron design. One randomized, controlled, before-and-after study in the UK found that fewer bats flew through cave gates when the spacing between horizontal bars was reduced. One before-and-after study in the USA4 found that significantly fewer bats emerged from a cave with a gate installed compared with a cave with a fence.
Assessment: trade-off between benefit and harms (effectiveness 70%; certainty 50%; harms 20%).

https://www.conservationevidence.com/actions/999

Unknown effectiveness

Install fencing around cave entrances to restrict public access

Two studies evaluated the effects of installing fencing around cave entrances on bat populations. One study was in the USA and one study was in Spain.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, site comparison study in Spain found no difference in the population growth rates of bats roosting in caves with and without fencing or gates installed.
BEHAVIOUR (2 STUDIES)
Use (1 study): One replicated, site comparison study in Spain found no difference in the occupancy rates of bats roosting in caves with and without fencing or gates installed.

Behaviour change (1 study): One controlled, before-and-after study in the USA found that significantly more southeastern myotis bats and gray myotis bats emerged from a cave after a steel gate was replaced with a fence.
Assessment: unknown effectiveness (effectiveness 40%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1991

Minimize noise levels within caves

One study evaluated the effects of minimizing noise levels within caves on bat populations. The study was in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Behaviour change (1 study): One controlled study in the USA found that experimental cave tours with groups that did not talk resulted in fewer bat flights than when groups did talk, but talking did not have an effect on the number of bat movements.
Assessment: unknown effectiveness (effectiveness 40%; certainty 21%; harms 0%).

https://www.conservationevidence.com/actions/1995

Restrict artificial lighting in caves and around cave entrances

One study evaluated the effects of restricting artificial lighting in caves on bat populations. The study was in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Behaviour change (1 study): One controlled study in the USA found that using low intensity white lights or red lights in caves resulted in fewer bat flights than with full white lighting, but the number of bat movements was similar between all three light treatments.
Assessment: unknown effectiveness (effectiveness 15%; certainty 12%; harms 0%).

https://www.conservationevidence.com/actions/1994

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Inform the public of ways to reduce disturbance to bats in caves
- Introduce guidelines for sustainable cave development and use
- Minimize alterations to caves for tourism
- Provide artificial subterranean bat roosts to replace roosts in disturbed caves
- Restore and maintain microclimate in modified caves
- Retain bat access points to caves
- Train tourist guides to minimize disturbance and promote bat conservation.

2.7 Threat: Natural system modifications

2.7.1 Fire or fire suppression

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for fire or fire suppression?	
Likely to be beneficial	• Use prescribed burning

Likely to be beneficial

Use prescribed burning

Twelve studies evaluated the effects of prescribed burning on bat populations. Eleven studies were in the USA and one study was in Australia.

COMMUNITY RESPONSE (1 STUDY)

Community composition (1 study): One replicated, controlled, before-and-after, paired sites study in Australia found that the composition of bat species differed between burned and unburned woodland sites.

POPULATION RESPONSE (8 STUDIES)

Abundance (8 studies): Two replicated, site comparison studies (including one controlled study) in the USA found that the activity (relative abundance) of open habitat bat species and evening bats increased with the number of prescribed fires, but there was no effect on other bat species, including cluttered habitat bat species. Three replicated, before-and-after or site comparison

studies (including two controlled studies) in the USA and Australia found that prescribed burning or prescribed burning along with thinning resulted in higher overall bat activity or activity of Florida bonneted bats. One site comparison study in the USA found that two of seven sites that had been burned alongside other restoration practices had higher bat activity than unrestored sites. One replicated, randomized, site comparison study in the USA found that three of four burning and thinning treatments resulted in higher overall bat activity. One replicated, controlled, site comparison study in the USA found similar activity of three bat species in burned and unburned tree stands.

BEHAVIOUR (4 STUDIES)

Use (4 studies): One replicated, controlled before-and-after study in the USA found that more female northern myotis bats roosted in burned than unburned forest. Two replicated, controlled, site comparison studies in the USA found that fewer female northern myotis bats and male Indiana bats roosted in burned than unburned forest. One replicated study in the USA found that evening bats roosted in burned but not unburned forest.

Behaviour change (3studies): Two replicated, controlled, site comparison studies in the USA found no difference in roost switching frequency or the distance between roost trees for female northern myotis bats and male Indiana bats in burned and unburned forests. One replicated, controlled, before-and-after study in the USA found that female northern myotis home ranges and core areas did not differ in size between burned and unburned forests, but home ranges were closer to burned forest than unburned forest.

Assessment: likely to be beneficial (effectiveness 60%; certainty 50%; harms 18%).

https://www.conservationevidence.com/actions/1006

2.7.2 Dams and water management/use

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for dams and water management/use?	
Unknown effectiveness	• Create or maintain small dams to provide foraging and drinking habitat for bats • Relocate bat colonies roosting inside dams

Unknown effectiveness

Create or maintain small dams to provide foraging and drinking habitat for bats

One study evaluated the effects of maintaining small dams as foraging and drinking habitat for bats on bat populations. The study was in Portugal.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Abundance (1 study): One replicated, site comparison study in Portugal found that reservoirs created using small dams had greater activity (relative abundance) of four bat species than the streams feeding into them.

BEHAVIOUR (0 STUDIES)

Assessment: unknown effectiveness (effectiveness 51%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1997

Relocate bat colonies roosting inside dams

One study evaluated the effects of relocating bat colonies inside dams on bat populations. The study was in Argentina.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Abundance (1 study): One study in Argentina found that almost two-thirds of a large colony of Brazilian free-tailed bats relocated to a different dam compartment five months after being displaced from six compartments where the colony originally roosted.

BEHAVIOUR (0 STUDIES)

Assessment: unknown effectiveness (effectiveness 5%; certainty 5%; harms 5%).

https://www.conservationevidence.com/actions/1998

2.8 Threat: Invasive or problematic species and disease

2.8.1 Invasive species

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for invasive species?	
Likely to be beneficial	• Control invasive predators
Unknown effectiveness	• Control invasive plant species
No evidence found (no assessment)	• Control harmful invasive bat prey species • Control invasive non-predatory competitors • Exclude domestic and feral cats from bat roosts and roost entrances • Keep domestic cats indoors at night • Use collar-mounted devices on cats to reduce predation of bats

Likely to be beneficial

Control invasive predators

One study evaluated the effects of controlling invasive predators on bat populations. The study was in New Zealand.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Survival (1 study): One replicated, before-and-after study in New Zealand found that controlling ship rats resulted in increased survival probabilities for female long-tailed bats.

BEHAVIOUR (0 STUDIES)

Assessment: likely to be beneficial (effectiveness 80%; certainty 40%; harms 0%).

https://www.conservationevidence.com/actions/1007

Unknown effectiveness

Control invasive plant species

One study evaluated the effects of controlling invasive plant species on bat populations. The study was in the USA.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Abundance (1 study): One site comparison study in the USA found that two of seven forest fragments where invasive plant species had been removed alongside other restoration practices had significantly higher bat activity (relative abundance) than two unrestored forest fragments.

BEHAVIOUR (0 STUDIES)

Assessment: unknown effectiveness (effectiveness 20%; certainty 10%; harms 0%).

https://www.conservationevidence.com/actions/1008

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Control harmful invasive bat prey species
- Control invasive non-predatory competitors
- Exclude domestic and feral cats from bat roosts and roost entrances
- Keep domestic cats indoors at night
- Use collar-mounted devices on cats to reduce predation of bats.

2.8.2 White-nose syndrome

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for white-nose syndrome?	
Unknown effectiveness	• Modify bat hibernacula environments to increase bat survival • Treat bats for infection with white-nose syndrome
No evidence found (no assessment)	• Breed bats in captivity to supplement wild populations affected by white-nose syndrome • Cull infected bats • Decontaminate clothing and equipment after entering caves • Restrict human access to bat caves to prevent spread of disease • Treat bat hibernacula environments to reduce pathogen reservoir • Vaccinate bats against the white-nose syndrome pathogen

Unknown effectiveness

Modify bat hibernacula environments to increase bat survival

One study evaluated the effects of modifying hibernacula environments to increase bat survival. The study was in the USA.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Survival (1 study): One randomized, replicated, controlled study in the USA found that a greater number of little brown bats infected with the white-nose syndrome fungus survived in hibernation chambers at 4°C than at 10°

BEHAVIOUR (1 STUDY)

Behaviour change (1 study): One randomized, replicated, controlled study in the USA found that little brown bats infected with the white-nose syndrome fungus stayed in hibernation for longer in hibernation chambers at 4°C than at 10°.

Assessment: unknown effectiveness (effectiveness 50%; certainty 30%; harms 10%).

https://www.conservationevidence.com/actions/1013

Treat bats for infection with white-nose syndrome

One study evaluated the effects of treating bats with a probiotic bacterium to reduce white-nose syndrome infection. The study was in Canada.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Survival (1 study): One randomized, replicated, controlled study in Canada found that treating little brown bats with a probiotic bacterium at the time of infection with white-nose syndrome increased survival, but treating bats 21 days prior to infection had no effect.
Condition (1 study): One randomized, replicated, controlled study in Canada found that treating little brown bats with a probiotic bacterium at the time of infection with white-nose syndrome reduced the symptoms of the disease, but treating bats 21 days prior to infection made symptoms worse.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 30%; certainty 25%; harms 10%).

https://www.conservationevidence.com/actions/2008

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Breed bats in captivity to supplement wild populations affected by white-nose syndrome
- Cull infected bats
- Decontaminate clothing and equipment after entering caves
- Restrict human access to bat caves to prevent spread of disease
- Treat bat hibernacula environments to reduce pathogen reservoir
- Vaccinate bats against the white-nose syndrome pathogen.

2.8.3 Disease

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for disease?	
No evidence found (no assessment)	• Carry out surveillance of bats for early treatment/action to reduce disease/viruses

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Carry out surveillance of bats for early treatment/action to reduce disease/viruses.

2.8.4 Problematic native species

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for problematic native species?	
No evidence found (no assessment)	• Modify bats roosts to reduce negative impacts of one bat species on another • Protect bats within roosts from disturbance or predation by native species

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Modify bats roosts to reduce negative impacts of one bat species on another
- Protect bats within roosts from disturbance or predation by native species.

2.9 Threat: Pollution

2.9.1 Domestic and urban waste water

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for domestic and urban waste water?	
Unknown effectiveness	• Change effluent treatments of domestic and urban waste water
No evidence found (no assessment)	• Prevent pollution from sewage treatment facilities from entering watercourses • Reduce or prevent the use of septic systems near caves

Unknown effectiveness

Change effluent treatments of domestic and urban waste water

One study evaluated the effects of different sewage treatments on the activity of foraging bats. The study was in the UK. We found no studies that evaluated the effects of changing effluent treatments of domestic and urban waste water discharged into rivers on bat populations.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Abundance (1 study): One replicated, site comparison study in the UK found higher activity (relative abundance) of foraging bats over filter bed sewage treatment works than over active sludge systems.

BEHAVIOUR (0 STUDIES)

Assessment: unknown effectiveness (effectiveness 25%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1014

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Prevent pollution from sewage treatment facilities from entering watercourses
- Reduce or prevent the use of septic systems near caves.

2.9.2 Agricultural and forestry effluents

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for agricultural and forestry effluents?	
Likely to be beneficial	• Reduce pesticide, herbicide or fertiliser use
No evidence found (no assessment)	• Change effluent treatments used in agriculture and forestry • Introduce legislation to control the use of hazardous substances • Plant riparian buffer strips • Prevent pollution from agricultural land or forestry from entering watercourses • Use organic pest control instead of synthetic pesticides

Likely to be beneficial

Reduce pesticide, herbicide or fertiliser use

Three studies evaluated the effects of reducing pesticide, herbicide and fertiliser use on bat populations. One study was in Mexico, one was in Portugal, and one in Germany.

COMMUNITY RESPONSE (3 STUDIES)

Community composition (1 study): One replicated, site comparison study in Portugal found that farms using few or no chemicals had different compositions of bat species to farms using high chemical inputs.

Richness/diversity (2 studies): One site comparison study in Mexico found that coffee agroforestry plantations using few or no chemicals had a higher diversity of insect-eating bat species than plantations with high chemical inputs, but the diversity of fruit and nectar-eating bat species did not differ. One paired sites study in Germany recorded more bat species over grassland with moderate or no fertiliser applications than grassland with high fertiliser applications.

POPULATION RESPONSE (2 STUDIES)

Abundance (2 studies): Two site comparison or paired sites studies (one replicated) in Portugal and Germany found that farms or grasslands with few or no chemical inputs had higher overall bat activity (relative abundance) than those using high chemical inputs.

BEHAVIOUR (0 STUDIES)

Assessment: likely to be beneficial (effectiveness 72%; certainty 50%; harms 0%).

https://www.conservationevidence.com/actions/2013

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Change effluent treatments used in agriculture and forestry
- Introduce legislation to control the use of hazardous substances
- Plant riparian buffer strips
- Prevent pollution from agricultural land or forestry from entering watercourses
- Use organic pest control instead of synthetic pesticides.

2.9.3 Light pollution

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for light pollution?	
Likely to be beneficial	• Avoid illumination of bat commuting routes • Leave bat roosts and roost entrances unlit • Use low intensity lighting • Use red lighting rather than other lighting colours

Unknown effectiveness	• Avoid illumination of bat foraging, drinking and swarming sites • Restrict timing of lighting • Use UV filters on lights
No evidence found (no assessment)	• Direct lighting away from bat access points or habitats • Use 'warm white' rather than 'cool' LED lights • Use glazing treatments to reduce light spill from inside lit buildings

Likely to be beneficial

Avoid illumination of bat commuting routes

Three studies evaluated the effects of avoiding the illumination of bat commuting routes on bat populations. One study was in the Netherlands and two in the UK.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (3 STUDIES)

Abundance (2 studies): One replicated, before-and-after study in the Netherlands found similar numbers of pond bats flying along unlit canals and canals illuminated with lamps. Two replicated, controlled studies in the UK found greater activity (relative abundance) of lesser horseshoe bats and myotis bats along unlit hedges than along hedges illuminated with street lights, but activity was similar for common and soprano pipistrelles and Nyctalus/Eptesicus species along unlit and illuminated hedges.

BEHAVIOUR (2 STUDIES)

Behaviour change (2 studies): One replicated, before-and-after study in the Netherlands found that 28–96% of pond bats changed their flight paths along canals to avoid light spill from lamps. One replicated, controlled study in the UK found that lesser horseshoe bats were active earlier along unlit hedges than along those illuminated with street lights.

Assessment: likely to be beneficial (effectiveness 70%; certainty 50%; harms 0%).

https://www.conservationevidence.com/actions/2017

Leave bat roosts and roost entrances unlit

Three studies evaluated the effects of leaving bat roosts and roost entrances unlit on bat populations. One study was in the UK, one in Hungary and one in Sweden.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Condition (1 study): One replicated, controlled study in Hungary found that juvenile bats had a higher body mass and greater forearm length at unlit roosts than at roosts with artificial lighting.

BEHAVIOUR (3 STUDIES)

Use (1 study): One replicated, before-and-after study in Sweden found that all of 13 unlit churches continued to be used by brown long-eared bat colonies over 25 years, but bat colonies abandoned their roosts at 14 of 23 churches that were either partly or fully lit with floodlights.

Behaviour change (2 studies): Two replicated, controlled studies in the UK and Hungary found that more bats emerged, and bats emerged earlier and foraged for shorter periods, when roosts were left unlit than when they had artificial lighting.

Assessment: likely to be beneficial (effectiveness 80%; certainty 46%; harms 0%).

https://www.conservationevidence.com/actions/1017

Use low intensity lighting

Three studies evaluated the effects of using low intensity lighting on bat populations. The three studies were in the UK.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (2 STUDIES)

Abundance (2 studies): One replicated, randomized, controlled study in the UK found that activity (relative abundance) of lesser horseshoe bats, but not myotis bats, was higher along hedges with medium or low intensity lighting than hedges with high intensity lighting. One replicated, randomized, controlled study in the UK found that activity of myotis bats, but not common pipistrelles, was higher along treelined roads with street lights dimmed to an intensity of 25% than roads with streetlights dimmed to 50% or left undimmed.

BEHAVIOUR (1 STUDY)

Behaviour change (1 study): One replicated, controlled study in the UK found that more soprano pipistrelles emerged from two roosts when the intensity of red lights was reduced by placing filters over them.
Assessment: likely to be beneficial (effectiveness 65%; certainty 50%; harms 5%).

https://www.conservationevidence.com/actions/1018

Use red lighting rather than other lighting colours

Three studies evaluated the effects of red lighting on bat populations. One study was in the UK, and two studies were in the Netherlands.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (2 STUDIES)
Abundance (2 studies): One replicated, controlled, site comparison study in the Netherlands found that red lighting resulted in higher activity (relative abundance) for one of three bat species groups than white or green lighting. One site comparison study in the Netherlands found that culverts illuminated with red light had similar activity of commuting Daubenton's bats as culverts illuminated with white or green light.
BEHAVIOUR (1 STUDY)
Behaviour (1 study): One replicated, controlled study in the UK found that more soprano pipistrelles emerged from a roost when lit with red light than when lit with white light, but no difference was found between red and blue lights.
Assessment: likely to be beneficial (effectiveness 50%; certainty 50%; harms 0%).

https://www.conservationevidence.com/actions/2021

Unknown effectiveness

Avoid illumination of bat foraging, drinking and swarming sites

One study evaluated the effects of avoiding the illumination of key bat habitats on bat populations. The study was in Italy.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, randomized, before-and-after study in Italy found that unlit water troughs had greater activity (relative abundance) of five of six bat species/species groups than troughs illuminated with artificial light.

BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 72%; certainty 35%; harms 0%).

https://www.conservationevidence.com/actions/2018

Restrict timing of lighting

One study evaluated the effects of restricting the timing of lighting on bat populations. The study was in France.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, paired sites study in France found that turning off streetlights for part of the night resulted in mixed results for activity (relative abundance), depending on bat species, when compared with leaving streetlights switched on all night.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 38%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1019

Use UV filters on lights

One study evaluated the effects of using ultraviolet filters on lights on bat populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One randomized, replicated, controlled study in the UK found that hedges lit with ultraviolet filtered lights had higher soprano pipistrelle, but not common pipistrelle activity (relative abundance) than hedges lit with unfiltered light.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 45%; certainty 22%; harms 0%).

https://www.conservationevidence.com/actions/1020

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Direct lighting away from bat access points or habitats
- Use 'warm white' rather than 'cool' LED lights
- Use glazing treatments to reduce light spill from inside lit buildings.

2.9.4 Timber treatments

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for timber treatments?	
Likely to be ineffective or harmful	• Restrict timing of timber treatment application
No evidence found (no assessment)	• Use mammal-safe timber treatments in roof spaces

Likely to be ineffective or harmful

Restrict timing of timber treatment application

One study evaluated the effects of restricting the timing of timber treatment application on bat populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Survival (1 study): One replicated, controlled laboratory study in the UK found that treating timber with lindane and pentachlorophenol 14 months prior to exposure by bats increased survival but did not prevent death.
BEHAVIOUR (0 STUDIES)
Assessment: likely to be ineffective or harmful (effectiveness 5%; certainty 55%; harms 50%).

https://www.conservationevidence.com/actions/1023

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Use mammal-safe timber treatments in roof spaces.

2.9.5 Industrial effluents

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for industrial effluents?	
No evidence found (no assessment)	• Introduce or enforce legislation to prevent ponds and streams from being contaminated by toxins

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Introduce or enforce legislation to prevent ponds and streams from being contaminated by toxins.

2.9.6 Noise pollution

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for noise pollution?	
No evidence found (no assessment)	• Impose noise limits in proximity to bat roosts and habitats • Install sound barriers in proximity to bat roosts and habitats

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Impose noise limits in proximity to bat roosts and habitats
- Install sound barriers in proximity to bat roosts and habitats.

2.10 Threat: Climate change and severe weather

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for climate change and severe weather?	
No evidence found (no assessment)	• Adapt bat roost structures to buffer against temperature extremes • Enhance natural habitat features to improve landscape connectivity to allow for range shifts of bats • Manage natural water bodies in arid areas to prevent desiccation • Provide suitable bat foraging and roosting habitat at expanding range fronts

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Adapt bat roost structures to buffer against temperature extremes
- Enhance natural habitat features to improve landscape connectivity to allow for range shifts of bats
- Manage natural water bodies in arid areas to prevent desiccation
- Provide suitable bat foraging and roosting habitat at expanding range fronts.

2.11 Habitat protection

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for habitat protection?	
Likely to be beneficial	• Legally protect bat habitats
Unknown effectiveness	• Conserve roosting sites for bats in old structures or buildings
No evidence found (no assessment)	• Retain buffer zones around core bat habitat • Retain connectivity between habitat patches • Retain existing bat commuting routes • Retain native forest and woodland • Retain remnant habitat patches • Retain veteran and standing dead trees as roosting sites for bats • Retain wetlands

Likely to be beneficial

Legally protect bat habitats

Five studies evaluated the effects of legally protecting bat habitats on bat populations. Four studies were in Europe, and one in India.

COMMUNITY RESPONSE (2 STUDIES)

Community composition (1 study): One replicated, site comparison study in India found that the composition of bat species was similar in protected forest and unprotected forest fragments.

Richness/diversity (2 studies): Two replicated, site comparison or paired sites studies in Europe and India found that the number of bat species did

not differ between protected and unprotected forests or forest fragments. One replicated, site comparison study in France found that protected sites had a greater number of bat species than unprotected sites.
POPULATION RESPONSE (4 STUDIES)
Abundance (4 studies): One replicated, site comparison study in the UK found that the activity (relative abundance) of Daubenton's bats was higher over rivers on farms in protected areas than in unprotected areas. One replicated, paired sites study in Europe found that the activity of common noctule bats was higher in protected forests than unprotected forests, but bat activity overall did not differ. Two replicated, site comparison studies in France and India found higher overall bat activity, higher activity of three of six bat species/species groups and a greater number of bats in protected sites and forests than unprotected sites and forests.
BEHAVIOUR (1 STUDY)
Use (1 study): One study in Spain found that the distributions of 10 of 11 bat species overlapped with areas designated to protect them significantly more than by chance.
Assessment: likely to be beneficial (effectiveness 50%; certainty 41%; harms 0%).

https://www.conservationevidence.com/actions/2045

Unknown effectiveness

Conserve roosting sites for bats in old structures or buildings

Two studies evaluated the effects of conserving roosting sites for bats in old structures or buildings on bat populations. Both studies were in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One before-and-after study in the UK found that a greater number of bats hibernated in a railway tunnel after walls with access grilles were installed at the tunnel entrances and wood was attached to the tunnel walls.
BEHAVIOUR (1 STUDY)
Use (1 study): One before-and-after study in the UK found that Natterer's bats used a roost that was 'boxed-in' within a church, but the number of bats using the roost was reduced by half.
Assessment: unknown effectiveness (effectiveness 50%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/2046

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Retain buffer zones around core bat habitat
- Retain connectivity between habitat patches
- Retain existing bat commuting routes
- Retain native forest and woodland
- Retain remnant habitat patches
- Retain veteran and standing dead trees as roosting sites for bats
- Retain wetlands.

2.12 Habitat restoration and creation

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for habitat restoration and creation?	
Likely to be beneficial	• Create artificial water sources • Restore or create wetlands
Unknown effectiveness	• Create artificial caves or hibernacula for bats • Create artificial hollows and cracks in trees for roosting bats • Reinstate bat roosts in felled tree trunks • Restore or create forest or woodland • Restore or create grassland
No evidence found (no assessment)	• Create new unlit commuting routes using planting • Restore or create linear habitat features/green corridors

Likely to be beneficial

Create artificial water sources

Five studies evaluated the effects of creating artificial water sources for bats on bat populations. One study was in the USA, one in Germany, one in South Africa, one in Israel, and one in Mexico.

COMMUNITY RESPONSE (1 STUDY)

Richness/diversity (1 study): One replicated, paired sites study in South Africa found a similar number of bat species over farm ponds and in grassland/crops, trees, vineyards or orchards.
POPULATION RESPONSE (5 STUDIES)
Abundance (5 studies): Five replicated studies (including four site comparisons and one paired sites study) in Israel, the USA, Germany, South Africa and Mexico found that bat activity (relative abundance) was similar or higher over reservoirs and waste water treatment pools, heliponds and drainage ditches, retention ponds and farm/cattle ponds compared to over natural wetlands, nearby vineyards, surrounding forest or grassland/crops, trees and orchards.
BEHAVIOUR (0 STUDIES)
Assessment: likely to be beneficial (effectiveness 70%; certainty 55%; harms 0%).

https://www.conservationevidence.com/actions/959

Restore or create wetlands

One study evaluated the effects of restoring wetlands on bat populations. The study was in the USA.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, controlled, before-and-after study in the USA found that restoring wetlands increased overall bat activity (relative abundance), and restored wetlands had similar bat activity to undisturbed wetlands.
BEHAVIOUR (0 STUDIES)
Assessment: likely to be beneficial (effectiveness 62%; certainty 40%; harms 0%).

https://www.conservationevidence.com/actions/2036

Unknown effectiveness

Create artificial caves or hibernacula for bats

Two studies evaluated the effects of creating artificial caves or hibernacula for bats on bat populations. Both studies were in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (2 STUDIES)
Uptake (1 study): One study in the UK found that the number of bats using an artificial hibernaculum increased in each of nine years after it was built.

Use (2 studies): One study in the UK found that an artificial cave was used by a small number of brown long-eared bats. One study in the UK found that an artificial hibernaculum was used by four bat species.
Assessment: unknown effectiveness (effectiveness 55%; certainty 22%; harms 0%).

https://www.conservationevidence.com/actions/2049

Create artificial hollows and cracks in trees for roosting bats

One study evaluated the effects of creating artificial hollows and cracks in trees for roosting bats. The study was in Australia.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One replicated study in Australia found that eight of 16 artificial hollows cut into trees for bats, birds and marsupials with two different entrance designs were used by roosting long-eared bats.
Assessment: unknown effectiveness (effectiveness 50%; certainty 23%; harms 0%).

https://www.conservationevidence.com/actions/2047

Reinstate bat roosts in felled tree trunks

One study evaluated the effects of reinstating a bat roost within a felled tree trunk on bat populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (0 STUDIES)
BEHAVIOUR (1 STUDY)
Use (1 study): One before-and-after study in the UK found that a roost reinstated by attaching the felled tree trunk to a nearby tree continued to be used by common noctule bats as a maternity roost.
Assessment: unknown effectiveness (effectiveness 35%; certainty 10%; harms 0%).

https://www.conservationevidence.com/actions/2048

Restore or create forest or woodland

Two studies evaluated the effects of restoring forests on bat populations. One study was in Brazil and one in Australia.
COMMUNITY RESPONSE (1 STUDY)
Richness/diversity (1 study): One site comparison study in Brazil found that a reforested area had significantly lower bat diversity than a native forest fragment.

POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, controlled, site comparison study in Australia found that forests restored after mining had significantly higher or similar bat activity (relative abundance) as unmined forests for five of seven bat species.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 40%; certainty 15%; harms 0%).

https://www.conservationevidence.com/actions/2050

Restore or create grassland

One study evaluated the effects of creating grassland on bat populations. The study was in the UK.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (1 STUDY)
Abundance (1 study): One replicated, paired sites study in the UK found that pipistrelle activity (relative abundance) did not differ between species-rich grassland created on agri-environment scheme farms and improved pasture or crop fields on conventional farms.
BEHAVIOUR (0 STUDIES)
Assessment: unknown effectiveness (effectiveness 2%; certainty 10%; harms 0%).

https://www.conservationevidence.com/actions/2051

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Create new unlit commuting routes using planting
- Restore or create linear habitat features/green corridors.

2.13 Species management

2.13.1 Species management

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for species management?	
Unknown effectiveness	• Manage microclimate of artificial bat roosts • Provide bat boxes for roosting bats
No evidence found (no assessment)	• Legally protect bat species • Regularly clean bat boxes to increase occupancy • Release captive-bred bats

Unknown effectiveness

Manage microclimate of artificial bat roosts

Three studies evaluated the effects of managing the microclimate of artificial bat roosts on bat populations. Two studies were in the UK, and one in Spain.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (1 STUDY)

Abundance (1 study): One before-and-after study in Spain found more bats in two artificial roosts within buildings after they had been modified to reduce internal roost temperatures.

BEHAVIOUR (2 STUDIES)

Use (2 studies): One replicated, before-and-after study in the UK found that heated bat boxes were used by common pipistrelle bats at one of seven sites, but none were used by maternity colonies. One replicated study in the UK

found that none of the 12 heated bat boxes installed within churches were used by displaced Natterer's bats.

Assessment: unknown effectiveness (effectiveness 40%; certainty 30%; harms 0%).

https://www.conservationevidence.com/actions/2052

Provide bat boxes for roosting bats

Forty-two studies evaluated the effects of providing bat boxes for roosting bats on bat populations. Twenty-six studies were in Europe, nine studies were in North America, four studies were in Australia, two studies were in South America, and one study was a worldwide review.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (0 STUDIES)

BEHAVIOUR (42 STUDIES)

Uptake (9 studies): Nine replicated studies in Europe and the USA found that the number of bats using bat boxes increased by 2–10 times up to 10 years after installation.

Use (42 studies): Thirty-six of 41 studies (including 33 replicated studies and two reviews) in Europe, the USA, South America, and Australia found that bats used bat boxes installed under bridges and in forest or woodland, forestry plantations, farmland, pasture, wetlands, urban areas or unknown habitats. The other two studies in the USA and UK found that bats displaced from buildings did not use any of 43 bat houses of four different designs or 12 heated bat boxes of one design. One review of 109 studies across Europe, North America and Asia found that 72 bat species used bat boxes, although only 18 species commonly used them, and 31 species used them as maternity roosts. Twenty-one studies (including sixteen replicated studies, one before-and-after study and two reviews) found bats occupying less than half of bat boxes provided (0–49%). Nine replicated studies found bats occupying more than half of bat boxes provided (54–100%).

OTHER (21 STUDIES)

Bat box design (15 studies): Two studies in Germany and Portugal found that bats used black bat boxes more than grey or white boxes. One of two studies in Spain and the USA found higher occupancy rates in larger bat boxes. One study in the USA found that bats used both resin and wood cylindrical bat boxes, but another study in the USA found that resin bat boxes became occupied more quickly than wood boxes. One study in the UK found higher occupancy rates in concrete than wooden bat boxes. One study in the USA

found that Indiana bats used rocket boxes more than wooden bat boxes or bark-mimic roosts. One study in Spain found that more bats occupied bat boxes that had two compartments than one compartment in the breeding season. One study in Lithuania found that bat breeding colonies occupied standard and four/five chamber bat boxes and individuals occupied flat bat boxes. Three studies in the USA, UK and Spain found bats selecting four of nine, three of five and three of four bat box designs. One study in the UK found that different bat box designs were used by different species. One study in Costa Rica found that bat boxes simulating tree trunks were used by 100% of bats and in group sizes similar to natural roosts.

Bat box position (11 studies): Three studies in Germany, Spain and the USA found that bat box orientation and/or the amount of exposure to sunlight affected bat occupancy, and one study in Spain found that orientation did not have a significant effect on occupancy. Two studies in the UK and Italy found that bat box height affected occupancy, and two studies in Spain and the USA found no effect of height. Two studies in the USA and Spain found higher occupancy of bat boxes on buildings than on trees. One study in Australia found that bat boxes were occupied more often in farm forestry sites than in native forest, one study in Poland found higher occupancy in pine relative to mixed deciduous stands, and one study in Costa Rica found higher occupancy in forest fragments than in pasture. One study in the USA found higher occupancy rates in areas where bats were known to roost prior to installing bat boxes.

Assessment: unknown effectiveness (effectiveness 30%; certainty 20%; harms 0%).

https://www.conservationevidence.com/actions/1024

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Legally protect bat species
- Regularly clean bat boxes to increase occupancy
- Release captive-bred bats.

2.13.2 Ex-situ conservation

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for ex-situ conservation?	
Unknown effectiveness	• Rehabilitate injured/orphaned bats to maintain wild bat populations
Unlikely to be beneficial	• Breed bats in captivity

Unknown effectiveness

Rehabilitate injured/orphaned bats to maintain wild bat populations

Four studies evaluated the effects of rehabilitating injured/orphaned bats on bat populations. Two studies were in the UK, one was in Italy and one in Brazil.

COMMUNITY RESPONSE (0 STUDIES)

POPULATION RESPONSE (4 STUDIES)

Survival (4 studies): One study in Brazil found that two hand-reared orphaned greater spear-nosed bats survived for over three months in captivity. Two studies in the UK and Italy found that 70–90% of hand-reared pipistrelle bats survived for at least 4–14 days after release into the wild, and six of 21 bats joined wild bat colonies. One study in the UK found that pipistrelle bats that flew in a large flight cage for long periods before release survived for longer and were more active than bats that flew for short periods or in a small enclosure. One study in the UK found that 13% of ringed hand-reared pipstrelle bats were found alive in bat boxes 38 days to almost four years after release into the wild.

Condition (1 study): One study in Brazil found that two orphaned greater spear-nosed bats increased in body weight and size after being hand-reared, and reached a normal size for the species after 60 days.

BEHAVIOUR (0 STUDIES)

Assessment: unknown effectiveness (effectiveness 47%; certainty 27%; harms 0%).

https://www.conservationevidence.com/actions/2054

Unlikely to be beneficial

Breed bats in captivity

Six studies evaluated the effects of breeding bats in captivity on bat populations. Three studies were in the USA, two in the UK and one in Brazil.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (6 STUDIES)
Reproductive success (5 studies): Five studies in the USA, UK and Brazil found that 6–100% of female bats captured in the wild successfully conceived, gave birth and reared young in captivity. Two studies in the UK and Brazil found that two of five and two of three bats born in captivity successfully gave birth to live young.
Survival (6 studies): Six studies in the USA, UK and Brazil found that 20–86% of bat pups born in captivity survived from between 10 days to adulthood.
BEHAVIOUR (0 STUDIES)
Assessment: unlikely to be beneficial (effectiveness 30%; certainty 40%; harms 18%).

https://www.conservationevidence.com/actions/2053

2.13.3 Translocation

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for translocation?	
Likely to be ineffective or harmful	• Translocate bats

Likely to be ineffective or harmful

Translocate bats

Two studies evaluated the effects of translocating bats on bat populations. One study was in New Zealand and one study was in Switzerland.
COMMUNITY RESPONSE (0 STUDIES)
POPULATION RESPONSE (2 STUDIES)

Reproductive success (1 study): One study in Switzerland found that a female greater horseshoe bat that settled at a release site after translocation had a failed pregnancy.
Survival (1 study): One study in Switzerland found that four of 18 bats died after translocation.
Condition (1 study): One study in New Zealand found that lesser short-tailed bats captured at release sites eight months after translocation were balding and had damaged, infected ears.
BEHAVIOUR (2 STUDIES)
Uptake (2 studies): Two studies in New Zealand and Switzerland found that low numbers of bats remained at release sites after translocation.
Behaviour change (1 study): One study in Switzerland found that bats homed after release at translocation sites less than 20 km from their original roosts.
Assessment: likely to be ineffective or harmful (effectiveness 5%; certainty 40%; harms 80%).

https://www.conservationevidence.com/actions/1009

2.14 Education and awareness raising

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for education and awareness raising?	
No evidence found (no assessment)	• Educate farmers, land managers and local communities about the benefits of bats to improve management of bat habitats • Educate farmers, local communities and pest controllers to reduce indiscriminate culling of vampire bats • Educate pest controllers and homeowners/ tenants to reduce the illegal use of pesticides in bat roosts • Educate the public to improve perception of bats to improve behaviour towards bats • Engage policymakers to make policy changes beneficial to bats • Promote careful bat-related eco-tourism to improve behaviour towards bats • Provide training to conservationists, land managers, and the building and development sector on bat ecology and conservation to reduce bat roost disturbance

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Educate farmers, land managers and local communities about the benefits of bats to improve management of bat habitats
- Educate farmers, local communities and pest controllers to reduce indiscriminate culling of vampire bats
- Educate pest controllers and homeowners/tenants to reduce the illegal use of pesticides in bat roosts
- Educate the public to improve perception of bats to improve behaviour towards bats
- Engage policymakers to make policy changes beneficial to bats
- Promote careful bat-related eco-tourism to improve behaviour towards bats
- Provide training to conservationists, land managers, and the building and development sector on bat ecology and conservation to reduce bat roost disturbance.