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Providing evidence to improve practice

What Works in Conservation

2015

Edited by
William J. Sutherland, Lynn V. Dicks,
Nancy Ockendon and Rebecca K. Smith

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Contents

Introduction

This book has been created to help you make decisions about practical conservation management by providing an assessment, from the available scientific evidence, of what works and what does not work in conservation. It also tells you if no evidence has been found about whether or not a conservation intervention is effective.

Who is *What Works in Conservation* for?

This book is for people who have to make decisions about how best to support or conserve biodiversity. These include land managers, conservationists in the public or private sector, farmers, campaigners, advisors or consultants, policymakers, researchers or people taking action to protect local wildlife. *What Works in Conservation* and the associated synopses summarize scientific evidence relevant to conservation objectives and the actions that could be taken to achieve them. *What Works in Conservation* also provides an assessment of the effectiveness of interventions based on available evidence.

We do not aim to make decisions for people, but to support decision-making by providing what evidence there is (or is not) about the effects that your planned actions could have. It is important that you read the full details of the evidence, freely available online at www.conservationevidence.com, before making any decisions about implementing an intervention.

The Conservation Evidence project

The Conservation Evidence project has four parts, all of which are available from our website conservationevidence.com:

1. An ever-expanding searchable **database of over 4,200 summaries** of previously published scientific papers, reports,

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reviews or systematic reviews that document the effects of interventions.

2. **Synopses** of the evidence captured in part 1) relating to particular species groups, habitats or conservation issues. Synopses bring together the evidence for all possible interventions. Synopses are also available to purchase in printed book form.
3. ***What Works in Conservation*** provides an assessment of the effectiveness of interventions based on available evidence. It contains both the key messages from the evidence for each conservation intervention from the relevant synopses, and an assessment of the effectiveness of each intervention by expert panels.
4. An online, **open access journal** *Conservation Evidence* that publishes new pieces of research on the effects of conservation management interventions. All our papers are written by, or in conjunction with, those who carried out the conservation work and include some monitoring of its effects.

Alongside this project, the Centre for Evidence-Based Conservation (www.cebc.bangor.ac.uk) and the Collaboration for Environmental Evidence (www.environmentalevidence.org) carry out and compile systematic reviews of evidence on the effectiveness of particular conservation interventions. We recommend carrying out a systematic review, which is more comprehensive than our summaries of evidence, when decisions have to be made with particularly important consequences. Systematic reviews are included in the Conservation Evidence database.

Which conservation interventions are included?

Lists of interventions for each synopsis are developed and agreed in partnership with an advisory board made up of international conservationists and academics with expertise in the subject. We aim to include all actions that have been carried out or advised for the conservation of the specific group of species or habitat or for the specific conservation issue.

The lists of interventions are organized into categories based on the International Union for the Conservation of Nature (IUCN) classifications of direct threats and conservation actions (http://www.iucnredlist.org/

technical-documents/classification-schemes/). Interventions are primarily grouped according to the relevant direct threats. However, some interventions can be used in response to many different threats and so these have been grouped according to conservation action.

How we review the literature

We gather evidence by searching relevant scientific journals from volume one through to the most recent volume. Thirty general conservation journals are regularly searched by Conservation Evidence. Specialist journals are also searched for each synopsis (156 have been searched so far). We also search reports, unpublished literature and evidence provided by our advisory boards. Two of the synopses used systematic mapping exercises undertaken by, or in partnership with, other institutions. Systematic mapping uses a rigorous search protocol (involving an array of specified search terms) to retrieve studies from several scientific databases. Evidence published in languages other than English is included when it is identified.

Evidence from all around the world is included in synopses. One exception is farmland conservation, which only covers northern Europe (all European countries west of Russia, but not those south of France, Switzerland, Austria, Hungary and Romania). Any apparent bias towards evidence from some regions in a particular synopsis reflects the current biases in published research papers available to Conservation Evidence.

The criteria for inclusion of studies in the Conservation Evidence database are as follows:

- A conservation intervention must have been carried out.
- The effects of the intervention must have been monitored quantitatively.

These criteria exclude studies examining the effects of specific interventions without actually doing them. For example, predictive modelling studies and studies looking at species distributions in areas with long-standing management histories (correlative studies) are excluded. Such studies can suggest that an intervention could be effective, but do not provide direct evidence of a causal relationship between the intervention and the observed biodiversity pattern.

We summarise the results of each study that are relevant to each intervention. Unless specifically stated, results reflect statistical tests performed on the data within the papers.

What does *What Works in Conservation* include?

What Works in Conservation includes **only the key messages from each synopsis**, which provide a rapid overview of the evidence. These messages are condensed from the summary text for each intervention within each synopsis. **For the full text and references see www.conservationevidence.com.**

Panels of experts have assessed the collated evidence for each intervention to determine effectiveness, certainty of the evidence and, in most cases, whether there are negative side-effects (harms). Using these assessments, interventions are categorized based on a combination of effectiveness (the size of benefit or harm) and certainty (the strength of the evidence). The following categories are used: Beneficial, Likely to be beneficial, Trade-off between benefit and harms, Unknown effectiveness, Unlikely to be beneficial, Likely to be ineffective or harmful (for more details see below).

Expert assessment of the evidence

The average of several experts' opinions is likely to be a more reliable and accurate assessment than the opinion of a single expert. We therefore ask a panel of experts to use their judgement to assess whether evidence within the synopsis indicates that an intervention is effective or not. They are also asked to assess how certain they are of the effectiveness given the quality of evidence available for that intervention (certainty of the evidence). Negative side-effects described in the collated evidence are also assessed (harms). They base their assessment solely on the evidence in the synopsis.

We use a modified Delphi method to quantify the effectiveness and certainty of evidence of each intervention, based on the summarized evidence. The Delphi method is a structured process that involves asking a panel of experts to state their individual opinion on a subject by scoring anonymously. They can then revise their own scores after seeing a summary of scores and comments from the rest of the panel. Final scores are then collated. Scores and comments are kept anonymous throughout the process so that participants are not overly influenced by any single member of the panel.

For each intervention, experts are asked to read the summarized evidence in the synopsis and then score to indicate their assessment of the following:

Effectiveness: 0 = no effect, 100% = always effective.

Certainty of the evidence: 0 = no evidence, 100% = high quality evidence; complete certainty. This is certainty of effectiveness of intervention, not of harms.

Harms: 0 = none, 100% = major negative side-effects to the group of species/habitat of concern.

Categorization of interventions

After one or two rounds of initial scoring, interventions are categorized by their effectiveness, as assessed by the expert panel. The median score from all the experts' assessments is calculated for the effectiveness, certainty and harms for each intervention. Categorization is based on these median values i.e. on a combination of the size of the benefit and harm and the strength of the evidence. Table 1 and Figure 1 show how interventions are categorized using the median scores. There is an important distinction between lack of benefit and lack of evidence of benefit.

Once interventions are categorized, experts are given the chance to object if they believe an intervention has been categorized incorrectly. Interventions that receive a specified number (depending on the size of the panel) of strong objections from experts are re-scored by the expert panel and re-categorized accordingly. Experts did not see the categories for the farmland synopsis or for the 'Reduce predation by other species' section of the bird synopsis and so those categories are based on the second round of scoring.

How to use *What Works in Conservation*

Please remember that the categories provided in this book are meant as a guide and a starting point in assessing the effectiveness of conservation interventions. The assessments are based on the available evidence for the target group of species for each intervention and 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 to your 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 our 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.

Table 1. Categories of effectiveness.

Category	Description	General criteria	Thresholds
Beneficial	Effectiveness has been demonstrated by clear evidence. Expectation of harms is small compared with the benefits	High median benefit score High median certainty score Low median harm score	Effectiveness: >60% Certainty: >60% Harm: <20%
Likely to be beneficial	Effectiveness is less well established than for those listed under 'effective' **OR** There is clear evidence of medium effectiveness	High benefit score Lower certainty score Low harm score **OR** Medium benefit score High certainty score Low harm score	Effectiveness: >60% Certainty: 40-60% Harm: <20% **OR** Effectiveness: 40-60% Certainty: ≥40% Harm: <20%
Trade-off between benefit and harms	Interventions for which practitioners must weigh up the beneficial and harmful effects according to individual circumstances and priorities	Medium benefit and medium harm scores **OR** High benefit and high harm scores High certainty score	Effectiveness: ≥40% Certainty: ≥40% Harm: ≥20%
Unknown effectiveness (limited evidence)	Currently insufficient data, or data of inadequate quality	Low certainty score	Effectiveness: Any Certainty: <40% Harm: Any
Unlikely to be beneficial	Lack of effectiveness is less well established than for those listed under 'likely to be ineffective or harmful'	Low benefit score Medium certainty score and/or some variation between experts	Effectiveness: <40% Certainty: 40-60% Harm: <20%
Likely to be ineffective or harmful	Ineffectiveness or harmfulness has been demonstrated by clear evidence	Low benefit score High certainty score (regardless of harms) **OR** Low benefit score High harm score (regardless of certainty of effectiveness)	Effectiveness: <40% Certainty: >60% Harm: Any **OR** Effectiveness: <40% Certainty: ≥ 40% Harm: ≥20%

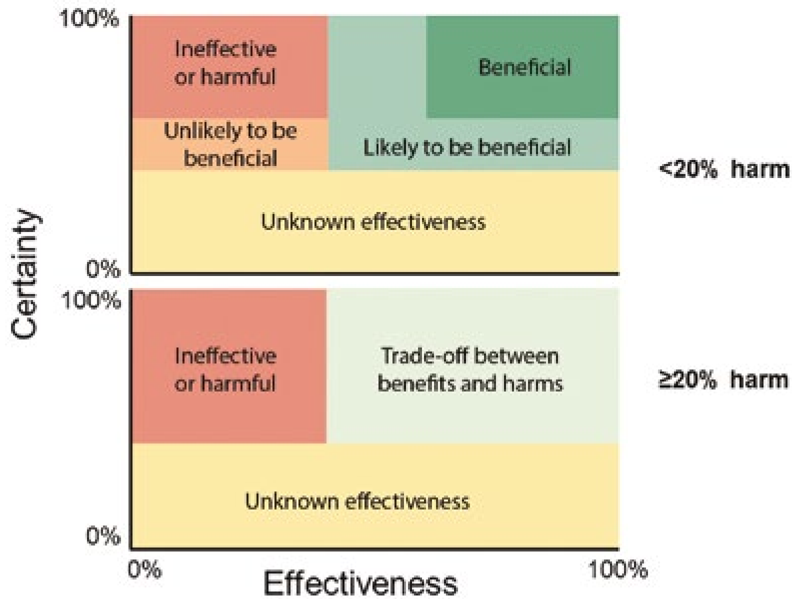

Figure 1. Categories of effectiveness based on a combination of effectiveness (the size of the benefit and harm) and certainty (the strength of the evidence). The top graph refers to interventions with harms <20% and the bottom graph to interventions with harms ≥20%.

1. AMPHIBIAN CONSERVATION

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

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.

1.1 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 (limited evidence)	• Legal protection of species
No evidence found (no assessment)	• Protect brownfield or ex-industrial sites • Restrict herbicide, fungicide and pesticide use on and around ponds on golf courses

Unknown effectiveness (limited evidence)

Legal protection of species

Three reviews, including one systematic review, in the Netherlands and UK found that legal protection of amphibians was not effective at protecting populations during development. Two reviews found that the number of great crested newt mitigation licences issued in England and Wales increased over 10 years. *Assessment: unknown effectiveness – limited evidence (effectiveness 10%; certainty 35%; harms 7%).*

http://www.conservationevidence.com/actions/779

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Protect brownfield or ex-industrial sites
- Restrict herbicide, fungicide and pesticide use on and around ponds on golf courses

1.2 Threat: Agriculture

1.2.1 Engage farmers and other volunteers

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for engaging farmers and other volunteers?	
Likely to be beneficial	• Engage landowners and other volunteers to manage land for amphibians • Pay farmers to cover the costs of conservation measures

Likely to be beneficial

Engage landowners and other volunteers to manage land for amphibians

Three studies, including one replicated and one controlled study, in Estonia, Mexico and Taiwan found that engaging landowners and other volunteers in habitat management increased amphibian populations and axolotl weight. Six studies in Estonia, the USA and UK found that up to 41,000 volunteers were engaged in habitat restoration programmes for amphibians and restored up to 1,023 ponds or 11,500 km^2 of habitat. *Assessment: likely to be beneficial (effectiveness 70%; certainty 55%; harms 5%).*

http://www.conservationevidence.com/actions/777

Pay farmers to cover the costs of conservation measures

Four of five studies, including two replicated studies, in Denmark, Sweden and Taiwan found that payments to farmers increased amphibian populations, numbers of species or breeding habitat. One found that amphibian habitat was not maintained. *Assessment: likely to be beneficial (effectiveness 70%; certainty 53%; harms 10%).*

http://www.conservationevidence.com/actions/818

1.2.2 Terrestrial habitat management

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for terrestrial habitat management in agricultural systems?	
Unknown effectiveness (limited evidence)	• Manage cutting regime • Manage grazing regime
No evidence found (no assessment)	• Maintain or restore hedges • Plant new hedges • Reduced tillage

Manage silviculture practices in plantations

Studies investigating the effects of silviculture practices are discussed in 'Threat: Biological resource use – Logging and wood harvesting'.

Unknown effectiveness (limited evidence)

Manage cutting regime

One before-and-after study in Australia found that restoration that included reduced mowing increased numbers of frog species. *Assessment for 'Change mowing regime' from 'Habitat restoration and creation' section: unknown effectiveness – limited evidence (effectiveness 50%; certainty 30%; harms 0%).*

http://www.conservationevidence.com/actions/788

Manage grazing regime

Two studies, including one replicated, controlled study, in the UK and USA found that grazed plots had lower numbers of toads than ungrazed plots and that grazing, along with burning, decreased numbers of amphibian species. Five studies, including four replicated studies, in Denmark, Estonia and the UK found that habitat management that included reintroduction of grazing maintained or increased toad populations. *Assessment: unknown effectiveness – limited evidence (effectiveness 45%; certainty 39%; harms 10%).*

http://www.conservationevidence.com/actions/780

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Maintain or restore hedges
- Plant new hedges
- Reduced tillage

1.2.3 Aquatic habitat management

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for aquatic habitat management in agricultural systems?	
Likely to be beneficial	• Manage ditches
Likely to be ineffective or harmful	• Exclude domestic animals or wild hogs from ponds by fencing

Likely to be beneficial

Manage ditches

One controlled, before-and-after study in the UK found that managing ditches increased toad numbers. One replicated, site comparison study in the Netherlands found that numbers of amphibians and species were higher in ditches managed under agri-environment schemes compared to those managed conventionally. *Assessment: likely to be beneficial (effectiveness 71%; certainty 60%; harms 0%).*

http://www.conservationevidence.com/actions/749

Likely to be ineffective or harmful

● Exclude domestic animals or wild hogs from ponds by fencing

Four replicated studies, including one randomized, controlled, before-and-after study, in the USA found that excluding livestock from streams or ponds did not increase overall numbers of amphibians, species, eggs or larval survival, but did increase larval and metamorph abundance. One before-and-after study in the UK found that pond restoration that included livestock exclusion increased pond use by breeding toads. *Assessment: likely to be ineffective or harmful (effectiveness 31%; certainty 50%; harms 25%).*

http://www.conservationevidence.com/actions/746

1.3 Threat: Energy production and mining

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for energy production and mining?	
Unknown effectiveness (limited evidence)	● Artificially mist habitat to keep it damp

Unknown effectiveness (limited evidence)

Artificially mist habitat to keep it damp

One before-and-after study in Tanzania found that installing a sprinkler system to mitigate against a reduction of river flow did not maintain a population of Kihansi spray toads. *Assessment: unknown effectiveness – limited evidence (effectiveness 24%; certainty 20%; harms 0%).*

http://www.conservationevidence.com/actions/755

1.4 Threat: Transportation and service corridors

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for transportation and service corridors?	
Likely to be beneficial	● Close roads during seasonal amphibian migration ● Modify gully pots and kerbs
Trade-off between benefit and harms	● Install barrier fencing along roads ● Install culverts or tunnels as road crossings
Unknown effectiveness (limited evidence)	● Use signage to warn motorists
Unlikely to be beneficial	● Use humans to assist migrating amphibians across roads

Likely to be beneficial

● Close roads during seasonal amphibian migration

Two studies, including one replicated study, in Germany found that road closure sites protected large numbers of amphibians from mortality during breeding migrations. *Assessment: likely to be beneficial (effectiveness 85%; certainty 50%; harms 0%).*

http://www.conservationevidence.com/actions/842

Modify gully pots and kerbs

One before-and-after study in the UK found that moving gully pots 10 cm away from the kerb decreased the number of great crested newts that fell in by 80%. *Assessment: likely to be beneficial (effectiveness 80%; certainty 40%; harms 0%).*

http://www.conservationevidence.com/actions/782

Trade-off between benefit and harms

Install barrier fencing along roads

Seven of eight studies, including one replicated and two controlled studies, in Germany, Canada and the USA found that barrier fencing with culverts decreased amphibian road deaths, in three cases depending on fence design. One study found that few amphibians were diverted by barriers. *Assessment: trade-offs between benefits and harms (effectiveness 65%; certainty 68%; harms 23%).*

http://www.conservationevidence.com/actions/756

Install culverts or tunnels as road crossings

Thirty-two studies investigated the effectiveness of installing culverts or tunnels as road crossings for amphibians. Six of seven studies, including three replicated studies, in Canada, Europe and the USA found that installing culverts or tunnels decreased amphibian road deaths. One found no effect on road deaths. Fifteen of 24 studies, including one review, in Australia, Canada, Europe and the USA found that tunnels were used by amphibians. Four found mixed effects depending on species, site or culvert type. Five found that culverts were not used or were used by less than 10% of amphibians. Six studies, including one replicated, controlled study, in Canada, Europe and the USA investigated the use of culverts with flowing water. Two found that they were used by amphibians. Three found that they were rarely or not used. Certain culvert designs were found not to be suitable for amphibians. *Assessment: trade-offs between benefits and harms (effectiveness 60%; certainty 75%; harms 25%).*

http://www.conservationevidence.com/actions/884

Unknown effectiveness (limited evidence)

Use signage to warn motorists

One study in the UK found that despite warning signs and human assistance across roads, some toads were still killed on roads. *Assessment: unknown effectiveness – limited evidence (effectiveness 10%; certainty 10%; harms 0%).*

http://www.conservationevidence.com/actions/841

Unlikely to be beneficial

Use humans to assist migrating amphibians across roads

Three studies, including one replicated study, in Italy and the UK found that despite assisting toads across roads during breeding migrations, toads were still killed on roads and 64-70% of populations declined. Five studies in Germany, Italy and the UK found that large numbers of amphibians were moved across roads by up to 400 patrols. *Assessment: unlikely to be beneficial (effectiveness 35%; certainty 40%; harms 3%).*

http://www.conservationevidence.com/actions/784

1.5 Threat: Biological resource use

1.5.1 Hunting and collecting terrestrial animals

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for hunting and collecting terrestrial animals?	
Likely to be beneficial	• Reduce impact of amphibian trade
Unknown effectiveness (limited evidence)	• Use legislative regulation to protect wild populations
No evidence found (no assessment)	• Commercially breed amphibians for the pet trade • Use amphibians sustainably

Likely to be beneficial

Reduce impact of amphibian trade

One review found that reducing trade through legislation allowed frog populations to recover from over-exploitation. *Assessment: likely to be beneficial (effectiveness 76%; certainty 40%; harms 0%).*

http://www.conservationevidence.com/actions/824

Unknown effectiveness (limited evidence)

Use legislative regulation to protect wild populations

One review found that legislation to reduce trade resulted in the recovery of frog populations. One study in South Africa found that the number of permits issued for scientific and educational use of amphibians increased from 1987 to 1990. *Assessment: unknown effectiveness – limited evidence (effectiveness 60%; certainty 30%; harms 5%).*

http://www.conservationevidence.com/actions/785

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Commercially breed amphibians for the pet trade
- Use amphibians sustainably

1.5.2 Logging and wood harvesting

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for logging and wood harvest?	
Likely to be beneficial	• Retain riparian buffer strips during timber harvest • Use shelterwood harvesting instead of clearcutting
Trade-off between benefit and harms	• Leave coarse woody debris in forests
Unknown effectiveness (limited evidence)	• Use patch retention harvesting instead of clearcutting
Unlikely to be beneficial	• Leave standing deadwood/snags in forests • Use leave-tree harvesting instead of clearcutting
Likely to be ineffective or harmful	• Harvest groups of trees instead of clearcutting • Thin trees within forests

Likely to be beneficial

Retain riparian buffer strips during timber harvest

Six replicated and/or controlled studies in Canada and the USA compared amphibian numbers following clearcutting with or without riparian buffer strips. Five found mixed effects and one found that abundance was higher with riparian buffers. Two of four replicated studies, including one randomized, controlled, before-and-after study, in Canada and the USA found that numbers of species and abundance were greater in wider buffer strips. Two found no effect of buffer width. *Assessment: likely to be beneficial (effectiveness 50%; certainty 61%; harms 10%).*

http://www.conservationevidence.com/actions/747

Use shelterwood harvesting instead of clearcutting

Three studies, including two randomized, replicated, controlled, before-and-after studies, in the USA found that compared to clearcutting, shelterwood harvesting resulted in higher or similar salamander abundance. One meta-analysis of studies in North America found that partial harvest, which included shelterwood harvesting, resulted in smaller reductions in salamander populations than clearcutting. *Assessment: likely to be beneficial (effectiveness 40%; certainty 57%; harms 10%).*

http://www.conservationevidence.com/actions/851

Trade-off between benefit and harms

Leave coarse woody debris in forests

Two replicated, controlled studies in the USA found that abundance was similar in clearcuts with woody debris retained or removed for eight of nine amphibian species, but that the overall response of amphibians was more negative where woody debris was retained. Two replicated, controlled studies in the USA and Indonesia found that the removal of coarse woody debris from standing forest did not affect amphibian diversity or overall amphibian abundance, but did reduce species richness. One replicated, controlled study in the USA found that migrating amphibians used clearcuts where woody debris was retained more than where it was removed. One replicated, site comparison study in the USA found that within clearcut forest, survival of juvenile amphibians was significantly higher within piles of woody debris than in open areas. *Assessment: trade-offs between benefits and harms (effectiveness 40%; certainty 60%; harms 26%).*

http://www.conservationevidence.com/actions/843

Unknown effectiveness (limited evidence)

Use patch retention harvesting instead of clearcutting

We found no evidence for the effect of retaining patches of trees rather than clearcutting on amphibian populations. One replicated study in Canada found that although released red-legged frogs did not move towards retained tree patches, large patches were selected more and moved out of less than small patches. *Assessment: unknown effectiveness – limited evidence (effectiveness 20%; certainty 25%; harms 0%).*

http://www.conservationevidence.com/actions/847

Unlikely to be beneficial

Leave standing deadwood/snags in forests

One randomized, replicated, controlled, before-and-after study in the USA found that compared to total clearcutting, leaving dead and wildlife trees did not result in higher abundances of salamanders. One randomized, replicated, controlled study in the USA found that numbers of amphibians and species were similar with removal or creation of dead trees within forest. *Assessment: unlikely to be beneficial (effectiveness 5%; certainty 58%; harms 2%).*

http://www.conservationevidence.com/actions/845

Use leave-tree harvesting instead of clearcutting

Two studies, including one randomized, replicated, controlled, before-and-after study, in the USA found that compared to clearcutting, leaving a low density of trees during harvest did not result in higher salamander abundance. *Assessment: unlikely to be beneficial (effectiveness 10%; certainty 48%; harms 11%).*

http://www.conservationevidence.com/actions/846

Likely to be ineffective or harmful

Harvest groups of trees instead of clearcutting

Three studies, including two randomized, replicated, controlled, before-and-after studies, in the USA found that harvesting trees in small groups resulted in similar amphibian abundance to clearcutting. One meta-analysis and one randomized, replicated, controlled, before-and-after study in North America and the USA found that harvesting, which included harvesting groups of trees, resulted in smaller reductions in salamander populations than clearcutting. *Assessment: likely to be ineffective or harmful (effectiveness 33%; certainty 60%; harms 23%).*

http://www.conservationevidence.com/actions/844

Thin trees within forests

Six studies, including five replicated and/or controlled studies, in the USA compared amphibians in thinned to unharvested forest. Three found that thinning had mixed effects and one found no effect on abundance. One found that amphibian abundance increased following thinning but the body condition of ensatina salamanders decreased. One found a negative overall response of amphibians. Four studies, including two replicated, controlled studies, in the USA compared amphibians in thinned to clearcut forest. Two found that thinning had mixed effects on abundance and two found higher amphibian abundance or a less negative overall response of amphibians following thinning. One meta-analysis of studies in North America found that partial harvest, which included thinning, decreased salamander populations, but resulted in smaller reductions than clearcutting. *Assessment: likely to be ineffective or harmful (effectiveness 35%; certainty 60%; harms 40%).*

http://www.conservationevidence.com/actions/852

1.6 Threat: Human intrusions and disturbance

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for human intrusions and disturbance?	
No evidence found (no assessment)	• Use signs and access restrictions to reduce disturbance

No evidence found (no assessment)

We have captured no evidence for the following intervention:

- Use signs and access restrictions to reduce disturbance

1.7 Threat: Natural system modifications

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for natural system modifications?	
Beneficial	• Regulate water levels
Unknown effectiveness (limited evidence)	• Mechanically remove mid-storey or ground vegetation
Likely to be ineffective or harmful	• Use herbicides to control mid-storey or ground vegetation • Use prescribed fire or modifications to burning regime: forests • Use prescribed fire or modifications to burning regime: grassland

Beneficial

● Regulate water levels

Three studies, including one replicated, site comparison study, in the UK and USA found that maintaining pond water levels, in two cases with other habitat management, increased or maintained amphibian populations or increased breeding success. One replicated, controlled study in Brazil found that keeping rice fields flooded after harvest did not change amphibian abundance or numbers of species, but changed species composition. One replicated, controlled study in the USA found that draining ponds increased abundance and numbers of amphibian species. *Assessment: beneficial (effectiveness 70%; certainty 65%; harms 10%).*

http://www.conservationevidence.com/actions/833

Unknown effectiveness (limited evidence)

Mechanically remove mid-storey or ground vegetation

One randomized, replicated, controlled study in the USA found that mechanical understory reduction increased numbers of amphibian species, but not amphibian abundance. *Assessment: unknown effectiveness – limited evidence (effectiveness 40%; certainty 30%; harms 0%).*

http://www.conservationevidence.com/actions/781

Likely to be ineffective or harmful

Use herbicides to control mid-storey or ground vegetation

Three studies, including two randomized, replicated, controlled studies, in the USA found that understory removal using herbicide had no effect or negative effects on amphibian abundance. One replicated, site comparison study in Canada found that following logging, abundance was similar or lower in stands with herbicide treatment and planting compared to those left to regenerate naturally. *Assessment: likely to be ineffective or harmful (effectiveness 10%; certainty 50%; harms 50%).*

http://www.conservationevidence.com/actions/778

Use prescribed fire or modifications to burning regime (forests)

Eight of 15 studies, including three randomized, replicated, controlled studies, in Australia, North America and the USA found no effect of prescribed forest fires on amphibian abundance or numbers of species. Four found that fires had mixed effects on abundance. Four found that abundance, numbers of species or hatching success increased and one that abundance decreased. *Assessment: likely to be ineffective or harmful (effectiveness 30%; certainty 58%; harms 40%).*

http://www.conservationevidence.com/actions/877

Use prescribed fire or modifications to burning regime (grassland)

Two of three studies, including one replicated, before-and-after study, in the USA and Argentina found that prescribed fires in grassland decreased amphibian abundance or numbers of species. One found that spring, but not autumn or winter burns in grassland, decreased abundance. *Assessment: likely to be ineffective or harmful (effectiveness 10%; certainty 40%; harms 70%).*

http://www.conservationevidence.com/actions/862

1.8 Threat: Invasive and other problematic species

1.8.1 Reduce predation by other species

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for reducing predation by other species?	
Beneficial	● Remove or control fish by drying out ponds
Likely to be beneficial	● Remove or control fish population by catching ● Remove or control invasive bullfrogs ● Remove or control invasive viperine snake ● Remove or control mammals
Trade-off between benefit and harms	● Remove or control fish using Rotenone
Unknown effectiveness (limited evidence)	● Exclude fish with barriers
No evidence found (no assessment)	● Encourage aquatic plant growth as refuge against fish predation ● Remove or control non-native crayfish

Beneficial

● Remove or control fish by drying out ponds

One before-and-after study in the USA found that draining ponds to eliminate fish increased numbers of amphibian species. Four studies, including one review, in Estonia, the UK and USA found that pond drying to eliminate fish, along with other management activities, increased amphibian abundance, numbers of species and breeding success. *Assessment: beneficial (effectiveness 80%; certainty 66%; harms 3%).*

http://www.conservationevidence.com/actions/826

Likely to be beneficial

Remove or control fish population by catching

Four of six studies, including two replicated, controlled studies, in Sweden, the USA and UK found that removing fish by catching them increased amphibian abundance, survival and recruitment. Two found no significant effect on newt populations or toad breeding success. *Assessment: likely to be beneficial (effectiveness 50%; certainty 52%; harms 0%).*

http://www.conservationevidence.com/actions/827

Remove or control invasive bullfrogs

Two studies, including one replicated, before-and-after study, in the USA and Mexico found that removing American bullfrogs increased the size and range of frog populations. One replicated, before-and-after study in the USA found that following bullfrog removal, frogs were found out in the open more. *Assessment: likely to be beneficial (effectiveness 79%; certainty 60%; harms 0%).*

http://www.conservationevidence.com/actions/825

Remove or control invasive viperine snake

One before-and-after study in Mallorca found that numbers of Mallorcan midwife toad larvae increased after intensive, but not less intensive, removal of viperine snakes. *Assessment: likely to be beneficial (effectiveness 50%; certainty 40%; harms 0%).*

http://www.conservationevidence.com/actions/830

Remove or control mammals

One controlled study in New Zealand found that controlling rats had no significant effect on numbers of Hochstetter's frog. Two studies, one of which was controlled, in New Zealand found that predator-proof enclosures enabled or increased survival of frog species. *Assessment: likely to be beneficial (effectiveness 50%; certainty 40%; harms 0%).*

http://www.conservationevidence.com/actions/839

Trade-off between benefit and harms

Remove or control fish using Rotenone

Three studies, including one replicated study, in Sweden, the UK and USA found that eliminating fish using rotenone increased numbers of amphibians, amphibian species and recruitment. One review in Australia, the UK and USA found that fish control that included using rotenone increased breeding success. Two replicated studies in Pakistan and the UK found that rotenone use resulted in frog deaths and negative effects on newts. *Assessment: trade-offs between benefits and harms (effectiveness 65%; certainty 60%; harms 52%).*

http://www.conservationevidence.com/actions/828

Unknown effectiveness (limited evidence)

Exclude fish with barriers

One controlled study in Mexico found that excluding fish using a barrier increased weight gain of axolotls. *Assessment: unknown effectiveness – limited evidence (effectiveness 30%; certainty 20%; harms 0%).*

http://www.conservationevidence.com/actions/829

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Encourage aquatic plant growth as refuge against fish predation
- Remove or control non-native crayfish

1.8.2 Reduce competition with other species

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for reducing competition with other species?	
Unknown effectiveness (limited evidence)	• Reduce competition from native amphibians • Remove or control invasive Cuban tree frogs
No evidence found (no assessment)	• Remove or control invasive cane toads

Unknown effectiveness (limited evidence)

Reduce competition from native amphibians

One replicated, site comparison study in the UK found that common toad control did not increase natterjack toad populations. *Assessment: unknown effectiveness – limited evidence (effectiveness 10%; certainty 23%; harms 0%).*

http://www.conservationevidence.com/actions/821

Remove or control invasive Cuban tree frogs

One before-and-after study in the USA found that removal of invasive Cuban tree frogs increased numbers of native frogs. *Assessment: unknown effectiveness – limited evidence (effectiveness 65%; certainty 30%; harms 0%).*

http://www.conservationevidence.com/actions/822

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Remove or control invasive cane toads

1.8.3 Reduce adverse habitat alteration by other species

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for reducing adverse habitat alteration by other species?	
Trade-off between benefit and harms	• Control invasive plants
No evidence found (no assessment)	• Prevent heavy usage/exclude wildfowl from aquatic habitat

Trade-off between benefit and harms

Control invasive plants

One before-and-after study in the UK found that habitat and species management that included controlling swamp stonecrop, increased a population of natterjack toads. One replicated, controlled study in the USA found that more Oregon spotted frogs laid eggs in areas where invasive reed canarygrass was mown. *Assessment: likely to be beneficial (effectiveness 60%; certainty 47%; harms 0%).*

http://www.conservationevidence.com/actions/823

No evidence found (no assessment)

We have captured no evidence for the following intervention:

- Prevent heavy usage/exclude wildfowl from aquatic habitat

1.8.4 Reduce parasitism and disease – chytridiomycosis

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for reducing chytridiomycosis?	
Likely to be beneficial	• Use temperature treatment to reduce infection
Trade-off between benefit and harms	• Use antifungal treatment to reduce infection
Unknown effectiveness (limited evidence)	• Add salt to ponds • Immunize amphibians against infection • Remove the chytrid fungus from ponds • Sterilize equipment when moving between amphibian sites • Treating amphibians in the wild or pre-release • Use gloves to handle amphibians
Unlikely to be beneficial	• Use antibacterial treatment to reduce infection • Use antifungal skin bacteria or peptides to reduce infection
No evidence found (no assessment)	• Use zooplankton to remove zoospores

Likely to be beneficial

Use temperature treatment to reduce infection

Four of five studies, including four replicated, controlled studies, in Australia, Switzerland and the USA found that increasing enclosure or water temperature to 30-37°C for over 16 hours cured amphibians of chytridiomycosis. One found that treatment did not cure frogs. *Assessment: likely to be beneficial (effectiveness 60%; certainty 70%; harms 10%).*

http://www.conservationevidence.com/actions/770

Trade-off between benefit and harms

Use antifungal treatment to reduce infection

Twelve of 16 studies, including four randomized, replicated, controlled studies, in Europe, Australia, Tasmania, Japan and the USA found that antifungal treatment cured or increased survival of amphibians with chytridiomycosis. Four studies found that treatments did not cure chytridiomycosis, but did reduce infection levels or had mixed results. Six of the eight studies testing treatment with itraconazole found that it was effective at curing chytridiomycosis. One found that it reduced infection levels and one found mixed effects. Six studies found that specific fungicides caused death or other negative side effects in amphibians. *Assessment: trade-offs between benefits and harms (effectiveness 71%; certainty 70%; harms 50%).*

http://www.conservationevidence.com/actions/882

Unknown effectiveness (limited evidence)

Add salt to ponds

One study in Australia found that following addition of salt to a pond containing the chytrid fungus, a population of green and golden bell frogs remained free of chytridiomycosis for over six months. *Assessment: unknown effectiveness – limited evidence (effectiveness 41%; certainty 25%; harms 50%).*

http://www.conservationevidence.com/actions/762

Immunize amphibians against infection

One randomized, replicated, controlled study in the USA found that vaccinating mountain yellow-legged frogs with formalin-killed chytrid fungus did not significantly reduce chytridiomycosis infection rate or mortality. *Assessment: unknown effectiveness – limited evidence (effectiveness 0%; certainty 25%; harms 0%).*

http://www.conservationevidence.com/actions/765

Remove the chytrid fungus from ponds

One before-and-after study in Mallorca found that drying out a pond and treating resident midwife toads with fungicide reduced levels of infection but did not eradicate chytridiomycosis. *Assessment: unknown effectiveness – limited evidence (effectiveness 25%; certainty 25%; harms 0%).*

http://www.conservationevidence.com/actions/766

Sterilize equipment when moving between amphibian sites

We found no evidence for the effects of sterilizing equipment when moving between amphibian sites on the spread of disease between amphibian populations or individuals. Two randomized, replicated, controlled study in Switzerland and Sweden found that Virkon S disinfectant did not affect survival, mass or behaviour of eggs, tadpoles or hatchlings. However, one of the studies found that bleach significantly reduced tadpole survival. *Assessment: unknown effectiveness – limited evidence (effectiveness 10%; certainty 30%; harms 40%).*

http://www.conservationevidence.com/actions/768

Treating amphibians in the wild or pre-release

One before-and-after study in Mallorca found that treating wild toads with fungicide and drying out the pond reduced infection levels but did not eradicate chytridiomycosis. *Assessment: unknown effectiveness – limited evidence (effectiveness 27%; certainty 30%; harms 0%).*

http://www.conservationevidence.com/actions/767

Use gloves to handle amphibians

We found no evidence for the effects of using gloves on the spread of disease between amphibian populations or individuals. A review for Canada and the USA found that there were no adverse effects of handling 22 amphibian species using disposable gloves. However, three replicated studies in Australia and Austria found that deaths of tadpoles were caused by latex, vinyl and nitrile gloves for 60-100% of species tested. *Assessment: unknown effectiveness – limited evidence (effectiveness 9%; certainty 35%; harms 65%).*

http://www.conservationevidence.com/actions/769

Unlikely to be beneficial

Use antibacterial treatment to reduce infection

Two studies, including one randomized, replicated, controlled study, in New Zealand and Australia found that treatment with chloramphenicol antibiotic, with other interventions in some cases, cured frogs of chytridiomycosis. One replicated, controlled study found that treatment with trimethoprim-sulfadiazine increased survival time but did not cure infected frogs. *Assessment: unlikely to be beneficial (effectiveness 38%; certainty 45%; harms 10%).*

http://www.conservationevidence.com/actions/763

Use antifungal skin bacteria or peptides to reduce infection

Three of four randomized, replicated, controlled studies in the USA found that introducing antifungal bacteria to the skin of chytrid infected amphibians did not reduce infection rate or deaths. One found that it prevented infection and death. One randomized, replicated, controlled study in the USA found that adding antifungal skin bacteria to soil significantly reduced chytridiomycosis infection rate in salamanders. One randomized, replicated, controlled study in Switzerland found that treatment with antimicrobial skin peptides before or after infection with chytridiomycosis did not increase toad survival. *Assessment: unlikely to be beneficial (effectiveness 29%; certainty 50%; harms 10%).*

http://www.conservationevidence.com/actions/764

No evidence found (no assessment)

We have captured no evidence for the following intervention:

- Use zooplankton to remove zoospores

1.8.5 Reduce parasitism and disease – ranaviruses

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for reducing ranaviruses?	
No evidence found (no assessment)	• Sterilize equipment to prevent ranaviruses

No evidence found (no assessment)

We have captured no evidence for the following intervention:

- Sterilize equipment to prevent ranaviruses

1.9 Threat: Pollution

1.9.1 Agricultural pollution

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for agricultural pollution?	
Unknown effectiveness (limited evidence)	• Create walls or barriers to exclude pollutants • Plant riparian buffer strips • Reduce pesticide, herbicide or fertilizer use
No evidence found (no assessment)	• Prevent pollution from agricultural lands or sewage treatment facilities entering watercourses

Unknown effectiveness (limited evidence)

Create walls or barriers to exclude pollutants

One controlled study in Mexico found that installing filters across canals to improve water quality and exclude fish increased weight gain in axolotls. *Assessment: unknown effectiveness – limited evidence (effectiveness 35%; certainty 29%; harms 0%).*

http://www.conservationevidence.com/actions/771

Plant riparian buffer strips

One replicated, controlled study in the USA found that planting buffer strips along streams did not increase amphibian abundance or numbers of species. *Assessment: unknown effectiveness – limited evidence (effectiveness 0%; certainty 30%; harms 0%).*

http://www.conservationevidence.com/actions/819

Reduce pesticide, herbicide or fertilizer use

One study in Taiwan found that halting pesticide use, along with habitat management, increased a population of frogs. *Assessment: unknown effectiveness – limited evidence (effectiveness 71%; certainty 26%; harms 0%).*

http://www.conservationevidence.com/actions/832

No evidence found (no assessment)

We have captured no evidence for the following intervention:

- Prevent pollution from agricultural lands or sewage treatment facilities entering watercourses

1.9.2 Industrial pollution

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for industrial pollution?	
Trade-off between benefit and harms	• Add limestone to water bodies to reduce acidification
No evidence found (no assessment)	• Augment ponds with ground water to reduce acidification

Trade-off between benefit and harms

Add limestone to water bodies to reduce acidification

Five before-and-after studies, including one controlled, replicated study, in the Netherlands and UK found that adding limestone to ponds resulted in establishment of one of three translocated amphibian populations, a temporary increase in breeding and metamorphosis by natterjack toads and increased egg and larval survival of frogs. One replicated, site comparison study in the UK found that habitat management that included adding limestone to ponds increased natterjack toad populations. However, two before-and-after studies, including one controlled study, in the UK found that adding limestone to ponds resulted in increased numbers of abnormal eggs, high tadpole mortality and pond abandonment. *Assessment: trade-offs between benefits and harms (effectiveness 47%; certainty 50%; harms 50%).*

http://www.conservationevidence.com/actions/748

No evidence found (no assessment)

We have captured no evidence for the following intervention:

- Augment ponds with ground water to reduce acidification

1.10 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?	
Beneficial	• Deepen ponds to prevent desiccation (deepen, de-silt or re-profile)
Unknown effectiveness (limited evidence)	• Use irrigation systems for amphibian sites (artificially mist habitat)
No evidence found (no assessment)	• Artificially shade ponds to prevent desiccation • Protect habitat along elevational gradients • Provide shelter habitat

Create microclimate and microhabitat refuges

Studies investigating the effects of creating refuges are discussed in 'Habitat restoration and creation' and 'Biological resource use – Leave coarse woody debris in forests'.

Maintain ephemeral ponds

Studies investigating the effects of regulating water levels and deepening ponds are discussed in 'Threat: Natural system modifications – Regulate water levels' and 'Habitat restoration and creation – Deepen, de-silt or re-profile ponds'.

Beneficial

Deepen ponds to prevent desiccation

Four studies, including one replicated, controlled study, in France, Denmark and the UK found that pond deepening and enlarging or re-profiling resulted in establishment or increased populations of amphibians. Four before-and-after studies in Denmark and the UK found that pond deepening, along with other interventions, maintained newt or increased toad populations. *Assessment for 'Deepen, de-silt or re-profie ponds' from* 'Habitat restoration and creation' section*: beneficial (effectiveness 71%; certainty 65%; harms 0%).*

http://www.conservationevidence.com/actions/806

Unknown effectiveness (limited evidence)

Use irrigation systems for amphibian sites

One before-and-after study in Tanzania found that installing a sprinkler system to mitigate against a reduction of river flow did not maintain a population of Kihansi spray toads. *Assessment for 'Artificially mist habitat to keep it damp' from 'Threat: Energy production and mining' section: unknown effectiveness – limited evidence (effectiveness 24%; certainty 20%; harms 0%).*

http://www.conservationevidence.com/actions/804

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Artificially shade ponds to prevent desiccation
- Protect habitat along elevational gradients
- Provide shelter habitat

1.11 Habitat protection

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for habitat protection?	
Trade-off between benefit and harms	• Retain buffer zones around core habitat
Unknown effectiveness (limited evidence)	• Protect habitats for amphibians • Retain connectivity between habitat patches

Trade-off between benefit and harms

Retain buffer zones around core habitat

Two studies, including one replicated, controlled study, in Australia and the USA found that retaining unmown buffers around ponds increased numbers of frog species, but had mixed effects on tadpole mass and survival. One replicated, site comparison study in the USA found that retaining buffers along ridge tops within harvested forest increased salamander abundance, body condition and genetic diversity. However, one replicated study in the USA found that 30 m buffer zones around wetlands were not sufficient to protect marbled salamanders. *Assessment: trade-offs between benefits and harms (effectiveness 50%; certainty 50%; harms 25%).*

http://www.conservationevidence.com/actions/850

Unknown effectiveness (limited evidence)

Protect habitats for amphibians

One replicated, site comparison study in the UK found that statutory level habitat protection helped protect natterjack toad populations. One before-and-after study in the UK found that protecting a pond during development had mixed effects on populations of amphibians. *Assessment: unknown effectiveness – limited evidence (effectiveness 51%; certainty 31%; harms 9%).*

http://www.conservationevidence.com/actions/820

Retain connectivity between habitat patches

One before-and-after study in Australia found that retaining native vegetation corridors maintained populations of frogs over 20 years. *Assessment: unknown effectiveness – limited evidence (effectiveness 60%; certainty 31%; harms 0%).*

http://www.conservationevidence.com/actions/853

1.12 Habitat restoration and creation

1.12.1 Terrestrial habitat

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for terrestrial habitat restoration and creation?	
Beneficial	● Replant vegetation
Likely to be beneficial	● Clear vegetation ● Create artificial hibernacula or aestivation sites ● Create refuges ● Restore habitat connectivity
Unknown effectiveness (limited evidence)	● Change mowing regime
No evidence found (no assessment)	● Create habitat connectivity

Beneficial

● Replant vegetation

Four studies, including one replicated study, in Australia, Spain and the USA found that amphibians colonized replanted forest, reseeded grassland and seeded and transplanted upland habitat. Three of four studies, including two replicated studies, in Australia, Canada, Spain and the USA found that areas planted with trees or grass had similar amphibian abundance or community composition to natural sites and one found similar or lower abundance compared to naturally regenerated forest. One found that wetlands within reseeded grasslands were used less than those in natural grasslands. One before-and-after study in Australia found that numbers of frog species increased following restoration that included planting shrubs and trees. *Assessment: beneficial (effectiveness 70%; certainty 63%; harms 3%).*

http://www.conservationevidence.com/actions/849

Likely to be beneficial

Clear vegetation

Seven studies, including four replicated studies, in Australia, Estonia and the UK found that vegetation clearance, along with other habitat management and in some cases release of amphibians, increased or maintained amphibian populations or increased numbers of frog species. However, great crested newt populations were only maintained for six years, but not in the longer term. *Assessment: likely to be beneficial (effectiveness 60%; certainty 54%; harms 10%).*

http://www.conservationevidence.com/actions/761

Create artificial hibernacula or aestivation sites

Two replicated studies in the UK found that artificial hibernacula were used by two of three amphibian species and along with other terrestrial habitat management maintained populations of great crested newts. *Assessment: likely to be beneficial (effectiveness 50%; certainty 44%; harms 0%).*

http://www.conservationevidence.com/actions/759

Create refuges

Two replicated, controlled studies, one of which was randomized, in the USA and Indonesia found that adding coarse woody debris to forest floors had no effect on the number of amphibian species or overall abundance, but had mixed effects on abundance of individual species. One before-and-after study in Australia found that restoration that included reintroducing coarse woody debris to the forest floor increased frog species. Three studies, including two replicated studies, in New Zealand, the UK and USA found that artificial refugia were used by amphibians and, along with other interventions, maintained newt populations. *Assessment: likely to be beneficial (effectiveness 45%; certainty 55%; harms 0%).*

http://www.conservationevidence.com/actions/772

Restore habitat connectivity

One before-and-after study in Italy found that restoring habitat connectivity by raising a road on a viaduct significantly decreased amphibian deaths. *Assessment: likely to be beneficial (effectiveness 75%; certainty 40%; harms 0%).*

http://www.conservationevidence.com/actions/840

Unknown effectiveness (limited evidence)

Change mowing regime

One before-and-after study in Australia found that restoration that included reduced mowing increased numbers of frog species. *Assessment: unknown effectiveness – limited evidence (effectiveness 50%; certainty 30%; harms 0%).*

http://www.conservationevidence.com/actions/783

No evidence found (no assessment)

We have captured no evidence for the following intervention:

- Create habitat connectivity

1.12.2 Aquatic habitat

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for aquatic habitat restoration and creation?	
Beneficial	• Create ponds (amphibians in general) • Create ponds: frogs • Create ponds: natterjack toads • Create ponds: salamanders (including newts) • Create wetlands • Deepen, de-silt or re-profile ponds • Restore wetlands

Likely to be beneficial	• Create ponds: great crested newts • Create ponds: green toads • Create ponds: toads • Remove specific aquatic plants (invasive species) • Restore ponds
Unknown effectiveness (limited evidence)	• Remove tree canopy to reduce pond shading
No evidence found (no assessment)	• Add nutrients to new ponds as larvae food source • Add specific plants to aquatic habitats • Add woody debris to ponds • Create refuge areas in aquatic habitats

Beneficial

Create ponds (amphibians in general)

Twenty-eight studies investigated the colonization of created ponds by amphibians in general, all of which found that amphibians used all or some of the created ponds. Five of nine studies in Australia, Canada, Spain, the UK and USA found that numbers of species were similar or higher in created compared to natural ponds. Nine studies in Europe and the USA found that amphibians established stable populations, used or reproduced in created ponds. Four found that species composition differed, and abundance, juvenile productivity or size in created ponds depended on species. One study found that numbers of species were similar or lower in created ponds. Sixteen studies in Europe and the USA found that created ponds were used or colonized by up to 15 naturally colonizing species, up to 10 species that reproduced or by captive-bred amphibians. Five studies in Europe and the USA found that pond creation, with restoration in three cases, maintained and increased populations or increased species. *Assessment: beneficial (effectiveness 80%; certainty 80%; harms 0%).*

http://www.conservationevidence.com/actions/869

Create ponds (frogs)

Six of nine studies in Australia, Italy, Spain, the UK and USA found that frogs established breeding populations or reproduced in created ponds.

One study in Denmark found that frogs colonized created ponds. One study in the Netherlands found that pond creation, along with vegetation clearance, increased frog populations. One study in the USA found that survival increased with age of created ponds. *Assessment: beneficial (effectiveness 75%; certainty 70%; harms 0%).*

http://www.conservationevidence.com/actions/865

Create ponds (natterjack toads)

Five studies in the UK and Denmark found that pond creation, along with other interventions, maintained or increased populations at 75-100% of sites. One study in the UK found that compared to natural ponds, created ponds had lower tadpole mortality from desiccation, but higher mortality from predation by invertebrates. *Assessment: beneficial (effectiveness 75%; certainty 70%; harms 10%).*

http://www.conservationevidence.com/actions/866

Create ponds (salamanders including newts)

Three studies in France, Germany and the USA found that alpine newts, captive-bred smooth newts and translocated spotted salamanders established stable breeding populations in 20-100% of created ponds. Three studies in France, China and the USA found that alpine newts, Chinhai salamanders and translocated spotted salamanders, but not tiger salamanders, reproduced in created ponds. *Assessment: beneficial (effectiveness 70%; certainty 65%; harms 0%).*

http://www.conservationevidence.com/actions/867

Create wetlands

Fifteen studies, including one review and seven replicated studies, in Australia, Kenya and the USA, investigated the effectiveness of creating wetlands for amphibians. Six studies found that created wetlands had similar amphibian abundance, numbers of species or communities as natural wetlands or in one case adjacent forest. Two of those studies found that created wetlands had fewer amphibians, amphibian species and different communities compared to natural wetlands. One global review and two other studies combined created and restored wetlands and found that amphibian abundance and numbers of species were similar or higher compared to natural wetlands. Five of the studies found that up to 15 amphibian species used created wetlands. One study found that captive-bred frogs did not establish in a created wetland. *Assessment: beneficial (effectiveness 75%; certainty 70%; harms 0%).*

http://www.conservationevidence.com/actions/880

● Deepen, de-silt or re-profile ponds

Four studies, including one replicated, controlled study, in France, Denmark and the UK found that pond deepening and enlarging or re-profiling resulted in establishment or increased populations of amphibians. Four before-and-after studies in Denmark and the UK found that pond deepening, along with other interventions, maintained newt or increased toad populations. *Assessment: beneficial (effectiveness 71%; certainty 65%; harms 0%).*

http://www.conservationevidence.com/actions/817

● Restore wetlands

Seventeen studies, including one review and 11 replicated studies, in Canada, Taiwan and the USA, investigated the effectiveness of wetland restoration for amphibians. Seven of ten studies found that amphibian abundance, numbers of species and species composition were similar in restored and natural wetlands. Two found that abundance or numbers of species were lower and species composition different to natural wetlands. One found mixed results. One global review found that in 89% of cases, restored and created wetlands had similar or higher amphibian abundance or numbers of species to natural wetlands. Seven of nine studies found that wetland restoration increased numbers of amphibian species, with breeding populations establishing in some cases, and maintained or increased abundance of individual species. Three found that amphibian abundance or numbers of species did not increase with restoration. Three of the studies found that restored wetlands were colonized by up to eight amphibian species. *Assessment: beneficial (effectiveness 80%; certainty 73%; harms 0%).*

http://www.conservationevidence.com/actions/879

Likely to be beneficial

Create ponds (great crested newts)

Three studies in Germany and the UK found that great crested newts established breeding populations in created ponds. One systematic review in the UK found that there was no conclusive evidence that mitigation, which often included pond creation, resulted in self-sustaining populations. Four studies in the UK found that great crested newts colonized up to 88% of, or reproduced in 38% of created ponds. *Assessment: likely to be beneficial (effectiveness 60%; certainty 61%; harms 0%).*

http://www.conservationevidence.com/actions/863

Create ponds (green toads)

Two studies in Denmark found that pond creation, along with other interventions, significantly increased green toad populations. One study in Sweden found that green toads used or reproduced in 41-59% of created ponds. *Assessment: likely to be beneficial (effectiveness 73%; certainty 59%; harms 0%).*

http://www.conservationevidence.com/actions/864

Create ponds (toads)

Five studies in Germany, Switzerland, the UK and USA found that toads established breeding populations or reproduced in 16-100% of created ponds. Two studies in Denmark and Switzerland found that wild but not captive-bred toads colonized 29-100% of created ponds. One study in Denmark found that creating ponds, along with other interventions, increased toad populations. *Assessments: likely to be beneficial (effectiveness 70%; certainty 60%; harms 0%).*

http://www.conservationevidence.com/actions/868

Remove specific aquatic plants

One before-and-after study in the UK found that habitat and species management that included controlling swamp stonecrop, increased a population of natterjack toads. One replicated, controlled study in the USA found that more Oregon spotted frogs laid eggs in areas where invasive reed canarygrass was mown. *Assessment for 'Control invasive plants' from* 'Threat: Invasive alien and other problematic species': *likely to be beneficial (effectiveness 60%; certainty 47%; harms 0%).*

http://www.conservationevidence.com/actions/815

Restore ponds

Fifteen studies investigated the effectiveness of pond restoration for amphibians. Three studies, including one replicated, controlled, before-and-after study in Denmark, the UK and USA found that pond restoration did not increase or had mixed effects on population numbers and hatching success. One replicated, before-and-after study in the UK found that restoration increased pond use. One replicated study in Sweden found that only 10% of restored ponds were used for breeding. Three before-and-after studies, including one replicated, controlled study, in Denmark and Italy found that restored and created ponds were colonized by up to seven species. Eight of nine studies, including one systematic review, in Denmark, Estonia, Italy and the UK found that pond restoration, along with other habitat management, maintained or increased populations, or increased pond occupancy, ponds with breeding success or numbers of amphibian species. One found that numbers of species did not increase and one found that great crested newt populations did not establish. *Assessment: likely to be beneficial (effectiveness 60%; certainty 63%; harms 0%).*

http://www.conservationevidence.com/actions/878

Unknown effectiveness (limited evidence)

Remove tree canopy to reduce pond shading

One before-and-after study in the USA found that canopy removal did not increase hatching success of spotted salamanders. One before-and-after study in Denmark found that following pond restoration that included canopy removal, translocated toads established breeding populations. *Assessment: unknown effectiveness – limited evidence (effectiveness 30%; certainty 25%; harms 0%).*

http://www.conservationevidence.com/actions/758

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Add nutrients to new ponds as larvae food source
- Add specific plants to aquatic habitats
- Add woody debris to ponds
- Create refuge areas in aquatic habitats

1.13 Species management

Strict protocols should be followed when carrying out these interventions to minimise potential spread of disease-causing agents such as chytrid fungi and Ranavirus.

1.13.1 Translocate amphibians

Based on the collated evidence, what is the current assessment of the effectiveness of translocations?	
Likely to be beneficial	• Translocate amphibians (amphibians in general) • Translocate amphibians: great crested newts • Translocate amphibians: natterjack toads • Translocate amphibians: salamanders (including newts) • Translocate amphibians: toads • Translocate amphibians: wood frogs
Trade-off between benefit and harms	• Translocate amphibians: frogs

Likely to be beneficial

● Translocate amphibians (amphibians in general)

Overall, three global reviews and one study in the USA found that 65% of amphibian translocations that could be assessed resulted in established breeding populations or substantial recruitment to the adult population. A further two translocations resulted in breeding and one in survival following release. One review found that translocations of over 1,000 animals were more successful, but that success was not related to the source of animals (wild or captive), life-stage, continent or reason for translocation. *Assessment: likely to be beneficial (effectiveness 60%; certainty 60%; harms 19%).*

http://www.conservationevidence.com/actions/854

Translocate amphibians (great crested newts)

Four of six studies in the UK found that translocated great crested newts maintained or established breeding populations. One found that populations survived at least one year in 37% of cases, but one found that within three years breeding failed in 48% of ponds. A systematic review of 31 studies found no conclusive evidence that mitigation that included translocations resulted in self-sustaining populations. One review found that newts reproduced following 56% of translocations, in some cases along with other interventions. *Assessment: likely to be beneficial (effectiveness 50%; certainty 50%; harms 10%).*

http://www.conservationevidence.com/actions/858

Translocate amphibians (natterjack toads)

Three studies in France and the UK found that translocated natterjack toad eggs, tadpoles, juveniles or adults established breeding populations at some sites, although head-started or captive-bred animals were also released at some sites. Re-establishing toads on dune or saltmarsh habitat was more successful than on heathland. One study in the UK found that repeated translocations of wild rather than captive-bred toads were more successful. *Assessment: likely to be beneficial (effectiveness 60%; certainty 56%; harms 10%).*

http://www.conservationevidence.com/actions/859

Translocate amphibians (salamanders including newts)

Four studies in the UK and USA found that translocated eggs or adults established breeding populations of salamanders or smooth newts. One study in the USA found that one of two salamander species reproduced following translocation of eggs, tadpoles and metamorphs. One study in the USA found that translocated salamander eggs hatched and tadpoles had similar survival rates as in donor ponds. *Assessment: likely to be beneficial (effectiveness 70%; certainty 55%; harms 0%).*

http://www.conservationevidence.com/actions/860

Translocate amphibians (toads)

Two of four studies in Denmark, Germany, the UK and USA found that translocating eggs and/or adults established common toad breeding populations. One found populations of garlic toads established at two of four sites and one that breeding populations of boreal toads were not established. One study in Denmark found that translocating green toad eggs to existing populations, along with habitat management, increased population numbers. Four studies in Germany, Italy, South Africa and the USA found that translocated adult toads reproduced, survived up to six or 23 years, or some metamorphs survived over winter. *Assessment: likely to be beneficial (effectiveness 60%; certainty 56%; harms 10%).*

http://www.conservationevidence.com/actions/855

Translocate amphibians (wood frogs)

Two studies in the USA found that following translocation of wood frog eggs, breeding populations were established in 25-50% of created ponds. One study in the USA found that translocated eggs hatched and up to 57% survived as tadpoles in pond enclosures. *Assessment: likely to be beneficial (effectiveness 40%; certainty 50%; harms 0%).*

http://www.conservationevidence.com/actions/856

Trade-off between benefit and harms

Translocate amphibians (frogs)

Eight of ten studies in New Zealand, Spain, Sweden, the UK and USA found that translocating frog eggs, juveniles or adults established breeding populations. Two found that breeding populations went extinct within five years or did not establish. Five studies in Canada, New Zealand and the USA found that translocations of eggs, juveniles or adults resulted in little or no breeding at some sites. Five studies in Italy, New Zealand and the USA found that translocated juveniles or adults survived the winter or up to eight years. One study in the USA found that survival was lower for Oregon spotted frogs translocated as adults compared to eggs. Two studies in the USA found that 60-100% of translocated frogs left the release site and 35-73% returned to their original pond within 32 days. Two studies in found that frogs either lost or gained weight after translocation. *Assessment: trade-offs between benefits and harms (effectiveness 58%; certainty 65%; harms 20%).*

http://www.conservationevidence.com/actions/861

1.13.2 Captive breeding, rearing and releases

Based on the collated evidence, what is the current assessment of the effectiveness of captive breeding, rearing and releases?	
Likely to be beneficial	• Release captive-bred individuals (amphibians in general) • Release captive-bred individuals: frogs
Trade-off between benefit and harms	• Breed amphibians in captivity: frogs • Breed amphibians in captivity: harlequin toads • Breed amphibians in captivity: mallorcan midwife toad • Breed amphibians in captivity: salamanders (including newts) • Breed amphibians in captivity: toads • Head-start amphibians for release • Release captive-bred individuals: mallorcan midwife toads • Release captive-bred individuals: toads • Use artificial fertilization in captive breeding • Use hormone treatment to induce sperm and egg release
Unknown effectiveness (limited evidence)	• Release captive-bred individuals: salamanders (including newts)
Unlikely to be beneficial	• Freeze sperm or eggs for future use
Likely to be ineffective or harmful	• Release captive-bred individuals: green and golden bell frogs

Likely to be beneficial

Release captive-bred individuals (amphibians in general)

One review found that 41% of release programmes of captive-bred or head-started amphibians showed evidence of breeding in the wild for multiple generations, 29% showed some evidence of breeding and 12% evidence of survival following release. *Assessment: likely to be beneficial (effectiveness 55%; certainty 50%; harms 10%).*

http://www.conservationevidence.com/actions/871

Release captive-bred individuals (frogs)

Five of six studies in Europe, Hong Kong and the USA found that captive-bred frogs released as tadpoles, juveniles or adults established breeding populations and in some cases colonized new sites. Three studies in Australia and the USA found that a high proportion of frogs released as eggs survived to metamorphosis, some released tadpoles survived the first few months, but few released froglets survived. Four studies in Australia, Italy, the UK and USA found that captive-bred frogs reproduced at 31-100% of release sites, or that breeding was limited. *Assessment: likely to be beneficial (effectiveness 60%; certainty 60%; harms 15%).*

http://www.conservationevidence.com/actions/870

Trade-off between benefit and harms

Breed amphibians in captivity (frogs)

Twenty-three of 33 studies across the world found that amphibians produced eggs in captivity. Seven found mixed results, with some species or populations reproducing successfully, but with other species difficult to maintain or raise to adults. Two found that frogs did not breed successfully or died in captivity. Seventeen of the studies found that captive-bred frogs were raised successfully to hatching, tadpoles, froglets or adults in captivity. Four studies in Canada, Fiji, Hong Kong and Italy found that 30-88% of eggs hatched, or survival to metamorphosis was 75%, as froglets was 17-51% or to adults was 50-90%. *Assessment: trade-offs between benefits and harms (effectiveness 60%; certainty 68%; harms 30%).*

http://www.conservationevidence.com/actions/835

Breed amphibians in captivity (harlequin toads)

Four of five studies in Colombia, Ecuador, Germany and the USA found that harlequin toads reproduced in captivity. One found that eggs were only produced by simulating a dry and wet season and one found that breeding was difficult. One found that captive-bred harlequin toads were raised successfully to metamorphosis in captivity and two found that most toads died before or after hatching. *Assessment: trade-offs between benefits and harms (effectiveness 44%; certainty 50%; harms 28%).*

http://www.conservationevidence.com/actions/836

Breed amphibians in captivity (Mallorcan midwife toad)

Two studies in the UK found that Mallorcan midwife toads produced eggs that were raised to metamorphs or toadlets in captivity. However, clutches dropped by males were not successfully maintained artificially. One study in the UK found that toads bred in captivity for nine or more generations had slower development, reduced genetic diversity and predator defence traits. *Assessment: trade-offs between benefits and harms (effectiveness 69%; certainty 55%; harms 40%).*

http://www.conservationevidence.com/actions/837

Breed amphibians in captivity (salamanders including newts)

Four of six studies in Japan, Germany, the UK and USA found that eggs were produced successfully in captivity. Captive-bred salamanders were raised to yearlings, larvae or adults. One review found that four of five salamander species bred successfully in captivity. Four studies in Germany, Mexico and the USA found that egg production, larval development, body condition and survival were affected by water temperature, density or enclosure type. *Assessment: trade-offs between benefits and harms (effectiveness 60%; certainty 50%; harms 25%).*

http://www.conservationevidence.com/actions/838

Breed amphibians in captivity (toads)

Ten studies in Germany, Italy, Spain, the UK and USA found that toads produced eggs in captivity. Eight found that toads were raised successfully to tadpoles, toadlets or adults in captivity. Two found that most died after hatching or metamorphosis. Two reviews found mixed results with four species of toad or 21% of captive populations of Puerto Rican crested toads breeding successfully. Four studies in Germany, Spain and the USA found that reproductive success was affected by tank location and humidity. *Assessment: trade-offs between benefits and harms (effectiveness 65%; certainty 60%; harms 25%).*

http://www.conservationevidence.com/actions/848

Head-start amphibians for release

Twenty-two studies head-started amphibians from eggs and monitored them after release. A global review and six of 10 studies in Europe and the USA found that released head-started tadpoles, metamorphs or juveniles established breeding populations or increased existing populations. Two found mixed results with breeding populations established in 71% of studies reviewed or at 50% of sites. Two found that head-started metamorphs or adults did not establish a breeding population or prevent a population decline. An additional 10 studies in Australia, Canada, Europe and the USA measured aspects of survival or breeding success of released head-started amphibians and found mixed results. Three studies in the USA only provided results for head-starting in captivity. Two of those found that eggs could be reared to tadpoles, but only one successfully reared adults. *Assessment: trade-offs between benefits and harms (effectiveness 60%; certainty 60%; harms 25%).*

http://www.conservationevidence.com/actions/881

Release captive-bred individuals (Mallorcan midwife toad)

Three studies in Mallorca found that captive-bred midwife toads released as tadpoles, toadlets or adults established breeding populations at 38-100% of sites. One study in the UK found that predator defences were maintained, but genetic diversity was reduced in a captive-bred population. *Assessment: trade-offs between benefits and harms (effectiveness 68%; certainty 58%; harms 20%).*

http://www.conservationevidence.com/actions/873

Release captive-bred individuals (toads)

Two of three studies in Denmark, Sweden and the USA found that captive-bred toads released as tadpoles, juveniles or metamorphs established populations. The other found that populations were not established. Two studies in Puerto Rico found that survival of released captive-bred Puerto Rican crested toads was low. *Assessment: trade-offs between benefits and harms (effectiveness 40%; certainty 50%; harms 20%).*

http://www.conservationevidence.com/actions/875

Use artificial fertilization in captive breeding

Three replicated studies, including two randomized studies, in Australia and the USA found that the success of artificial fertilization depended on the type and number of doses of hormones used to stimulate egg production. One replicated study in Australia found that 55% of eggs were fertilized artificially, but soon died. *Assessment: trade-offs between benefits and harms (effectiveness 40%; certainty 40%; harms 20%).*

http://www.conservationevidence.com/actions/834

Use hormone treatment to induce sperm and egg release

One review and nine of 10 replicated studies, including two randomized, controlled studies, in Austria, Australia, China, Latvia, Russia and the USA found that hormone treatment of male amphibians stimulated or increased sperm production, or resulted in successful breeding. One found that hormone treatment of males and females did not result in breeding. One review and nine of 14 replicated studies, including six randomized and/or controlled studies, in Australia, Canada, China, Ecuador, Latvia and the USA found that hormone treatment of female amphibians had mixed results, with 30-71% of females producing viable eggs following treatment, or with egg production depending on the combination, amount or number of doses of hormones. Three found that hormone treatment stimulated egg production or successful breeding. Two found that treatment did not stimulate or increase egg production. *Assessment: trade-offs between benefits and harms (effectiveness 50%; certainty 65%; harms 30%).*

http://www.conservationevidence.com/actions/883

Unknown effectiveness (limited evidence)

Release captive-bred individuals (salamanders including newts)

One study in Germany found that captive-bred great crested newts and smooth newts released as larvae, juveniles and adults established stable breeding populations. *Assessment: unknown effectiveness – limited evidence (effectiveness 70%; certainty 30%; harms 0%).*

http://www.conservationevidence.com/actions/874

Unlikely to be beneficial

Freeze sperm or eggs for future use

Ten replicated studies, including three controlled studies, in Austria, Australia, Russia, the UK and USA found that following freezing, viability of amphibian sperm, and in one case eggs, depended on species, cryoprotectant used, storage temperature or method and freezing or thawing rate. One found that sperm could be frozen for up to 58 weeks. *Assessment: unlikely to be beneficial (effectiveness 35%; certainty 50%; harms 10%).*

http://www.conservationevidence.com/actions/876

Likely to be ineffective or harmful

Release captive-bred individuals (green and golden bell frogs)

Three studies in Australia found that captive-bred green and golden bell frogs released mainly as tadpoles did not established breeding populations, or only established breeding populations in 25% of release programmes. One study in Australia found that some frogs released as tadpoles survived at least 13 months. *Assessment: likely to be ineffective or harmful (effectiveness 20%; certainty 50%; harms 20%).*

http://www.conservationevidence.com/actions/872

1.14 Education and awareness raising

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for education and awareness raising?	
Likely to be beneficial	• Engage volunteers to collect amphibian data (citizen science) • Provide education programmes about amphibians • Raise awareness amongst the general public through campaigns and public information

Likely to be beneficial

Engage volunteers to collect amphibian data (citizen science)

Five studies in Canada, the UK and USA found that amphibian data collection projects engaged up to 10,506 volunteers and were active in 16-17 states in the USA. Five studies in the UK and USA found that volunteers surveyed up to 7,872 sites, swabbed almost 6,000 amphibians and submitted thousands of amphibian records. *Assessment: likely to be beneficial (effectiveness 66%; certainty 60%; harms 0%).*

http://www.conservationevidence.com/actions/760

Provide education programmes about amphibians

One study in Taiwan found that education programmes about wetlands and amphibians, along with other interventions, doubled a population of Taipei frogs. Four studies, including one replicated study, in Germany, Mexico, Slovenia, Zimbabwe and the USA found that education programmes increased the amphibian knowledge of students. *Assessment: likely to be beneficial (effectiveness 58%; certainty 55%; harms 0%).*

http://www.conservationevidence.com/actions/776

Raise awareness amongst the general public through campaigns and public information

Two studies, including one replicated, before-and-after study, in Estonia and the UK found that raising public awareness, along with other interventions, increased amphibian breeding habitat and numbers of toads. One before-and-after study in Mexico found that raising awareness in tourists increased their knowledge of axolotls. However, one study in Taiwan found that holding press conferences had no effect on a frog conservation project. *Assessment: likely to be beneficial (effectiveness 60%; certainty 51%; harms 0%).*

http://www.conservationevidence.com/actions/831