

What Works in Conservation



2015

EDITED BY

WILLIAM J. SUTHERLAND, LYNN V. DICKS,
NANCY OCKENDON AND REBECCA K. SMITH

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



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Contents

Introduction	1
Who is <i>What Works in Conservation</i> for?	1
The Conservation Evidence project	1
Which conservation interventions are included?	2
How we review the literature	3
What does <i>What Works in Conservation</i> include?	4
Expert assessment of the evidence	4
Categorization of interventions	5
How to use <i>What Works in Conservation</i>	5
 1. AMPHIBIAN CONSERVATION	 9
1.1 Threat: Residential and commercial development	11
Legal protection of species	11
Protect brownfield or ex-industrial sites	12
Restrict herbicide, fungicide and pesticide use on and around ponds on golf courses	12
1.2 Threat: Agriculture	13
1.2.1 Engage farmers and other volunteers	13
Engage landowners and other volunteers to manage land for amphibians	13
Pay farmers to cover the costs of conservation measures	13
1.2.2 Terrestrial habitat management	14
Manage silviculture practices in plantations	14
Manage cutting regime	14
Manage grazing regime	14
Maintain or restore hedges	15
Plant new hedges	15
Reduced tillage	15
1.2.3 Aquatic habitat management	15
Manage ditches	15
Exclude domestic animals or wild hogs from ponds by fencing	16

1.3 Threat: Energy production and mining	17
Artificially mist habitat to keep it damp	17
1.4 Threat: Transportation and service corridors	18
Close roads during seasonal amphibian migration	18
Modify gully pots and kerbs	19
Install barrier fencing along roads	19
Install culverts or tunnels as road crossings	19
Use signage to warn motorists	20
Use humans to assist migrating amphibians across roads	20
1.5 Threat: Biological resource use	21
1.5.1 Hunting and collecting terrestrial animals	21
Reduce impact of amphibian trade	21
Use legislative regulation to protect wild populations	22
Commercially breed amphibians for the pet trade	22
Use amphibians sustainably	22
1.5.2 Logging and wood harvesting	22
Retain riparian buffer strips during timber harvest	23
Use shelterwood harvesting instead of clearcutting	23
Leave coarse woody debris in forests	23
Use patch retention harvesting instead of clearcutting	24
Leave standing deadwood/snags in forests	24
Use leave-tree harvesting instead of clearcutting	24
Harvest groups of trees instead of clearcutting	25
Thin trees within forests	25
1.6 Threat: Human intrusions and disturbance	26
Use signs and access restrictions to reduce disturbance	26
1.7 Threat: Natural system modifications	27
Regulate water levels	27
Mechanically remove mid-storey or ground vegetation	28
Use herbicides to control mid-storey or ground vegetation	28
Use prescribed fire or modifications to burning regime (forests)	28
Use prescribed fire or modifications to burning regime (grassland)	29
1.8 Threat: Invasive and other problematic species	30
1.8.1 Reduce predation by other species	30
Remove or control fish by drying out ponds	30
Remove or control fish population by catching	31
Remove or control invasive bullfrogs	31
Remove or control invasive viperine snake	31
Remove or control mammals	31

Remove or control fish using Rotenone	32
Exclude fish with barriers	32
Encourage aquatic plant growth as refuge against fish predation	32
Remove or control non-native crayfish	32
1.8.2 Reduce competition with other species	33
Reduce competition from native amphibians	33
Remove or control invasive Cuban tree frogs	33
Remove or control invasive cane toads	33
1.8.3 Reduce adverse habitat alteration by other species	34
Control invasive plants	34
Prevent heavy usage/exclude wildfowl from aquatic habitat	34
1.8.4 Reduce parasitism and disease – chytridiomycosis	35
Use temperature treatment to reduce infection	35
Use antifungal treatment to reduce infection	35
Add salt to ponds	36
Immunize amphibians against infection	36
Remove the chytrid fungus from ponds	36
Sterilize equipment when moving between amphibian sites	37
Treating amphibians in the wild or pre-release	37
Use gloves to handle amphibians	37
Use antibacterial treatment to reduce infection	37
Use antifungal skin bacteria or peptides to reduce infection	38
Use zooplankton to remove zoospores	38
1.8.5 Reduce parasitism and disease – ranaviruses	38
Sterilize equipment to prevent ranaviruses	38
1.9 Threat: Pollution	39
1.9.1 Agricultural pollution	39
Create walls or barriers to exclude pollutants	39
Plant riparian buffer strips	39
Reduce pesticide, herbicide or fertilizer use	40
Prevent pollution from agricultural lands or sewage treatment facilities entering watercourses	40
1.9.2 Industrial pollution	40
Add limestone to water bodies to reduce acidification	40
Augment ponds with ground water to reduce acidification	41
1.10 Threat: Climate change and severe weather	42
Create microclimate and microhabitat refuges	42
Maintain ephemeral ponds	42
Deepen ponds to prevent desiccation	43
Use irrigation systems for amphibian sites	43

Artificially shade ponds to prevent desiccation	43
Protect habitat along elevational gradients	43
Provide shelter habitat	43
1.11 Habitat protection	44
Retain buffer zones around core habitat	44
Protect habitats for amphibians	44
Retain connectivity between habitat patches	45
1.12 Habitat restoration and creation	46
1.12.1 Terrestrial habitat	46
Replant vegetation	46
Clear vegetation	47
Create artificial hibernacula or aestivation sites	47
Create refuges	47
Restore habitat connectivity	48
Change mowing regime	48
Create habitat connectivity	48
1.12.2 Aquatic habitat	48
Create ponds (amphibians in general)	49
Create ponds (frogs)	49
Create ponds (natterjack toads)	50
Create ponds (salamanders including newts)	50
Create wetlands	50
Deepen, de-silt or re-profile ponds	51
Restore wetlands	51
Create ponds (great crested newts)	52
Create ponds (green toads)	52
Create ponds (toads)	52
Remove specific aquatic plants	52
Restore ponds	53
Remove tree canopy to reduce pond shading	53
Add nutrients to new ponds as larvae food source	54
Add specific plants to aquatic habitats	54
Add woody debris to ponds	54
Create refuge areas in aquatic habitats	54
1.13 Species management	55
1.13.1 Translocate amphibians	55
Translocate amphibians (amphibians in general)	55
Translocate amphibians (great crested newts)	56
Translocate amphibians (natterjack toads)	56
Translocate amphibians (salamanders including newts)	56
Translocate amphibians (toads)	57

Translocate amphibians (wood frogs)	57
Translocate amphibians (frogs)	57
1.13.2 Captive breeding, rearing and releases	58
Release captive-bred individuals (amphibians in general)	59
Release captive-bred individuals (frogs)	59
Breed amphibians in captivity (frogs)	59
Breed amphibians in captivity (harlequin toads)	60
Breed amphibians in captivity (Mallorcan midwife toad)	60
Breed amphibians in captivity (salamanders including newts)	60
Breed amphibians in captivity (toads)	60
Head-start amphibians for release	61
Release captive-bred individuals (Mallorcan midwife toad)	61
Release captive-bred individuals (toads)	61
Use artificial fertilization in captive breeding	62
Use hormone treatment to induce sperm and egg release	62
Release captive-bred individuals (salamanders including newts)	62
Freeze sperm or eggs for future use	63
Release captive-bred individuals (green and golden bell frogs)	63
1.14 Education and awareness raising	64
Engage volunteers to collect amphibian data (citizen science)	64
Provide education programmes about amphibians	64
Raise awareness amongst the general public through campaigns and public information	65
2. BAT CONSERVATION	67
2.1 Threat: Residential and commercial development	69
Protect brownfield sites	69
Provide foraging habitat in urban areas	70
Change timing of building works	70
Conserve existing roosts within developments	70
Conserve old buildings or structures as roosting sites for bats within developments	70
Create alternative roosts within buildings	70
Maintain bridges and retain crevices for roosting	70
Retain or relocate access points to bat roosts	70
Retain or replace existing bat commuting routes within development	70
2.2 Threat: Agriculture	71
2.2.1 Land use change	71
Protect or create wetlands as foraging habitat for bats	71

Retain or plant trees on agricultural land to replace foraging habitat	72
Conserve old buildings or structures on agricultural land as roosting sites for bats	72
Retain old or dead trees with hollows and cracks as roosting sites for bats on agricultural land	72
Retain or replace existing bat commuting routes on agricultural land	72
2.2.2 Intensive farming	72
Convert to organic farming	73
Encourage agroforestry	73
Introduce agri-environment schemes	73
2.3 Threat: Energy production – wind turbines	74
Switch off turbines at low wind speeds to reduce bat fatalities	74
Deter bats from turbines using ultrasound	75
Deter bats from turbines using radar	75
Automatically switch off wind turbines when bat activity is high	75
Close off nacelles on wind turbines to prevent roosting bats	75
Leave a minimum distance between turbines and habitat features used by bats	75
Modify turbine design to reduce bat fatalities	75
Modify turbine placement to reduce bat fatalities	75
Remove turbine lighting to avoid attracting bats	75
2.4 Threat: Energy production – mining	76
Legally protect bat hibernation sites in mines from reclamation	76
Provide artificial hibernacula to replace roosts lost in reclaimed mines	76
Relocate bats from reclaimed mines to new hibernation sites	76
2.5 Threat: Transportation and service corridors	77
Install underpasses as road crossing structures for bats	77
Divert bats to safe crossing points with plantings or fencing	78
Install bat gantries or bat bridges as road crossing structures for bats	78
Install overpasses as road crossing structures for bats	78
Deter bats with lighting	78
Install green bridges as road crossing structures for bats	78
Install hop-overs as road crossing structures for bats	78
Replace or improve habitat for bats around roads	78
2.6 Threat: Biological resource use	79
2.6.1 Hunting	79
Educate local communities about bats and hunting	79

Introduce and enforce legislation to control hunting of bats	79
Introduce sustainable harvesting of bats	79
2.6.2 Guano harvesting	79
Introduce and enforce legislation to regulate the harvesting of bat guano	80
Introduce sustainable harvesting of bat guano	80
2.6.3 Logging and wood harvesting	80
Incorporate forested corridors or buffers into logged areas	80
Use selective harvesting/reduced impact logging instead of clearcutting	81
Use shelterwood cutting instead of clearcutting	81
Retain residual tree patches in logged areas	81
Thin trees within forests	82
Manage woodland or forest edges for bats	82
Replant native trees	82
Retain deadwood/snags within forests for roosting bats	82
2.7 Threat: Human disturbance – caving and tourism	83
Impose restrictions on cave visits	83
Use cave gates to restrict public access	84
Educate the public to reduce disturbance to hibernating bats	84
Legally protect bat hibernation sites	84
Maintain microclimate at underground hibernation/roost sites	84
Provide artificial hibernacula for bats to replace disturbed sites	84
2.8 Threat: Natural system modification – natural fire and fire suppression	85
Use prescribed burning	85
2.9 Threat: Invasive species	86
2.9.1 Invasive species	86
Remove invasive plant species	86
Translocate to predator or disease free areas	86
Control invasive predators	87
2.9.2 White-nose syndrome	87
Control anthropogenic spread	87
Cull infected bats	87
Increase population resistance	87
Modify cave environments to increase bat survival	87
2.10 Threat: Pollution	88
2.10.1 Domestic and urban waste water	88
Change effluent treatments of domestic and urban waste water	88

2.10.2	Agricultural and forestry effluents	88
	Introduce legislation to control use	89
	Change effluent treatments used in agriculture and forestry	89
2.10.3	Light and noise pollution	89
	Leave bat roosts, roost entrances and commuting routes unlit	89
	Minimize excess light pollution	89
	Restrict timing of lighting	90
	Use low pressure sodium lamps or use UV filters	90
	Impose noise limits in proximity to roosts and bat habitats	90
2.10.4	Timber treatments	90
	Use mammal safe timber treatments in roof spaces	90
	Restrict timing of treatment	91
2.11	Providing artificial roost structures for bats	92
	Provide artificial roost structures for bats	92
2.12	Education and awareness raising	93
	Provide training to professionals	93
	Educate homeowners about building and planning laws	93
	Educate to improve public perception and raise awareness	93
3.	BIRD CONSERVATION	95
3.1	Habitat protection	97
	Legally protect habitats for birds	97
	Provide or retain un-harvested buffer strips	97
	Ensure connectivity between habitat patches	98
3.2	Education and awareness raising	99
	Raise awareness amongst the general public through campaigns and public information	99
	Provide bird feeding materials to families with young children	100
	Enhance bird taxonomy skills through higher education and training	100
	Provide training to conservationists and land managers on bird ecology and conservation	100
3.3	Threat: Residential and commercial development	101
	Angle windows to reduce bird collisions	101
	Mark windows to reduce bird collisions	101
3.4	Threat: Agriculture	103
3.4.1	All farming systems	103
	Plant wild bird seed or cover mixture	104
	Provide (or retain) set-aside areas in farmland	105
	Create uncultivated margins around intensive arable or pasture fields	105

Increase the proportion of natural/semi-natural habitat in the farmed landscape	106
Manage ditches to benefit wildlife	106
Pay farmers to cover the costs of conservation measures	106
Plant grass buffer strips/margins around arable or pasture fields	107
Plant nectar flower mixture/wildflower strips	107
Leave refuges in fields during harvest	107
Reduce conflict by deterring birds from taking crops (using bird scarers)	108
Relocate nests at harvest time to reduce nestling mortality	108
Use mowing techniques to reduce mortality	108
Control scrub on farmland	108
Offer per clutch payment for farmland birds	109
Manage hedges to benefit wildlife	109
Plant new hedges	109
Reduce conflict by deterring birds from taking crops (using repellents)	109
Take field corners out of management	110
Mark bird nests during harvest or mowing	110
Cross compliance standards for all subsidy payments	110
Food labelling schemes relating to biodiversity-friendly farming	110
Manage stone-faced hedge banks to benefit birds	110
Plant in-field trees	110
Protect in-field trees	110
Reduce field size (or maintain small fields)	110
Support or maintain low-intensity agricultural systems	110
Tree pollarding, tree surgery	110
3.4.2 Arable farming	111
Create 'skylark plots' (undrilled patches in cereal fields)	111
Leave overwinter stubbles	112
Leave uncropped cultivated margins or fallow land (includes lapwing and stone curlew plots)	112
Sow crops in spring rather than autumn	113
Undersow spring cereals, with clover for example	113
Reduce tillage	113
Implement mosaic management	114
Increase crop diversity	114
Plant more than one crop per field (intercropping)	114
Create beetle banks	114
Plant cereals in wide-spaced rows	115
Revert arable land to permanent grassland	115

Add 1% barley into wheat crop for corn buntings	115
Create corn bunting plots	115
Leave unharvested cereal headlands within arable fields	115
Plant nettle strips	115
3.4.3 Livestock farming	116
Delay mowing date on grasslands	116
Leave uncut rye grass in silage fields	117
Maintain species-rich, semi-natural grassland	117
Maintain traditional water meadows	117
Mark fencing to avoid bird mortality	118
Plant cereals for whole crop silage	118
Reduce grazing intensity	118
Reduce management intensity of permanent grasslands	119
Exclude livestock from semi-natural habitat	119
Create open patches or strips in permanent grassland	119
Maintain upland heath/moor	120
Protect nests from livestock to reduce trampling	120
Provide short grass for waders	120
Raise mowing height on grasslands	120
Use traditional breeds of livestock	121
Maintain lowland heathland	121
Maintain rush pastures	121
Maintain wood pasture and parkland	121
Plant Brassica fodder crops	121
Use mixed stocking	121
3.4.4 Perennial, non-timber crops	121
Maintain traditional orchards	121
Manage perennial bioenergy crops to benefit wildlife	122
3.4.5 Aquaculture	122
Deter birds from landing on shellfish culture gear	123
Disturb birds at roosts	123
Provide refuges for fish within ponds	123
Use electric fencing to exclude fish-eating birds	123
Use 'mussel socks' to prevent birds from attacking shellfish	124
Use netting to exclude fish-eating birds	124
Increase water turbidity to reduce fish predation by birds	124
Translocate birds away from fish farms	124
Use in-water devices to reduce fish loss from ponds	124
Disturb birds using foot patrols	125
Spray water to deter birds from ponds	125
Scare birds from fish farms	125

3.5 Threat: Energy production and mining	126
Paint wind turbines to increase their visibility	126
3.6 Threat: Transportation and service corridors	127
3.6.1 Verges and airports	127
Scare or otherwise deter birds from airports	127
Mow roadside verges	127
Sow roadside verges	128
3.6.2 Power lines and electricity pylons	128
Mark power lines	128
Bury or isolate power lines	129
Insulate electricity pylons	129
Remove earth wires from power lines	129
Use perch-deterrent lines	129
Thicken earth wires	129
Add perches to electricity pylons	130
Reduce electrocutions by using plastic, not metal, leg rings to mark birds	130
Use raptor models to deter birds from power lines	130
3.7 Threat: Biological resource use	131
3.7.1 Reducing exploitation and conflict	131
Scare fish-eating birds from areas to reduce conflict	131
Use legislative regulation to protect wild populations	132
Use wildlife refuges to reduce hunting disturbance	132
Employ local people as 'biomonitors'	132
Increase 'on-the-ground' protection to reduce unsustainable levels of exploitation	132
Introduce voluntary 'maximum shoot distances'	133
Mark eggs to reduce their appeal to collectors	133
Move fish-eating birds to reduce conflict with fishermen	133
Promote sustainable alternative livelihoods	133
Provide 'sacrificial grasslands' to reduce conflict with farmers	134
Relocate nestlings to reduce poaching	134
Use education programmes and local engagement to help reduce persecution or exploitation of species	134
Use alerts during shoots to reduce mortality of non-target species	134
3.7.2 Reducing fisheries bycatch	135
Use streamer lines to reduce seabird bycatch on longlines	136
Mark trawler warp cables to reduce seabird collisions	136
Reduce seabird bycatch by releasing offal overboard when setting longlines	137
Weight baits or lines to reduce longline bycatch of seabirds	137

Set lines underwater to reduce seabird bycatch	137
Set longlines at night to reduce seabird bycatch	137
Dye baits to reduce seabird bycatch	138
Thaw bait before setting lines to reduce seabird bycatch	138
Turn deck lights off during night-time setting of longlines to reduce bycatch	138
Use a sonic scarer when setting longlines to reduce seabird bycatch	138
Use acoustic alerts on gillnets to reduce seabird bycatch	138
Use bait throwers to reduce seabird bycatch	139
Use bird exclusion devices such as 'Brickle curtains' to reduce seabird mortality when hauling longlines	139
Use high visibility mesh on gillnets to reduce seabird bycatch	139
Use shark liver oil to deter birds when setting lines	139
Use a line shooter to reduce seabird bycatch	140
Reduce bycatch through seasonal or area closures	140
Reduce 'ghost fishing' by lost/discarded gear	140
Reduce gillnet deployment time to reduce seabird bycatch	140
Set longlines at the side of the boat to reduce seabird bycatch	140
Tow buoys behind longlining boats to reduce seabird bycatch	140
Use a water cannon when setting longlines to reduce seabird bycatch	140
Use high-visibility longlines to reduce seabird bycatch	140
Use larger hooks to reduce seabird bycatch on longlines	140
3.8 Threat: Human intrusions and disturbance	141
Provide paths to limit disturbance	141
Start educational programmes for personal watercraft owners	142
Use signs and access restrictions to reduce disturbance at nest sites	142
Use voluntary agreements with local people to reduce disturbance	142
Habituate birds to human visitors	142
Use nest covers to reduce the impact of research on predation of ground-nesting seabirds	143
Reduce visitor group sizes	143
Set minimum distances for approaching birds (buffer zones)	143
3.9 Threat: Natural system modifications	144
Create scrapes and pools in wetlands and wet grasslands	146
Provide deadwood/snags in forests (use ring-barking, cutting or silvicides)	146
Use patch retention harvesting instead of clearcutting	146

Clear or open patches in forests	147
Employ grazing in artificial grasslands/pastures	147
Employ grazing in natural grasslands	147
Employ grazing in non-grassland habitats	148
Manage water level in wetlands	148
Manually control or remove midstorey and ground-level vegetation (including mowing, chaining, cutting etc.) (forests)	148
Manually control or remove midstorey and ground-level vegetation (including mowing, chaining, cutting etc.) (mowing or cutting natural grasslands)	149
Manually control or remove midstorey and ground-level vegetation (including mowing, chaining, cutting etc.) (mowing or cutting semi-natural grasslands/pastures)	149
Manually control or remove midstorey and ground-level vegetation (including mowing, chaining, cutting etc.) (shrublands)	150
Raise water levels in ditches or grassland	150
Thin trees within forests	150
Use prescribed burning (grasslands)	151
Use prescribed burning (pine forests)	151
Use prescribed burning (savannahs)	152
Use prescribed burning (shrublands)	152
Use selective harvesting/logging instead of clearcutting	152
Clearcut and re-seed forests	153
Coppice trees	153
Fertilise grasslands	153
Manage woodland edges for birds	154
Manually control or remove midstorey and ground-level vegetation (including mowing, chaining, cutting etc.) (reedbeds)	154
Manually control or remove midstorey and ground-level vegetation (including mowing, chaining, cutting etc.) (savannahs)	154
Plant trees to act as windbreaks	154
Plough habitats	155
Provide deadwood/snags in forests (adding woody debris to forests)	155
Remove coarse woody debris from forests	155
Replace non-native species of tree/shrub	155
Re-seed grasslands	156
Use environmentally sensitive flood management	156
Use fire suppression/control	156
Use greentree reservoir management	156

Use prescribed burning (Australian sclerophyll forest)	157
Use shelterwood cutting instead of clearcutting	157
Use variable retention management during forestry operations	157
Apply herbicide to mid- and understorey vegetation	157
Treat wetlands with herbicides	158
Use prescribed burning (coastal habitats)	158
Use prescribed burning (deciduous forests)	158
Protect nest trees before burning	159
3.10 Habitat restoration and creation	160
Restore or create forests	160
Restore or create wetlands and marine habitats (inland wetlands)	161
Restore or create grassland	161
Restore or create traditional water meadows	162
Restore or create wetlands and marine habitats (coastal and intertidal wetlands)	162
Restore or create shrubland	162
Restore or create wetlands and marine habitats (kelp forests)	163
Restore or create wetlands and marine habitats (lagoons)	163
Restore or create savannahs	163
Revegetate gravel pits	163
3.11 Threat: Invasive alien and other problematic species	164
3.11.1 Reduce predation by other species	164
Control mammalian predators on islands	164
Remove or control predators to enhance bird populations and communities	165
Control avian predators on islands	165
Control invasive ants on islands	165
Reduce predation by translocating predators	166
Control predators not on islands	166
3.11.2 Reduce incidental mortality during predator eradication or control	167
Distribute poison bait using dispensers	167
Use coloured baits to reduce accidental mortality during predator control	167
Use repellents on baits	167
Do birds take bait designed for pest control?	168
3.11.3 Reduce nest predation by excluding predators from nests or nesting areas	168
Physically protect nests from predators using non-electric fencing	169
Physically protect nests with individual exclosures/barriers or provide shelters for chicks	169

Protect bird nests using electric fencing	169
Use artificial nests that discourage predation	170
Guard nests to prevent predation	170
Plant nesting cover to reduce nest predation	170
Protect nests from ants	170
Use multiple barriers to protect nests	171
Use naphthalene to deter mammalian predators	171
Use snakeskin to deter mammalian nest predators	171
Play spoken-word radio programs to deter predators	171
Use 'cat curfews' to reduce predation	171
Use lion dung to deter domestic cats	171
Use mirrors to deter nest predators	171
Use ultrasonic devices to deter cats	171
Can nest protection increase nest abandonment?	172
Can nest protection increase predation of adults and chicks?	172
3.11.4 Reduce mortality by reducing hunting ability or changing predator behaviour	172
Reduce predation by translocating nest boxes	173
Use collar-mounted devices to reduce predation	173
Use supplementary feeding to reduce predation	173
Use aversive conditioning to reduce nest predation	173
3.11.5 Reduce competition with other species for food and nest sites	174
Reduce inter-specific competition for food by removing or controlling competitor species	174
Protect nest sites from competitors	175
Reduce competition between species by providing nest boxes	175
Reduce inter-specific competition for nest sites by modifying habitats to exclude competitor species	175
Reduce inter-specific competition for nest sites by removing competitor species (ground nesting seabirds)	176
Reduce inter-specific competition for nest sites by removing competitor species (songbirds)	176
Reduce inter-specific competition for nest sites by removing competitor species (woodpeckers)	176
3.11.6 Reduce adverse habitat alteration by other species	177
Control or remove habitat-altering mammals	177
Reduce adverse habitat alterations by excluding problematic species (terrestrial species)	177
Reduce adverse habitat alterations by excluding problematic species (aquatic species)	178
Remove problematic vegetation	178
Use buffer zones to reduce the impact of invasive plant control	178

3.11.7	Reduce parasitism and disease	179
	Remove/control adult brood parasites	179
	Remove/treat endoparasites and diseases	180
	Alter artificial nest sites to discourage brood parasitism	180
	Exclude or control 'reservoir species' to reduce parasite burdens	180
	Remove brood parasite eggs from target species' nests	180
	Remove/treat ectoparasites to increase survival or reproductive success (provide beneficial nesting material)	181
	Remove/treat ectoparasites to increase survival or reproductive success (remove ectoparasites from feathers)	181
	Use false brood parasite eggs to discourage brood parasitism	181
	Remove/treat ectoparasites to increase survival or reproductive success (remove ectoparasites from nests)	181
3.11.8	Reduce detrimental impacts of other problematic species	182
	Use copper strips to exclude snails from nests	182
3.12	Threat: Pollution	183
3.12.1	Industrial pollution	183
	Use visual and acoustic 'scarers' to deter birds from landing on pools polluted by mining or sewage	183
	Relocate birds following oil spills	184
	Use repellents to deter birds from landing on pools polluted by mining	184
	Clean birds after oil spills	184
3.12.2	Agricultural pollution	185
	Leave headlands in fields unsprayed (conservation headlands)	185
	Provide food for vultures to reduce mortality from diclofenac	186
	Reduce pesticide, herbicide and fertiliser use generally	186
	Reduce chemical inputs in permanent grassland management	186
	Restrict certain pesticides or other agricultural chemicals	186
	Make selective use of spring herbicides	187
	Provide buffer strips along rivers and streams	187
	Provide unfertilised cereal headlands in arable fields	187
	Use buffer strips around in-field ponds	187
	Use organic rather than mineral fertilisers	187
3.12.3	Air-borne pollutants	187
	Use lime to reduce acidification in lakes	187
3.12.4	Excess energy	188
	Shield lights to reduce mortality from artificial lights	188

Turning off lights	188
Use flashing lights to reduce mortality from artificial lights	188
Use lights low in spectral red to reduce mortality from artificial lights	189
Reduce the intensity of lighthouse beams	189
Using volunteers to collect and rehabilitate downed birds	189
3.13 Threat: Climate change, extreme weather and geological events	190
Replace nesting habitats when they are washed away by storms	190
Water nests during droughts	191
3.14 General responses to small/declining populations	192
3.14.1 Inducing breeding, rehabilitation and egg removal	192
Rehabilitate injured birds	192
Remove eggs from wild nests to increase reproductive output	193
Use artificial visual and auditory stimuli to induce breeding in wild populations	193
3.14.2 Provide artificial nesting sites	193
Provide artificial nests (falcons)	194
Provide artificial nests (owls)	195
Provide artificial nests (songbirds)	195
Provide artificial nests (wildfowl)	196
Clean artificial nests to increase occupancy or reproductive success	196
Provide artificial nests (burrow-nesting seabirds)	197
Provide artificial nests (divers/loons)	197
Provide artificial nests (ground- and tree-nesting seabirds)	197
Provide artificial nests (oilbirds)	198
Provide artificial nests (raptors)	198
Provide artificial nests (wildfowl – artificial/floating islands)	198
Artificially incubate eggs or warm nests	198
Guard nests	199
Provide artificial nests (gamebirds)	199
Provide artificial nests (grebes)	199
Provide artificial nests (ibises and flamingos)	199
Provide artificial nests (parrots)	199
Provide artificial nests (pigeons)	200
Provide artificial nests (rails)	200
Provide artificial nests (rollers)	200
Provide artificial nests (swifts)	200
Provide artificial nests (trogons)	201
Provide artificial nests (waders)	201

Provide artificial nests (woodpeckers)	201
Provide nesting habitat for birds that is safe from extreme weather	201
Provide nesting material for wild birds	202
Remove vegetation to create nesting areas	202
Repair/support nests to support breeding	202
Use differently-coloured artificial nests	202
3.14.3 Foster chicks in the wild	203
Foster eggs or chicks with wild conspecifics (raptors)	203
Foster eggs or chicks with wild non-conspecifics (cross-fostering) (songbirds)	204
Foster eggs or chicks with wild conspecifics (bustards)	204
Foster eggs or chicks with wild conspecifics (cranes)	204
Foster eggs or chicks with wild conspecifics (gannets and boobies)	204
Foster eggs or chicks with wild conspecifics (owls)	205
Foster eggs or chicks with wild conspecifics (parrots)	205
Foster eggs or chicks with wild conspecifics (vultures)	205
Foster eggs or chicks with wild conspecifics (waders)	205
Foster eggs or chicks with wild conspecifics (woodpeckers)	206
Foster eggs or chicks with wild non-conspecifics (cross-fostering) (cranes)	206
Foster eggs or chicks with wild non-conspecifics (cross-fostering) (ibises)	206
Foster eggs or chicks with wild non-conspecifics (cross-fostering) (petrels and shearwaters)	206
Foster eggs or chicks with wild non-conspecifics (cross-fostering) (waders)	206
3.14.4 Provide supplementary food	207
Provide supplementary food to increase adult survival (songbirds)	209
Place feeders close to windows to reduce collisions	209
Provide calcium supplements to increase survival or reproductive success	210
Provide supplementary food to increase adult survival (cranes)	210
Provide supplementary food to increase reproductive success (gulls, terns and skuas)	210
Provide supplementary food to increase reproductive success (owls)	210
Provide supplementary food to increase reproductive success (raptors)	211
Provide supplementary food to increase reproductive success (songbirds)	211
Provide perches to improve foraging success	212

Provide supplementary food through the establishment of food populations	212
Provide supplementary food to allow the rescue of a second chick	213
Provide supplementary food to increase adult survival (gamebirds)	213
Provide supplementary food to increase adult survival (gulls, terns and skuas)	213
Provide supplementary food to increase adult survival (hummingbirds)	213
Provide supplementary food to increase adult survival (nectar-feeding songbirds)	214
Provide supplementary food to increase adult survival (pigeons)	214
Provide supplementary food to increase adult survival (raptors)	214
Provide supplementary food to increase adult survival (vultures)	215
Provide supplementary food to increase adult survival (waders)	215
Provide supplementary food to increase adult survival (wildfowl)	215
Provide supplementary food to increase adult survival (woodpeckers)	215
Provide supplementary food to increase reproductive success (auks)	216
Provide supplementary food to increase reproductive success (gamebirds)	216
Provide supplementary food to increase reproductive success (gannets and boobies)	216
Provide supplementary food to increase reproductive success (ibises)	217
Provide supplementary food to increase reproductive success (kingfishers)	217
Provide supplementary food to increase reproductive success (parrots)	217
Provide supplementary food to increase reproductive success (petrels)	217
Provide supplementary food to increase reproductive success (pigeons)	218
Provide supplementary food to increase reproductive success (rails and coots)	218
Provide supplementary food to increase reproductive success (vultures)	218
Provide supplementary food to increase reproductive success (waders)	219
Provide supplementary food to increase reproductive success (wildfowl)	219

Provide supplementary water to increase survival or reproductive success	219
3.14.5 Translocations	219
Translocate birds to re-establish populations or increase genetic variation (birds in general)	221
Translocate birds to re-establish populations or increase genetic variation (raptors)	221
Translocate birds to re-establish populations or increase genetic variation (parrots)	221
Translocate birds to re-establish populations or increase genetic variation (pelicans)	221
Translocate birds to re-establish populations or increase genetic variation (petrels and shearwaters)	222
Translocate birds to re-establish populations or increase genetic variation (rails)	222
Translocate birds to re-establish populations or increase genetic variation (songbirds)	222
Translocate birds to re-establish populations or increase genetic variation (wildfowl)	222
Translocate birds to re-establish populations or increase genetic variation (woodpeckers)	223
Use decoys to attract birds to new sites	223
Use techniques to increase the survival of species after capture	223
Use vocalisations to attract birds to new sites	224
Translocate birds to re-establish populations or increase genetic variation (gamebirds)	224
Alter habitats to encourage birds to leave	224
Ensure translocated birds are familiar with each other before release	224
Translocate birds to re-establish populations or increase genetic variation (auks)	225
Translocate birds to re-establish populations or increase genetic variation (herons, storks and ibises)	225
Translocate birds to re-establish populations or increase genetic variation (megapodes)	225
Translocate birds to re-establish populations or increase genetic variation (owls)	225
Translocate nests to avoid disturbance	226
Ensure genetic variation to increase translocation success	226
3.15 Captive breeding, rearing and releases (ex situ conservation)	227
3.15.1 Captive breeding	227
Artificially incubate and hand-rear birds in captivity (raptors)	229
Artificially incubate and hand-rear birds in captivity (seabirds)	229

Artificially incubate and hand-rear birds in captivity (songbirds)	229
Artificially incubate and hand-rear birds in captivity (waders)	230
Use captive breeding to increase or maintain populations (raptors)	230
Artificially incubate and hand-rear birds in captivity (bustards)	230
Artificially incubate and hand-rear birds in captivity (cranes)	231
Artificially incubate and hand-rear birds in captivity (gamebirds)	231
Artificially incubate and hand-rear birds in captivity (parrots)	231
Artificially incubate and hand-rear birds in captivity (penguins)	231
Artificially incubate and hand-rear birds in captivity (rails)	232
Artificially incubate and hand-rear birds in captivity (storks and ibises)	232
Artificially incubate and hand-rear birds in captivity (vultures)	232
Artificially incubate and hand-rear birds in captivity (wildfowl)	232
Freeze semen for artificial insemination	233
Use artificial insemination in captive breeding	233
Use captive breeding to increase or maintain populations (bustards)	233
Use captive breeding to increase or maintain populations (cranes)	234
Use captive breeding to increase or maintain populations (pigeons)	234
Use captive breeding to increase or maintain populations (rails)	234
Use captive breeding to increase or maintain populations (seabirds)	234
Use captive breeding to increase or maintain populations (songbirds)	234
Use captive breeding to increase or maintain populations (storks and ibises)	235
Use captive breeding to increase or maintain populations (tinamous)	235
Use puppets to increase the success of hand-rearing	235
Wash contaminated semen and use it for artificial insemination	236
Can captive breeding have deleterious effects on individual fitness?	236
3.15.2 Release captive-bred individuals	236
Provide supplementary food during and after release	237

Release captive-bred individuals into the wild to restore or augment wild populations (cranes)	238
Release captive-bred individuals into the wild to restore or augment wild populations (raptors)	238
Release captive-bred individuals into the wild to restore or augment wild populations (songbirds)	238
Release captive-bred individuals into the wild to restore or augment wild populations (vultures)	239
Clip birds' wings on release	239
Release birds as adults or sub-adults not juveniles	239
Release birds in groups	240
Release captive-bred individuals into the wild to restore or augment wild populations (bustards)	240
Release captive-bred individuals into the wild to restore or augment wild populations (gamebirds)	240
Release captive-bred individuals into the wild to restore or augment wild populations (owls)	240
Release captive-bred individuals into the wild to restore or augment wild populations (parrots)	241
Release captive-bred individuals into the wild to restore or augment wild populations (pigeons)	241
Release captive-bred individuals into the wild to restore or augment wild populations (rails)	241
Release captive-bred individuals into the wild to restore or augment wild populations (storks and ibises)	242
Release captive-bred individuals into the wild to restore or augment wild populations (waders)	242
Release captive-bred individuals into the wild to restore or augment wild populations (wildfowl)	242
Release chicks and adults in 'coveys'	242
Use 'anti-predator training' to improve survival after release	243
Use appropriate populations to source released populations	243
Use 'flying training' before release	243
Use holding pens at release sites	243
Use microlites to help birds migrate	244

4. FARMLAND CONSERVATION 245

4.1 All farming systems 247

Create uncultivated margins around intensive arable or pasture fields	248
Plant grass buffer strips/margins around arable or pasture fields	249
Plant nectar flower mixture/wildflower strips	249
Plant wild bird seed or cover mixture	250
Provide or retain set-aside areas in farmland	250

Manage hedgerows to benefit wildlife (includes no spray, gap-filling and laying)	250
Pay farmers to cover the cost of conservation measures (as in agri-environment schemes)	251
Provide supplementary food for birds or mammals	251
Connect areas of natural or semi-natural habitat	251
Increase the proportion of semi-natural habitat in the farmed landscape	252
Make direct payments per clutch for farmland birds	252
Manage ditches to benefit wildlife	252
Manage the agricultural landscape to enhance floral resources	252
Mark bird nests during harvest or mowing	253
Plant new hedges	253
Provide nest boxes for bees (solitary bees or bumblebees)	253
Provide nest boxes for birds	253
Provide other resources for birds (water, sand for bathing)	254
Provide refuges during harvest or mowing	254
Apply 'cross compliance' environmental standards linked to all subsidy payments	254
Implement food labelling schemes relating to biodiversity-friendly farming (organic, LEAF marque)	254
Introduce nest boxes stocked with solitary bees	254
Maintain in-field elements such as field islands and rockpiles	254
Manage stone-faced hedge banks to benefit wildlife	254
Manage woodland edges to benefit wildlife	254
Plant in-field trees (not farm woodland)	255
Protect in-field trees (includes management such as pollarding and surgery)	255
Provide badger gates	255
Provide foraging perches (e.g. for shrikes)	255
Provide otter holts	255
Provide red squirrel feeders	255
Reduce field size (or maintain small fields)	255
Restore or maintain dry stone walls	255
Support or maintain low-intensity agricultural systems	255
4.2 Arable farming	256
Create skylark plots	257
Leave cultivated, uncropped margins or plots (includes 'lapwing plots')	257
Create beetle banks	257
Leave overwinter stubbles	258
Reduce tillage	258

Undersow spring cereals, with clover for example	258
Convert or revert arable land to permanent grassland	259
Create rotational grass or clover leys	259
Implement 'mosaic management', a Dutch agri-environment option	259
Increase crop diversity	259
Plant cereals in wide-spaced rows	260
Plant crops in spring rather than autumn	260
Plant more than one crop per field (intercropping)	260
Plant nettle strips	260
Sow rare or declining arable weeds	260
Take field corners out of management	261
Add 1% barley into wheat crop for corn buntings	261
Create corn bunting plots	261
Leave unharvested cereal headlands within arable fields	261
Use new crop types to benefit wildlife (such as perennial cereal crops)	261
4.3 Perennial (non-timber) crops	262
Maintain traditional orchards	262
Manage short-rotation coppice to benefit wildlife (includes 8m rides)	262
Restore or create traditional orchards	262
4.4 Livestock farming	263
Restore or create species-rich, semi-natural grassland	264
Use mowing techniques to reduce mortality	264
Delay mowing or first grazing date on grasslands	265
Leave uncut strips of rye grass on silage fields	265
Maintain species-rich, semi-natural grassland	265
Maintain traditional water meadows (includes management for breeding and/or wintering waders/waterfowl)	266
Maintain upland heath/moorland	266
Reduce management intensity on permanent grasslands (several interventions at once)	266
Restore or create traditional water meadows	267
Add yellow rattle seed <i>Rhinanthus minor</i> to hay meadows	267
Create open patches or strips in permanent grassland	267
Employ areas of semi-natural habitat for rough grazing (includes salt marsh, lowland heath, bog, fen)	267
Exclude livestock from semi-natural habitat (including woodland)	268
Maintain wood pasture and parkland	268
Plant cereals for whole crop silage	268
Provide short grass for birds	268

Raise mowing height on grasslands	269
Restore or create upland heath/moorland	269
Restore or create wood pasture	269
Use mixed stocking	269
Use traditional breeds of livestock	270
Reduce grazing intensity on grassland (including seasonal removal of livestock)	270
Maintain rush pastures	270
Mark fencing to avoid bird mortality	270
Plant Brassica fodder crops (grazed in situ)	270
4.5 Threat: Residential and commercial development	271
Provide owl nest boxes (tawny owl, barn owl)	271
Maintain traditional farm buildings	271
Provide bat boxes, bat grilles, improvements to roosts	271
4.6 Threat: Agri-chemicals	272
Leave headlands in fields unsprayed (conservation headlands)	272
Reduce fertilizer, pesticide or herbicide use generally	273
Use organic rather than mineral fertilizers	273
Reduce chemical inputs in grassland management	273
Make selective use of spring herbicides	274
Provide buffer strips alongside water courses (rivers and streams)	274
Restrict certain pesticides	274
Buffer in-field ponds	274
4.7 Threat: Transport and service corridors	275
Manage land under power lines to benefit wildlife	275
4.8 Threat: Hunting and trapping (for pest control, food or sport)	276
Enforce legislation to protect birds against persecution	276
Provide 'sacrificial' grasslands to reduce the impact of wild geese on crops	276
Use scaring devices (e.g. gas guns) and other deterrents to reduce persecution of native species	277
Avoid use of lead shot	277
Use alerts to reduce grey partridge by-catch during shoots	277
4.9 Threat: Natural system modification	278
Raise water levels in ditches or grassland	278
Create scrapes and pools	279
Manage heather by swiping to simulate burning	279
Manage heather, gorse or grass by burning	279
Remove flood defence banks to allow inundation	279
Re-wet moorland	280

4.10 Threat: Invasive and other problematic species	281
Control predatory mammals and birds (foxes, crows, stoats and weasels)	281
Control bracken	282
Control invasive non-native plants on farmland (such as Himalayan balsam, Japanese knotweed)	282
Control mink	282
Control scrub	282
Control weeds without damaging other plants in conservation areas	283
Protect individual nests of ground-nesting birds	283
Provide medicated grit for grouse	283
Control grey squirrels	283
Erect predator-proof fencing around important breeding sites for waders	283
Manage wild deer numbers	283
Remove coarse fish	283
4.11 Threat: Education and awareness	284
Provide training for land managers, farmers and farm advisers	284
Provide specialist advice, assistance preparing conservation plans	284
5. SOME ASPECTS OF CONTROL OF FRESHWATER INVASIVE SPECIES	285
5.1 Threat: Invasive amphibians	287
5.1.1 American bullfrog <i>Lithobates catesbeiana</i>	287
Biological control using native predators	287
Direct removal of adults	288
Direct removal of juveniles	288
Dewatering	288
Application of a biocide	289
Biological control of facilitator species	289
Habitat manipulation	289
Collection of egg clutches	289
Fencing	289
Pond destruction	289
Public education	289
5.2 Threat: Invasive crustaceans	290
5.2.1 <i>Procambarus</i> spp. crayfish	290
Add chemicals to the water	290
Sterilization of males	291
Trapping and removal	291

Trapping combined with encouragement of predators	291
Create barriers	291
Food source removal	291
Encouraging predators	292
Draining the waterway	292
Relocate vulnerable crayfish	292
Remove the crayfish by electrofishing	292
6. SOME ASPECTS OF ENHANCING NATURAL PEST CONTROL	293
6.1 Reducing agricultural pollution	295
Alter the timing of insecticide use	295
Delay herbicide use	296
Incorporate parasitism rates when setting thresholds for insecticide use	297
Use pesticides only when pests or crop damage reach threshold levels	297
Convert to organic farming	298
6.2 All farming systems	300
Grow non-crop plants that produce chemicals that attract natural enemies	300
Use chemicals to attract natural enemies	301
Leave part of the crop or pasture unharvested or uncut	302
Plant new hedges	303
Use alley cropping	303
Use mass-emergence devices to increase natural enemy populations	304
6.3 Arable farming	305
Combine trap and repellent crops in a push-pull system	305
Use crop rotation in potato farming systems	306
Create beetle banks	307
Incorporate plant remains into the soil that produce weed-controlling chemicals	308
6.4 Perennial farming	310
Exclude ants that protect pests	310
Allow natural regeneration of ground cover beneath perennial crops	311
Isolate colonies of beneficial ants	312
6.5 Livestock farming and pasture	313
Grow plants that compete with damaging weeds	313
Delay mowing or first grazing date on pasture or grassland	314
Use grazing instead of cutting for pasture or grassland management	315
Use mixed pasture	315

7. ENHANCING SOIL FERTILITY	317
7.1 Reducing agricultural pollution	319
Change the timing of manure application	319
Reduce fertilizer, pesticide or herbicide use generally	320
7.2 All farming systems	321
Control traffic and traffic timing	321
Change tillage practices	322
Convert to organic farming	324
Plant new hedges	324
Change the timing of ploughing	325
7.3 Arable farming	326
Amend the soil using a mix of organic and inorganic amendments	327
Grow cover crops when the field is empty	327
Use crop rotation	328
Amend the soil with formulated chemical compounds	329
Grow cover crops beneath the main crop (living mulches) or between crop rows	330
Add mulch to crops	330
Amend the soil with fresh plant material or crop remains	331
Amend the soil with manures and agricultural composts	332
Amend the soil with municipal wastes or their composts	333
Incorporate leys into crop rotation	333
Retain crop residues	334
Amend the soil with bacteria or fungi	334
Amend the soil with composts not otherwise specified	335
Amend the soil with crops grown as green manures	335
Amend the soil with non-chemical minerals and mineral wastes	335
Amend the soil with organic processing wastes or their composts	335
Encourage foraging waterfowl	336
Use alley cropping	336
7.4 Livestock and pasture farming	337
Reduce grazing intensity	337
Restore or create low input grasslands	338

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](http://www.conservationevidence.com):

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

- 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%

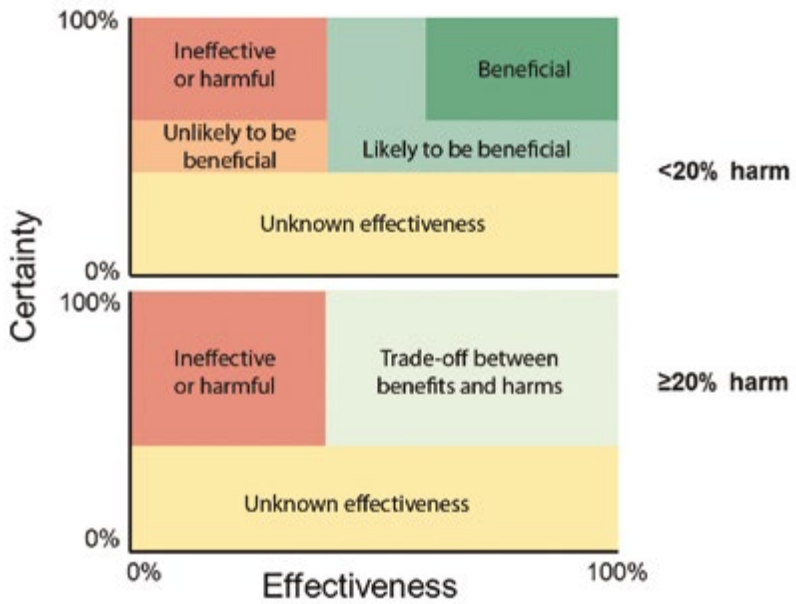


Figure 1. Categories of effectiveness based on a combination of effectiveness (the size of the benefit and harm) and certainty (the strength of the evidence). The top graph refers to interventions with harms <20% and the bottom graph to interventions with harms ≥20%.

1. AMPHIBIAN CONSERVATION

Rebecca K. Smith, Helen Meredith & William J. Sutherland

Expert assessors

Ariadne Angulo, Co-Chair of the Amphibian Specialist Group, Peru
Robert Brodman, Saint Joseph's College, Indiana, USA
Andrew Cunningham, Institute of Zoology, Zoological Society of London, UK
Jeff Dawson, Durrell Wildlife Conservation Trust, UK
Rob Gandola, University of Southampton, UK
Jaime García Moreno, IUCN, the Netherlands
Trent Garner, Institute of Zoology, Zoological Society of London, UK
Richard Griffiths, Durrell Institute of Conservation and Ecology, UK
Sergei Kuzmin, Russian Academy of Sciences
Michael Lanoo, Indiana University, USA
Michael Lau, WWF-Hong Kong
James Lewis, Amphibian Survival Alliance/Global Wildlife Conservation, USA
An Martel, Ghent University, Belgium
LeGrand Nono Gonwouo, Cameroon Herpetology-Conservation Biology Foundation
Deanna Olson, US Forest Service, USA
Timo Paasikunnas, Curator of Conservation at Helsinki Zoo, Finland
Frank Pasmans, Ghent University, Belgium
Silviu Petrovan, Froglife, UK
Carlos Martínez Rivera, Philadelphia Zoo, USA
Gonçalo Rosa, Institute of Zoology, Zoological Society of London, UK
David Sewell, Durrell Institute of Conservation and Ecology, UK
Rebecca Smith, Cambridge University, UK
Ben Tapley, Herpetology Department, Zoological Society of London, UK
Jeanne Tarrant, Endangered Wildlife Trust, South Africa
Karthikeyan Vasudevan, Wildlife Institute of India
Victor Wasonga, National Museums of Kenya
Ché Weldon, North-West University, South Africa
Sally Wren, Amphibian Specialist Group Programme Officer, New Zealand

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.

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 km² 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-profile 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.conservativevidence.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.conservativevidence.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.conservativevidence.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 establish 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>