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Cover image: A close up shot of the underside of a Dwarf Cavendish (*Musa acuminata*) by Ben Clough, CC BY-SA 3.0. Wikimedia http://commons.wikimedia.org/wiki/File:Dwarf_cavendish_leaf_2.jpg. Cover design: Heidi Coburn

10. SOME ASPECTS OF CONTROL OF FRESHWATER INVASIVE SPECIES

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Scope of assessment: for the control of 12 invasive freshwater species.

Assessed: American bullfrog and *Procambarus* spp. crayfish 2015; parrot's feather 2017; all other species 2016.

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 non-target native species. This was not assessed for some species in this chapter.

Potential impacts on non-target species should be considered carefully before implementing any control action.

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

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

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

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

10.1 Threat: Invasive plants

10.1.1 Parrot's feather *Myriophyllum aquaticum*

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling parrot's feather?	
Beneficial	• Chemical control using the herbicide 2,4-D
Likely to be beneficial	• Chemical control using the herbicide carfentrazone-ethyl • Chemical control using the herbicide triclopyr • Chemical control using the herbicide diquat • Chemical control using the herbicide endohall • Chemical control using other herbicides • Reduction of trade through legislation and codes of conduct
Trade-offs between benefit and harms	• Biological control using herbivores
Unknown effectiveness (limited evidence)	• Water level drawdown • Biological control using plant pathogens
No evidence found (no assessment)	• Mechanical harvesting or cutting • Mechanical excavation • Removal using water jets • Suction dredging and diver-assisted suction removal • Manual harvesting (hand-weeding) • Use of lightproof barriers • Dye application • Biological control using fungal-based herbicides • Use of salt

	• Decontamination / preventing further spread • Public education • Multiple integrated measures

Beneficial

Chemical control using the herbicide 2,4-D

Five laboratory studies (three replicated, controlled and two randomized, controlled) in the USA and Brazil and two replicated, randomized, field studies in Portugal reported that treatment with 2,4-D reduced growth, biomass or cover of parrot's feather. *Assessment: beneficial (effectiveness 80%; certainty 80%; harms 0%).*

https://www.conservationevidence.com/actions/1606

Likely to be beneficial

Chemical control using the herbicide carfentrazone-ethyl

Five laboratory studies (one replicated, controlled, before-and-after, three replicated, controlled and one randomized, controlled) in the USA reported that treatment with carfentrazone-ethyl reduced growth. *Assessment: likely to be beneficial (effectiveness 50%; certainty 40%; harms 5%).*

https://www.conservationevidence.com/actions/1676

Chemical control using the herbicide triclopyr

Three replicated, controlled laboratory studies in the USA and New Zealand reported that treatment with triclopyr reduced growth or that cover was lower than that of plants treated with glyphosate. One replicated, controlled field study and one replicated, before-and-after field study in New Zealand reported that cover was reduced after treatment with triclopyr but one of these studies reported that cover later increased to near pre-treatment levels. *Assessment: likely to be beneficial (effectiveness 60%; certainty 55%; harms 0%).*

https://www.conservationevidence.com/actions/1689

Chemical control using the herbicide diquat

Two replicated, controlled laboratory studies in the USA reported reduced growth after exposure to diquat. However, one replicated, randomized,

controlled field study in Portugal reported no reduction in biomass following treatment with diquat. *Assessment: likely to be beneficial (effectiveness 60%; certainty 40%; harms 0%).*

https://www.conservationevidence.com/actions/1680

Chemical control using the herbicide endohall

Two replicated, controlled laboratory studies in the USA and New Zealand reported a reduction in biomass after treatment with endothall. However, one replicated, controlled field study in New Zealand found that cover declined after treatment with endothall but later cover increased close to pre-treatment levels. *Assessment: likely to be beneficial (effectiveness 50%; certainty 40%; harms 0%).*

https://www.conservationevidence.com/actions/1681

Chemical control using other herbicides

One replicated, randomized, controlled field study in Portugal and one replicated, controlled, laboratory study in the USA reported reduced growth or vegetation cover after treatment with glyphosate. Two replicated, randomized, controlled laboratory studies (one of which was randomized) in the USA have found that the herbicide imazapyr reduced growth. Four replicated, controlled (one of which was randomized) laboratory studies in the USA and New Zealand reported reduced growth after treatment with the herbicides imazamox, flumioxazin, dichlobenil and florpyrauxifen-benzyl. Two replicated, controlled (one of which was randomized) field studies in Portugal and New Zealand reported a decrease in cover after treatment with dichlobenil followed by recovery. One replicated, randomized, controlled field study in Portugal reported reduced biomass after treatment with gluphosinate-ammonium. Three replicated, controlled laboratory studies in New Zealand and the USA found no reduction in growth after treatment with clopyralid, copper chelate or fluridone. *Assessment: likely to be beneficial (effectiveness 50%; certainty 40%; harms 0%).*

https://www.conservationevidence.com/actions/1699

Reduction of trade through legislation and codes of conduct

One randomized, before-and-after trial in the Netherlands reported that the implementation of a code of conduct reduced the trade of invasive aquatic plants banned from sale. One study in the USA found that despite a state-

wide trade ban on parrot's feather plants, these could still be purchased in some stores. *Assessment: likely to be beneficial (effectiveness 60%; certainty 45%; harms 0%).*

https://www.conservationevidence.com/actions/1604

Trade-off between benefit and harms

Biological control using herbivores

Two replicated, randomized studies in Argentina and the USA found that stocking with grass carp reduced the biomass or abundance of parrot's feather. However, one controlled laboratory study in Portugal found that grass carp did not reduce biomass or cover of parrot's feather. One field study in South Africa found that one *Lysathia* beetle species retarded the growth of parrot's feather. *Assessment: trade-offs between benefits and harms (effectiveness 50%; certainty 40%; harms 20%).*

https://www.conservationevidence.com/actions/1599

Unknown effectiveness (limited evidence)

Water level drawdown

One replicated, randomized, controlled laboratory study in the USA found that water removal to expose plants to drying during the summer led to lower survival of parrot's feather plants than water removal during winter. *Assessment: unknown effectiveness (effectiveness 60%; certainty 30%; harms 0%).*

https://www.conservationevidence.com/actions/1585

Biological control using plant pathogens

One study in South Africa found that exposure to a strain of the bacterium *Xanthomonas campestris* did not affect the survival of parrot's feather. *Assessment: unknown effectiveness (effectiveness 5%; certainty 10%; harms 0%).*

https://www.conservationevidence.com/actions/1601

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Mechanical harvesting or cutting

- Mechanical excavation
- Removal using water jets
- Suction dredging and diver-assisted suction removal
- Manual harvesting (hand-weeding)
- Use of lightproof barriers
- Dye application
- Biological control using fungal-based herbicides
- Use of salt
- Decontamination / preventing further spread
- Public education
- Multiple integrated measures

10.1.2 Floating pennywort *Hydrocotyle ranunculoides*

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling floating pennywort?	
Beneficial	• Chemical control using herbicides
Likely to be beneficial	• Flame treatment • Physical removal
Unknown effectiveness (limited evidence)	• Combination treatment using herbicides and physical removal
Unlikely to be beneficial	• Biological control using co-evolved, host-specific herbivores • Use of hydrogen peroxide
No evidence found (no assessment)	• Biological control using fungal-based herbicides • Biological control using native herbivores • Environmental control (e.g. shading, reduced flow, reduction of rooting depth, or dredging) • Excavation of banks • Public education • Use of liquid nitrogen

Beneficial

Chemical control using herbicides

A controlled, replicated field study in the UK found that the herbicide 2,4-D amine achieved almost 100% mortality of floating pennywort, compared with the herbicide glyphosate (applied without an adjuvant) which achieved negligible mortality. *Assessment: beneficial (effectiveness 80%; certainty 70%).*

https://www.conservationevidence.com/actions/1127

Likely to be beneficial

Flame treatment

A controlled, replicated study in the Netherlands found that floating pennywort plants were killed by a three second flame treatment with a three second repeat treatment 11 days later. *Assessment: likely to be beneficial (effectiveness 60%; certainty 50%).*

https://www.conservationevidence.com/actions/1131

Physical removal

Two studies, one in Western Australia and one in the UK, found physical removal did not completely eradicate floating pennywort. *Assessment: likely to be beneficial (effectiveness 40%; certainty 40%).*

https://www.conservationevidence.com/actions/1126

Unknown effectiveness (limited evidence)

Combination treatment using herbicides and physical removal

A before-and-after study in Western Australia found that a combination of cutting followed by a glyphosate chemical treatment, removed floating pennywort. *Assessment: unknown effectiveness (effectiveness 70%; certainty 35%).*

https://www.conservationevidence.com/actions/1128

Unlikely to be beneficial

Biological control using co-evolved, host-specific herbivores

A replicated laboratory and field study in South America found that the South American weevil fed on water pennywort but did not reduce the biomass. *Assessment: unlikely to be beneficial (effectiveness 20%; certainty 50%).*

https://www.conservationevidence.com/actions/1123

Use of hydrogen peroxide

A controlled, replicated study in the Netherlands found that hydrogen peroxide sprayed on potted floating pennywort plants at 30% concentration resulted in curling and transparency of the leaves but did not kill the plants. *Assessment: unlikely to be beneficial (effectiveness 10%; certainty 60%).*

https://www.conservationevidence.com/actions/1129

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Biological control using fungal-based herbicides
- Biological control using native herbivores
- Environmental control (e.g. shading, reduced flow, reduction of rooting depth, or dredging)
- Excavation of banks
- Public education
- Use of liquid nitrogen.

10.1.3 Water primrose *Ludwigia spp.*

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling water primrose?	
Likely to be beneficial	• Biological control using co-evolved, host specific herbivores • Chemical control using herbicides • Combination treatment using herbicides and physical removal

Unlikely to be beneficial	• Physical removal
No evidence found (no assessment)	• Biological control using fungal-based herbicides • Biological control using native herbivores • Environmental control (e.g. shading, altered flow, altered rooting depth, or dredging) • Excavation of banks • Public education • Use of a tarpaulin • Use of flame treatment • Use of hydrogen peroxide • Use of liquid nitrogen • Use of mats placed on the bottom of the water body

Likely to be beneficial

Biological control using co-evolved, host specific herbivores

A controlled, replicated study in China, found a flea beetle caused heavy feeding destruction to the prostrate water primrose. A before-and-after study in the USA found that the introduction of flea beetles to a pond significantly reduced the abundance of large-flower primrose-willow. *Assessment: likely to be beneficial (effectiveness 60%; certainty 50%).*

https://www.conservationevidence.com/actions/1135

Chemical control using herbicides

A controlled, replicated laboratory study in the USA found that the herbicide triclopyr TEA applied at concentrations of 0.25% killed 100% of young cultivated water primrose within two months. A before-and-after field study in the UK found that the herbicide glyphosate caused 97% mortality when mixed with a non-oil based sticking agent and 100% mortality when combined with TopFilm. A controlled, replicated, randomized study in Venezuela, found that use of the herbicide halosulfuron-methyl (Sempra) resulted in a significant reduction in water primrose coverage without apparent toxicity to rice plants. *Assessment: likely to be beneficial (effectiveness 80%; certainty 60%).*

https://www.conservationevidence.com/actions/1139

Combination treatment using herbicides and physical removal

A study in the USA found that application of glyphosate and a surface active agent called Cygnet-Plus followed by removal by mechanical means killed 75% of a long-standing population of water primrose. A study in Australia found that a combination of herbicide application, physical removal, and other actions such as promotion of native plants and mulching reduced the cover of Peruvian primrose-willow by 85–90%. *Assessment: likely to be beneficial (effectiveness 70%; certainty 55%).*

https://www.conservationevidence.com/actions/1140

Unlikely to be beneficial

Physical removal

A study in the USA found that hand pulling and raking water primrose failed to reduce its abundance at one site, whereas hand-pulling from the margins of a pond eradicated a smaller population of water primrose at a second site. *Assessment: unlikely to be beneficial (effectiveness 30%; certainty 50%).*

https://www.conservationevidence.com/actions/1138

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Biological control using fungal-based herbicides
- Biological control using native herbivores
- Environmental control (e.g. shading, reduced flow, reduction of rooting depth, or dredging)
- Excavation of banks
- Public education
- Use of a tarpaulin
- Use of flame treatment
- Use of hydrogen peroxide
- Use of liquid nitrogen
- Use of mats placed on the bottom of the waterbody.

10.1.4 Skunk cabbage *Lysichiton americanus*

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling skunk cabbage?	
Likely to be beneficial	• Chemical control using herbicides • Physical removal
No evidence found (no assessment)	• Biological control using co-evolved, host-specific herbivores • Biological control using fungal-based herbicides • Biological control using native herbivores • Combination treatment using herbicides and physical removal • Environmental control (e.g. shading, or promotion of native plants) • Public education • Use of a tarpaulin • Use of flame treatment • Use of hydrogen peroxide • Use of liquid nitrogen

Likely to be beneficial

Chemical control using herbicides

Two studies in the UK found that application of the chemical 2,4-D amine appeared to be successful in eradicating skunk cabbage stands. One of these studies also found glyphosate eradicated skunk cabbage. However, a study in the UK found that glyphosate did not eradicate skunk cabbage, but resulted in only limited reduced growth of plants. *Assessment: likely to be beneficial (effectiveness 60%; certainty 50%).*

https://www.conservationevidence.com/actions/1102

Physical removal

Two studies in Switzerland and the Netherlands, reported effective removal of recently established skunk cabbage plants using physical removal, one reporting removal of the entire stock within five years. A third study in

Germany reported that after four years of a twice yearly full removal programme, a large number of plants still needed to be removed each year. *Assessment: likely to be beneficial (effectiveness 65%; certainty 55%).*

https://www.conservationevidence.com/actions/1101

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Biological control using co-evolved, host-specific herbivores
- Biological control using fungal-based herbicides
- Biological control using native herbivores
- Combination treatment using herbicides and physical removal
- Environmental control (e.g. shading, or promotion of native plants)
- Public education
- Use of a tarpaulin
- Use of flame treatment
- Use of hydrogen peroxide
- Use of liquid nitrogen.

10.1.5 New Zealand pigmyweed *Crassula helmsii*

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling *Crassula helmsii*?	
Beneficial	• Chemical control using herbicides • Decontamination to prevent further spread
Likely to be beneficial	• Use lightproof barriers to control plants • Use salt water to kill plants
Unknown effectiveness (limited evidence)	• Use a combination of control measures
Unlikely to be beneficial	• Use dyes to reduce light levels • Use grazing to control plants • Use hot foam to control plants • Use hydrogen peroxide to control plants

No evidence found (no assessment)	• Alter environmental conditions to control plants (e.g. shading by succession, increasing turbidity, re-profiling or dredging) • Biological control using fungal-based herbicides • Biological control using herbivores • Bury plants • Dry out waterbodies • Physical control using manual/mechanical control or dredging • Plant other species to suppress growth • Public education • Surround with wire mesh • Use flame throwers • Use hot water • Use of liquid nitrogen

Beneficial

Chemical control using herbicides

Seven studies in the UK, including one replicated, controlled study, found that applying glyphosate reduced *Crassula helmsii*. Three out of four studies in the UK, including one controlled study, found that applying diquat or diquat alginate reduced or eradicated *C. helmsii*. One small trial found no effect of diquat on *C. helmsii* cover. One replicated, controlled study in the UK found dichlobenil reduced biomass of submerged *C. helmsii* but one small before-and-after study found no effect of dichlobenil on *C. helmsii*. A replicated, controlled study found that treatment with terbutryne partially reduced biomass of submerged *C. helmsii* and that asulam, 2,4-D amine and dalapon reduced emergent *C. helmsii*. *Assessment: beneficial (effectiveness 78%; certainty 75%).*

https://www.conservationevidence.com/actions/1279

Decontamination to prevent further spread

One controlled, replicated container trial in the UK found that submerging *Crassula helmsii* fragments in hot water led to higher mortality than drying out plants or a control. *Assessment: beneficial (effectiveness 80%; certainty 70%).*

https://www.conservationevidence.com/actions/1308

Likely to be beneficial

Use lightproof barriers to control plants

Five before-and-after studies in the UK found that covering with black sheeting or carpet eradicated or severely reduced cover of *Crassula helmsii*. *Assessment: likely to be beneficial (effectiveness 65%; certainty 50%).*

https://www.conservationevidence.com/actions/1294

Use salt water to kill plants

Two replicated, controlled container trials and two before-and-after field trials in the UK found that seawater eradicated *Crassula helmsii*. *Assessment: likely to be beneficial (effectiveness 80%; certainty 45%).*

https://www.conservationevidence.com/actions/1288

Unknown effectiveness (limited evidence)

Use a combination of control methods

One before-and-after study in the UK found that covering *Crassula helmsii* with carpet followed by treatment with glyphosate killed 80% of the plant. *Assessment: unknown effectiveness (effectiveness 75%; certainty 30%).*

https://www.conservationevidence.com/actions/1313

Unlikely to be beneficial

Use dyes to reduce light levels

One replicated, controlled study in the UK found that applying aquatic dye, along with other treatments, did not reduce cover of *Crassula helmsii*. *Assessment: unlikely to be beneficial (effectiveness 0%; certainty 53%).*

https://www.conservationevidence.com/actions/1293

Use grazing to control plants

One of two replicated, controlled studies in the UK found that excluding grazing reduce abundance and coverage of *Crassula helmsii*. The other study found that ungrazed areas had higher coverage of *C. helmsii* than grazed plots. *Assessment: unlikely to be beneficial (effectiveness 23%; certainty 43%).*

https://www.conservationevidence.com/actions/1301

Use hot foam to control plants

One replicated, controlled study in the UK found that treatment with hot foam, along with other treatments, did not control *Crassula helmsii*. A before-and-after study in the UK found that treatment with hot foam partially destroyed *C. helmsii*. *Assessment: unlikely to be beneficial (effectiveness 20%; certainty 50%).*

https://www.conservationevidence.com/actions/1286

Use hydrogen peroxide to control plants

One controlled tank trial in the UK found that hydrogen peroxide did not control *Crassula helmsii*. *Assessment: unlikely to be beneficial (effectiveness 0%; certainty 50%).*

https://www.conservationevidence.com/actions/1281

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Alter environmental conditions to control plants (e.g. shading by succession, increasing turbidity, re-profiling or dredging)
- Biological control using fungal-based herbicides
- Biological control using herbivores
- Bury plants
- Dry out waterbodies
- Physical control using manual/mechanical control or dredging
- Plant other species to suppress growth
- Public education
- Surround with wire mesh
- Use flame throwers
- Use hot water
- Use of liquid nitrogen.

10.2 Threat: Invasive molluscs

10.2.1 Asian clams

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling Asian clams?	
Beneficial	• Add chemicals to the water • Change salinity of the water • Mechanical removal
Likely to be beneficial	• Change temperature of water • Clean equipment • Use of gas-impermeable barriers
Unlikely to be beneficial	• Reduce oxygen in water
No evidence found (no assessment)	• Change pH of water • Drain the invaded waterbody • Exposure to disease-causing organisms • Exposure to parasites • Hand removal • Public awareness and education

Beneficial

Add chemicals to the water

Two replicated laboratory studies and one controlled, replicated field study found that chlorine, potassium and copper killed Asian clams. Increasing

chemical concentration and water temperature killed more clams in less time. One controlled field trial achieved 80% and 100% mortality of Asian clams using encapsulated control agents (SB1000 and SB2000 respectively) in irrigation systems. *Assessment: beneficial (effectiveness 75%; certainty 70%).*

https://www.conservationevidence.com/actions/1118

Change salinity of water

A controlled, replicated laboratory study from the USA found that exposure to saline water killed all Asian clams. *Assessment: beneficial (effectiveness 65%; certainty 68%).*

https://www.conservationevidence.com/actions/1115

Mechanical removal

A controlled before-and-after study from North America found suction dredging of sediment reduced an Asian clam population by 96%, and these effects persisted for a year. A replicated, controlled, before-and-after field trial in Ireland showed that three types of dredges were effective at removing between 74% and >95% of the Asian clam biomass. *Assessment: beneficial (effectiveness 80%; certainty 78%).*

https://www.conservationevidence.com/actions/1120

Likely to be beneficial

Change temperature of water

A controlled laboratory study from the USA found that exposure to water at temperatures of 37°C and 36°C killed all Asian clams within 2 and 4 days, respectively. *Assessment: likely to be beneficial (effectiveness 60%; certainty 55%).*

https://www.conservationevidence.com/actions/1116

Clean equipment

A field study from Portugal found that mechanical removal, followed by regular cleaning and maintenance of industrial pipes at a power plant permanently removed an Asian clam population. A field study from Portugal found that adding a sand filter to a water treatment plant reduced an Asian clam population. *Assessment: likely to be beneficial (effectiveness 75%; certainty 50%).*

https://www.conservationevidence.com/actions/1119

Use of gas-impermeable barriers

One controlled study from North America found that placing gas impermeable fabric barriers on a lake bottom (several small and one large area) reduced populations of Asian clams. *Assessment: likely to be beneficial (effectiveness 78%; certainty 60%).*

https://www.conservationevidence.com/actions/1117

Unlikely to be beneficial

Reduce oxygen in water

A controlled laboratory study from the USA found that Asian clams were not susceptible to low oxygen levels in the water. *Assessment: unlikely to be beneficial (effectiveness 10%; certainty 50%).*

https://www.conservationevidence.com/actions/1113

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Change pH of water
- Drain the invaded waterbody
- Exposure to disease-causing organisms
- Exposure to parasites
- Hand removal
- Public awareness and education.

10.3 Threat: Invasive crustaceans

10.3.1 Ponto-Caspian gammarids

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling Ponto-Caspian gammarids?	
Likely to be beneficial	• Change salinity of the water • Change water temperature • Dewatering (drying out) habitat • Exposure to parasites
Unlikely to be beneficial	• Add chemicals to water • Change water pH • Control movement of gammarids
No evidence found (no assessment)	• Biological control using predatory fish • Cleaning equipment • Exchange ballast water • Exposure to disease-causing organisms

Likely to be beneficial

Change salinity of the water

One of two replicated studies, including one controlled study, in Canada and the UK found that increasing the salinity level of water killed the majority

of invasive shrimp within five hours. One found that increased salinity did not kill invasive killer shrimp. *Assessment: likely to be beneficial (effectiveness 40%; certainty 50%).*

https://www.conservationevidence.com/actions/1091

Change water temperature

A controlled laboratory study from the UK found that heating water in excess of 40°C killed invasive killer shrimps. *Assessment: likely to be beneficial (effectiveness 80%; certainty 50%).*

https://www.conservationevidence.com/actions/1092

Dewatering (drying out) habitat

A replicated, controlled laboratory study from Poland found that lowering water levels in sand (dewatering) killed three species of invasive freshwater shrimp, although one species required water content levels of 4% and below before it was killed. *Assessment: likely to be beneficial (effectiveness 60%; certainty 50%).*

https://www.conservationevidence.com/actions/1094

Exposure to parasites

A replicated, controlled experimental study in Canada found that a parasitic mould reduced populations of freshwater invasive shrimp. *Assessment: likely to be beneficial (effectiveness 50%; certainty 50%).*

https://www.conservationevidence.com/actions/1089

Unlikely to be beneficial

Add chemicals to water

A controlled laboratory study from the UK found that four of nine substances added to freshwater killed invasive killer shrimp, but were impractical (iodine solution, acetic acid, Virkon S and sodium hypochlorite). Five substances did not kill invasive killer shrimp (methanol, citric acid, urea, hydrogen peroxide and sucrose). *Assessment: unlikely to be beneficial (effectiveness 35%; certainty 60%).*

https://www.conservationevidence.com/actions/1095

Change water pH

A controlled laboratory study from the UK found that lowering the pH of water did not kill invasive killer shrimp. *Assessment: unlikely to be beneficial (effectiveness 0%; certainty 50%).*

https://www.conservationevidence.com/actions/1093

Control movement of gammarids

Two replicated studies, including one controlled study, in the USA and UK found that movements of invasive freshwater shrimp slowed down or were stopped when shrimp were placed in water that had been exposed to predatory fish or was carbonated. *Assessment: likely to be beneficial (effectiveness 20%; certainty 40%).*

https://www.conservationevidence.com/actions/1088

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Biological control using predatory fish
- Cleaning equipment
- Exchange ballast water
- Exposure to disease-causing organisms.

10.3.2 *Procambarus* spp. crayfish

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling *Procambarus* spp. crayfish?	
Likely to be beneficial	• Add chemicals to the water • Sterilization of males • Trapping and removal • Trapping combined with encouragement of predators
Unknown effectiveness (limited evidence)	• Create barriers

Unlikely to be beneficial	• Encouraging predators
No evidence found (no assessment)	• Draining the waterway • Food source removal • Relocate vulnerable crayfish • Remove the crayfish by electrofishing

Likely to be beneficial

Add chemicals to the water

One replicated study in Italy found that natural pyrethrum at concentrations of 0.05 mg/l and above was effective at killing red swamp crayfish both in the laboratory and in a river, but not in drained burrows. *Assessment: likely to be beneficial (effectiveness 80%; certainty 50%; harms 0%).*

https://www.conservationevidence.com/actions/1036

Sterilization of males

One replicated laboratory study from Italy found that exposing male red swamp crayfish to X-rays reduced the number of offspring they produced. *Assessment: likely to be beneficial (effectiveness 50%; certainty 40%; harms 0%).*

https://www.conservationevidence.com/actions/1032

Trapping and removal

One controlled, replicated study from Italy found that food (tinned meat) was a more effective bait in trapping red swamp crayfish, than using pheromone treatments or no bait (control). Baiting with food increased trapping success compared to trapping without bait. *Assessment: likely to be beneficial (effectiveness 40%; certainty 60%; harms 0%).*

https://www.conservationevidence.com/actions/1029

Trapping combined with encouragement of predators

One before-and-after study in Switzerland and a replicated, paired site study from Italy found that a combination of trapping and predation was more effective at reducing red swamp crayfish populations than predation alone. *Assessment: likely to be beneficial (effectiveness 50%; certainty 50%; harms 0%).*

https://www.conservationevidence.com/actions/1031

Unknown effectiveness (limited evidence)

Create barriers

One before-and-after study from Italy found that the use of concrete dams across a stream was effective at containing spread of the population upstream. *Assessment: unknown effectiveness (effectiveness 30%; certainty 30%; harms 0%).*

https://www.conservationevidence.com/actions/1037

Unlikely to be beneficial

Encouraging predators

Two replicated, controlled studies in Italy found that eels fed on the red swamp crayfish and reduced population size. One replicated, controlled study found that pike predated red swamp crayfish. *Assessment: unlikely to be beneficial (effectiveness 30%; certainty 60%; harms 0%).*

https://www.conservationevidence.com/actions/1030

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Draining the waterway
- Food source removal
- Relocate vulnerable crayfish
- Remove the crayfish by electrofishing.

10.4 Threat: Invasive fish

10.4.1 Brown and black bullheads

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling brown and black bullheads?	
Beneficial	• Application of a biocide
Likely to be beneficial	• Netting
No evidence found (no assessment)	• Biological control of beneficial species • Biological control using native predators • Changing salinity • Changing pH • Draining invaded waterbodies • Electrofishing • Habitat manipulation • Increasing carbon dioxide concentrations • Public education • Trapping using sound or pheromonal lures • Using a combination of netting and electrofishing • UV radiation

Beneficial

Application of a biocide

Two studies in the UK and USA found that rotenone successfully eradicated black bullhead. *Assessment: beneficial (effectiveness 80%; certainty 80%).*

https://www.conservationevidence.com/actions/1050

Likely to be beneficial

Netting

A replicated study in a nature reserve in Belgium found that double fyke nets could be used to significantly reduce the population of large brown bullheads. *Assessment: likely to be beneficial (effectiveness 55%; certainty 55%).*

https://www.conservationevidence.com/actions/1051

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Biological control of beneficial species
- Biological control using native predators
- Changing salinity
- Changing pH
- Draining invaded waterbodies
- Electrofishing
- Habitat manipulation
- Increasing carbon dioxide concentrations
- Public education
- Trapping using sound or pheromonal lures
- Using a combination of netting and electrofishing
- UV radiation.

10.4.2 Ponto-Caspian gobies

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling Ponto-Caspian gobies?	
Beneficial	• Changing salinity
Likely to be beneficial	• Use of barriers to prevent migration
No evidence found (no assessment)	• Application of a biocide • Biological control of beneficial species • Biological control using native predators • Changing pH • Draining invaded waterbodies • Electrofishing • Habitat manipulation • Increasing carbon dioxide concentrations • Netting • Public education • Trapping using visual, sound and pheromonal lures • Using a combination of netting and electrofishing • UV radiation

Beneficial

Changing salinity

A replicated controlled laboratory study in Canada found 100% mortality of round gobies within 48 hours of exposure to water of 30% salinity. *Assessment: beneficial (effectiveness 90%; certainty 75%).*

https://www.conservationevidence.com/actions/1072

Likely to be beneficial

Use of barriers to prevent migration

A controlled, replicated field study in the USA found that an electrical barrier prevented movement of round gobies across it, and that increasing electrical pulse duration and voltage increased the effectiveness of the barrier. *Assessment: likely to be beneficial (effectiveness 50%; certainty 45%).*

https://www.conservationevidence.com/actions/1074

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Application of a biocide
- Biological control of beneficial species
- Biological control using native predators
- Changing pH
- Draining invaded waterbodies
- Electrofishing
- Habitat manipulation
- Increasing carbon dioxide concentrations
- Netting
- Public education
- Trapping using visual, sound and pheromonal lures
- Using a combination of netting and electrofishing
- UV radiation.

10.5 Threat: Invasive reptiles

10.5.1 Red-eared terrapin *Trachemys scripta*

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling red-eared terrapin?	
Likely to be beneficial	• Direct removal of adults
Unlikely to be beneficial	• Application of a biocide
No evidence found (no assessment)	• Biological control using native predators • Draining invaded waterbodies • Public education • Search and removal using sniffer dogs

Likely to be beneficial

Direct removal of adults

Two studies, a replicated study from Spain using Aranzadi turtle traps, and an un-replicated study in the British Virgin Islands using sein netting, successfully captured but did not eradicate red-eared terrapin populations. *Assessment: likely to be beneficial (effectiveness 40%; certainty 50%).*

https://www.conservationevidence.com/actions/1055

Unlikely to be beneficial

Application of a biocide

A replicated, controlled laboratory study in the USA, found that application of glyphosate to the eggs of red-eared terrapins reduced hatching success to 73% but only at the highest experimental concentration of glyphosate and a surface active agent. *Assessment: unlikely to be beneficial (effectiveness 15%; certainty 50%).*

https://www.conservationevidence.com/actions/1059

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Biological control using native predators
- Draining invaded waterbodies
- Public education
- Search and removal using sniffer dogs.

10.6 Threat: Invasive amphibians

10.6.1 American bullfrog *Lithobates catesbeiana*

Based on the collated evidence, what is the current assessment of the effectiveness of interventions for controlling American bullfrogs?	
Likely to be beneficial	• Biological control using native predators • Direct removal of adults • Direct removal of juveniles
Unknown effectiveness (limited evidence)	• Application of a biocide
No evidence found (no assessment)	• Biological control of co-occurring beneficial species • Collection of egg clutches • Draining ponds • Fencing • Habitat modification • Pond destruction • Public education

Likely to be beneficial

Biological control using native predators

One replicated, controlled study conducted in northeast Belgium found the introduction of the northern pike led to a strong decline in bullfrog tadpole numbers. *Assessment: likely to be beneficial (effectiveness 70%; certainty 40%; harms 0%).*

https://www.conservationevidence.com/actions/1039

Direct removal of adults

One replicated study in Belgium found catchability of adult bullfrogs in small shallow ponds using a double fyke net to be very low. One small study in the USA found that adult bullfrogs can be captured overnight in a single trap floating on the water surface. One replicated, controlled study in the USA found that bullfrog populations rapidly rebounded following intensive removal of the adults. One study in France found a significant reduction in the number of recorded adults and juveniles following the shooting of metamorphosed individuals before reproduction, when carried out as part of a combination treatment. *Assessment: likely to be beneficial (effectiveness 50%; certainty 70%; harms 0%).*

https://www.conservationevidence.com/actions/1045

Direct removal of juveniles

One replicated study in Belgium found double fyke nets were effective in catching bullfrog tadpoles in small shallow ponds. One study in France found a significant reduction in the number of recorded adults and juveniles following the removal of juveniles by trapping, when carried out as part of a combination treatment. *Assessment: likely to be beneficial (effectiveness 70%; certainty 60%; harms 0%).*

https://www.conservationevidence.com/actions/1046

Unknown effectiveness (limited evidence)

Application of a biocide

One replicated, controlled study in the USA reported a number of chemicals killed American bullfrogs, including caffeine (10% solution), chloroxylenol (5% solution), and a combined treatment of Permethrin (4.6% solution) and Rotenone (1% solution). *Assessment: unknown effectiveness (effectiveness 50%; certainty 20%; harms 0%).*

https://www.conservationevidence.com/actions/1048

No evidence found (no assessment)

We have captured no evidence for the following interventions:

- Biological control of co-occurring beneficial species
- Collection of egg clutches
- Draining ponds
- Fencing
- Habitat modification
- Pond destruction
- Public education.