1st Edition

A manual for the management of vertebrate invasive alien species of Union concern,

incorporating animal welfare

Disclaimer:

This document has been drafted within the framework of the contract No. 07.027746/2019/812504/SER/ENV.D.2. "Identification, Assessment, Sharing and Dissemination of Best Practices for Humane Management of Invasive Alien Species". The information and views set out in this document may not be comprehensive and do not necessarily reflect the official opinion of the Commission, IUCN, APHA, Eurogroup for Animals, EAZA, Newcastle University, or EARS. The Commission, or any of the project consortium organisations, do not guarantee the accuracy of the data included in this document. Neither the Commission nor IUCN or any person acting on the Commission's or IUCN's behalf, including any authors or contributors of the document themselves, may be held responsible for the use which may be made of the information contained therein. Reproduction is authorised provided the source is acknowledged.

Feedback: Comments which could support improvement of this document are welcome. Please send your comments by e-mail to ENV-IAS@ec.europa.eu

Recommended citation: Smith, K.G., Nunes, A.L., Aegerter, J., Baker, S.E., Di Silvestre, I., Ferreira, C.C., Griffith, M., Lane, J., Muir, A., Binding, S., Broadway, M., Robertson, P., Scalera, R., Adriaens, T., Åhlén, P-A., Aliaga, A., Baert, K., Bakaloudis, D.E., Bertolino, S., Briggs, L., Cartuyvels, E., Dahl, F., D'hondt, B., Eckert, M., Gethöffer, F., Gojdičová, E., Huysentruyt, F., Jelić, D., Lešová, A., Lužnik, M., Moreno, L., Nagy, G., Poledník, L., Preda, C., Skorupski, J., Telnov, D., Trichkova, T., Verreycken, H. and Vucić, M. (2022). A manual for the management of vertebrate invasive alien species of Union concern, incorporating animal welfare. 1st Edition. Technical report prepared for the European Commission within the framework of the contract no. 07.027746/2019/812504/SER/ENV.D.2.

Front cover photos: © Stanze CC BY-SA 2.0 (top), Dennis Irrgang CC BY 2.0 (bottom left), © Seotaro CC BY-SA 3.0 (bottom centre), © Budak CC BY-NC-ND 2.0 (bottom right)

Design and layout: Imre Sebestyén, Unit Graphics

A manual for the management of vertebrate invasive alien species of Union concern,

incorporating animal welfare

Contents

1. Introduction

1.1. Project overview

This manual has been produced through the European Commission (EC) service contract '*Identification, Assessment, Sharing and Dissemination of Best Practices for Humane Management of Invasive Alien Species*' (07.027746/2019/812504/SER/ENV.D.2.).

The aim of this project was to provide support for the management of vertebrate invasive alien species (vertebrate IAS), through lethal or non-lethal measures, including assessing their welfare implications, in order to strengthen the application of Regulation (EU) 1143/2014 on invasive alien species.

We have collected information on the feasible management measures for the 22 invasive alien vertebrate species of Union concern listed as of December 2021 (**Box 1**) with a view to eradicating, controlling and/or containing their populations in order to minimise their impact on biodiversity and related ecosystem services. These measures have been assessed in terms of their costs and effectiveness, welfare impacts (e.g. sparing any avoidable pain, distress or suffering) and other possible positive or negative side-effects (e.g. on other invasive alien species, on non-targeted native species, on the environment or on human health).

Box 1. The 22 vertebrate IAS of Union concern

Mammals:
Callosciurus erythraeus, Pallas' squirrel
Herpestes javanicus (=*H. auropunctatus*), Small Indian mongoose
Muntiacus reevesi, Muntjac deer
Myocastor coypus, Coypu
Nasua nasua, Coati
Nyctereutes procyonoides, Raccoon dog
Ondatra zibethicus, Muskrat
Procyon lotor, Raccoon
Sciurus carolinensis, Grey squirrel
Sciurus niger, Fox squirrel
Tamias sibiricus, Siberian chipmunk

Birds:
Acridotheres tristis, Common myna
Alopochen aegyptiaca, Egyptian goose
Corvus splendens, Indian house crow
Oxyura jamaicensis, Ruddy duck
Threskiornis aethiopicus, Sacred ibis

Amphibians and reptiles:
Lithobates catesbeianus, North-American bullfrog
Trachemys scripta, Red-eared, yellow-bellied and Cumberland sliders

Fishes:
Lepomis gibbosus, Pumpkinseed
Perccottus glenii, Amur sleeper
Plotosus lineatus, Striped eel catfish
Pseudorasbora parva, Stone moroko

Through a series of online technical workshops (**Table 1**) and additional engagement activities these assessments have been reviewed by experts from a range of stakeholder groups across the European Union, including from national authorities, academia, NGOs and practitioners in the field. Through these engagement activities, legislation regarding the management of IAS of Union concern within Member States, and any restrictions or bans on their application have also been identified.

The final 'management measure assessments' are presented in full in **Appendices 1 - 32**, and the information on legislation for each Member State can be found in the 'regional conditions' **Appendices 34 - 41**.

Table 1. Regional technical workshops. Regions approximately defined taking into account EU biogeographic regions (version EEA, 2016).

Workshop region	Member States included	Dates
Alpine	Austria, Slovakia , Slovenia (plus Liechtenstein)	10 & 11 June 2021
Atlantic	Belgium, France, Ireland, Netherlands (plus UK)	28 & 29 April 2021
Black Sea, Steppic & Continental (EAST)	Bulgaria, Romania	23 & 24 March 2021
Boreal	Estonia, Finland, Latvia, Lithuania, Sweden	25 & 26 March 2021
Continental (CENTRAL) & Pannonian	Croatia, Czechia, Hungary, Poland	12 & 13 May 2021
Continental (WEST)	Denmark, Germany, Luxembourg	5 & 6 May 2021
Mediterranean (EAST)	Cyprus, Greece	8 & 9 June 2021
Mediterranean (WEST)	Italy, Malta, Portugal, Spain	19 & 20 May 2021

Non-EU countries in brackets

1.1.1. Project consortium

The elaboration of this manual has been led by the International Union for Conservation of Nature (IUCN), working closely with the UK Animal and Plant Health Agency (APHA), European Association of Zoos and Aquaria (EAZA), Eurogroup for Animals, European Alliance of Rescue Centres and Sanctuaries (EARS), Newcastle University, and the IUCN Species Survival Commission Invasive Species Specialist Group (IUCN SSC ISSG). Information on each of the project partners is presented below.

1.2. Overview of relevant requirements of the EU IAS Regulation

Regulation (EU) 1143/2014 on invasive alien species (IAS) (hereafter 'IAS Regulation') came into force in January 2015. It establishes a European framework for addressing the threats posed by IAS, and includes dedicated articles on the prevention, early detection and rapid eradication, and management of IAS included on a Union List (see **Figure 1** infographic). As of 2019, when the project started, the Union List included 66 species (also known as IAS of Union concern), 22 of which vertebrates (included in this Manual). In 2022, the Union list was updated to include 22 more species, 10 of which vertebrates (not included in this Manual).

Member States need to carry out the following measures with regard to species on the Union list: (1) prevention, (2) early detection and rapid eradication of new invasions, and (3) management of IAS that are already widely spread.

The management of IAS included on the Union List raises concerns for animal welfare, especially as measures taken can impact large numbers of animals for sustained periods of time. There is an increasing public concern for invasive alien animals as sentient beings, and, more generally, an increasing interest from civil society in the humane treatment of animals.

The requirements of the EU IAS Regulation explicitly relevant to the application of measures for the rapid eradication and management of IAS on the Union List and their considerations for animal welfare are outlined in **Box 2**. Based on these requirements, it is up to individual Member States to select management measures that suit their own specific circumstances. However, it would be useful to provide guidance in order to support Member States in making these choices. Inappropriate measures could lead to unnecessary animal suffering, a lack of public acceptance and failure to achieve the objectives of the IAS Regulation. This manual aims to provide such guidance.

Box 2. The requirements of the EU IAS Regulation relevant to the rapid eradication and management of IAS of Union concern and their considerations for animal welfare

Preamble

Recital 25. Management measures should avoid any adverse impact on the environment as well as on human health. Eradicating and managing some animal invasive alien species, while necessary in some cases, *may induce pain, distress, fear or other forms of suffering to the animals, even when using the best available technical means*. For that reason, Member States and any operator involved in the eradication, control or containment of invasive alien species should *take the necessary measures to spare avoidable pain, distress and suffering of animals during the process, taking into account as far as possible the best practices in the field,* for example the Guiding Principles on Animal Welfare developed by the World Organisation for Animal Health. Non-lethal methods should be considered and any action taken should minimise the impact on non-targeted species.

Article 17. Rapid eradication at an early stage of invasion

1. After early detection … Member States shall apply eradication measures ….

2. When applying eradication measures, Member States shall ensure that the methods used are effective in achieving the complete and permanent removal of the population of the invasive alien species concerned, with due regard to human health and the environment, especially non-targeted species and their habitats, and *ensuring that animals are spared any avoidable pain, distress or suffering*.

Article 19. Management measures

1. […] Member States shall have in place effective management measures for those invasive alien species of Union concern which the Member States have found to be widely spread on their territory, so that their impact on biodiversity, the related ecosystem services, and, where applicable, on human health or the economy are minimised.

   Those management measures shall be proportionate to the impact on the environment and appropriate to the specific circumstances of the Member States, be based on an analysis of costs and benefits and also include, as far as is feasible, the restoration measures referred to in Article 20. They shall be prioritised based on the risk evaluation and their cost effectiveness.

2. The management measures shall consist of lethal or non-lethal physical, chemical or biological actions aimed at the eradication, population control or containment of a population of an invasive alien species. Where appropriate, management measures shall include actions applied to the receiving ecosystem aimed at increasing its resilience to current and future invasions. The commercial use of already established invasive alien species may be temporarily allowed as part of the management measures aimed at their eradication, population control or containment, under strict justification and provided that all appropriate controls are in place to avoid any further spread.

3. When applying management measures and selecting methods to be used, Member States shall have due regard to human health and the environment, especially non-targeted species and their habitats, and shall ensure that, *when animals are targeted, they are spared any avoidable pain, distress or suffering*, without compromising the effectiveness of the management measures.

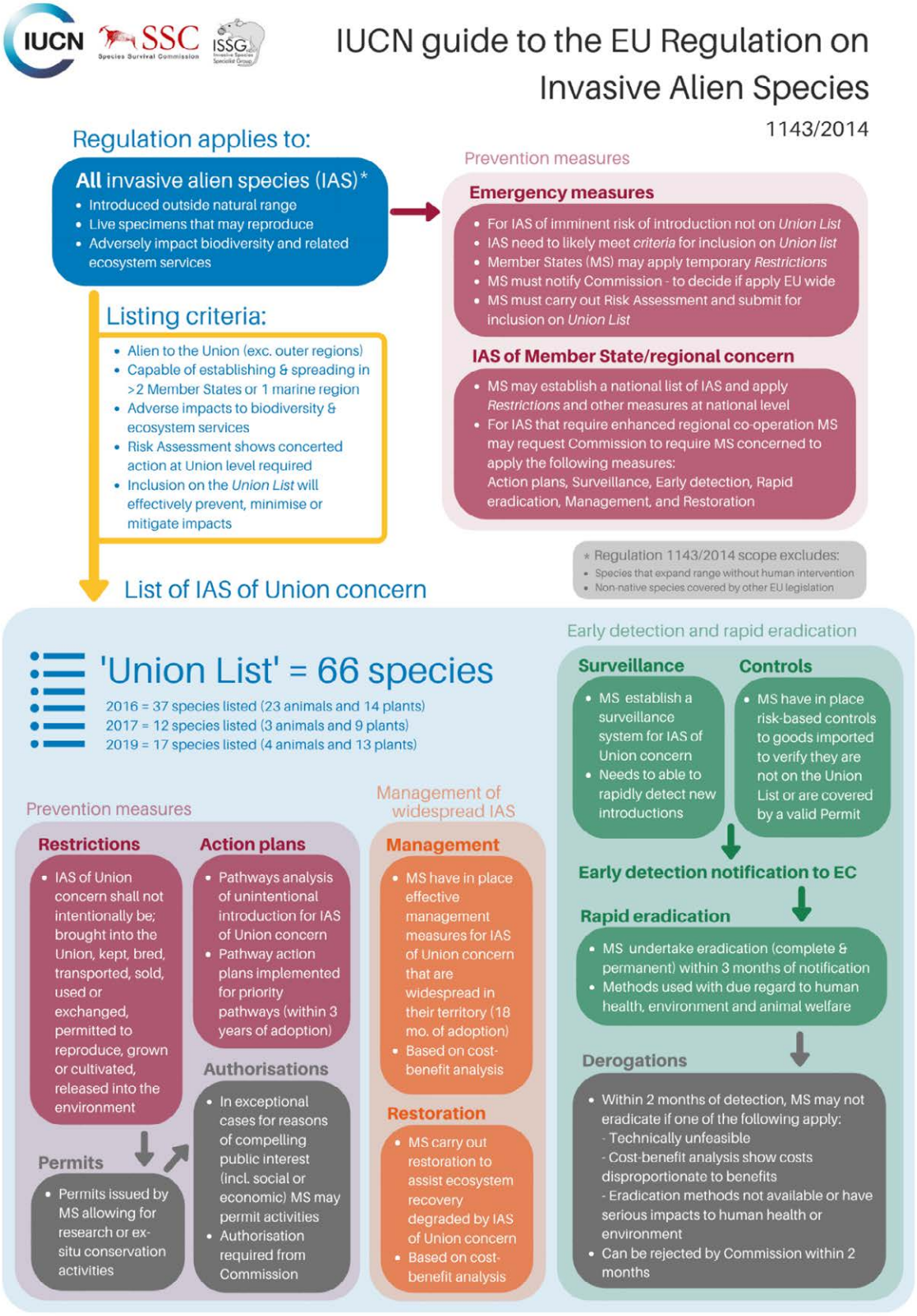


Figure 1. Key provisions of the EU IAS Regulation

Source: IUCN

1.3. Identification of measures and their assessment

1.3.1. Identification of all feasible measures

Feasible lethal and non-lethal measures that are or could be potentially applied to manage the 22 vertebrate IAS of Union concern have been identified through the expertise, knowledge and resources of the project partners, and additional literature searches.

1.3.2. Measures selected

For a measure to be included in this manual, it needed to pass a set of criteria that focused on selecting measures that were *feasible* (i.e. legal and appropriate), and [potentially] applied for relevant management objectives (**Box 3**). A detailed justification of the initial feasibility criteria, which is based on a framework of minimum welfare standards, is provided in **Section 2.3**.

Box 3. Criteria for selection of measures to be included in the manual

Criterion 1. Initial 'feasibility' criteria

All measures need to be:

- Legal in most EU Member States, based on readily available information.
- Considered as an 'appropriate' part of a modern IAS management programme (i.e. still in use, or likely to be used to manage IAS).

Criterion 2. Management objectives

All measures need to be [potentially] applied for the following management objectives:

- ***Rapid eradication*** = Complete and permanent removal of a population of IAS by lethal or non-lethal means (Article 3(13)). Applied to IAS of Union concern at an early stage of invasion, after an early detection of a new occurrence (cf. Article 17).
- ***Eradication*** = Complete and permanent removal of a population of IAS by lethal or non-lethal means (Article 3(13)). Applied to IAS of Union concern once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19).
- ***Control*** = Any lethal or non-lethal action applied to a population of IAS, … with the aim of keeping the number of individuals of a population of the IAS as low as possible, so that, while not being able to eradicate the species, its invasive capacity and adverse impact on biodiversity, the related ecosystem services, on human health or the economy, are minimised (Article 3(14)). Applied to IAS of Union concern, once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19).
- ***Containment*** = Creating barriers which minimises the risk of a population of an IAS dispersing and spreading beyond the invaded area (Article 3(15)). Applied to IAS of Union concern once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19).

During screening of the measures identified against the feasibility criteria, only one measure '*(using) hunting dogs to kill*' was removed, as it is illegal in many EU Member States and is also not considered to be an appropriate part of a modern day IAS management programme. However, it is important to note a number of measures have been included in this manual that have 'types' that are illegal or at least not currently authorised/approved for use in the EU. For example, within the '*Neck-hold traps and snares*' measure, leg-hold traps with sprung jaws are discussed; however, they are illegal in the EU (Council Regulation (EEC) No 3254/91) due to welfare concerns. Similarly, under '*Chemical treatment of the habitat*', certain chemical substances (e.g. rotenone) are currently not approved for use in the EU.

Additional measures were excluded under the secondary criteria on management objectives.

Some were measures used for detection alone, and some were used only for other objectives (e.g. to exclude animals from sensitive areas). These measures are briefly discussed in **Section 3**, focusing on their potential effectiveness and implications for animal welfare. An exception has been given to the measure '*Judas animals*' (i.e., an animal taken from captivity or captured from the wild and used to locate remnant individual animals or groups of feral animals in low-density populations), which is technically used for detection only. However, it does have potential welfare implications itself and is always integrated with measures used to remove animals from the wild and, therefore, is included in this manual.

Tables 2a and **2b** present the final measures identified, along with those that failed to pass the selection criteria in Box 3. They have been divided into two groups:

1. **Table 2a**. Measures used to restrain, capture and/or remove (kill/sterilise) in the field.

2. **Table 2b**. Measures used to remove (dispatch/sterilise/captivity) an individual once captured.

Table 2a. Measures to restrain, capture and/or remove in the field identified for assessment

Category	Measure name	Lethality	Selection criteria (Box 3)
Biological control	Native predators	Lethal	Pass
Habitat manipulation	Aquatic barriers	Both	Pass
Habitat manipulation	Aquatic habitat management - Pond drying/draining	Both	Pass
Habitat manipulation	Fences for exclusions from sensitive areas	Non-lethal	Fail - Crit. 2
Habitat manipulation	Habitat management to reduce invasion	Non-lethal	Fail - Crit. 2
Habitat manipulation	Physical terrestrial barriers	Non-lethal	Pass
Hand removal	Hand removal	Non-lethal	Pass
Hand removal	Physical fishing methods - including aquatic nets	Non-lethal	Pass
Other	Citizen science for early detection	Non-lethal	Fail - Crit. 2
Other	Egg oiling	Lethal	Pass
Other	Electrofishing	Non-lethal	Pass
Other	Chemical fertility control	Non-lethal	Pass
Other	Hunting dogs (tracking/baying)	Non-lethal	Pass
Other	Hunting dogs (tracking/killing)	Lethal	Fail - Crit. 1
Other	Systematic surveys for early detection	Non-lethal	Fail – Crit. 2
Other	Judas animals	Non-lethal	Pass
Poisoning or toxicants	Stupefying bait	Non-lethal	Pass
Poisoning or toxicants	Chemical treatment of habitats	Lethal	Pass
Poisoning or toxicants	Poisons and toxins in bait	Lethal	Pass
Shooting	Shooting	Lethal	Pass
Trapping	Drowning traps	Lethal	Pass
Trapping	Goodnature self-resetting traps	Lethal	Pass
Trapping	Spring operated traps	Lethal	Pass
Trapping	Cage traps	Non-lethal	Pass
Trapping	Neck-hold traps, and snares	Non-lethal	Pass
Trapping	Live decoy traps	Non-lethal	Pass

Table 2b. Measures to dispatch or remove an individual once captured identified for assessment

Measure name	Lethality	Selection criteria
Cervical dislocation	Lethal	Pass
Cranial depression	Lethal	Pass
Decapitation	Lethal	Pass
Electrocution	Lethal	Pass
Freezing	Lethal	Pass
Injection euthanasia	Lethal	Pass
Keeping in captivity	Non-lethal	Pass
Modified atmospheres	Lethal	Pass
Shooting - dispatch restrained animals	Lethal	Pass
Slaughter with a knife	Lethal	Pass
Surgical sterilisation	Non-lethal	Pass

1.3.3. Assessment of measures

Information for each of the measures identified, and on their application to the 22 vertebrate IAS of Union concern, was collated through research using publications made available by project partners and additional online searches, and accessing relevant online IAS databases. Once this information was collated, an assessment was undertaken for each of the measures including on their humaneness (i.e. animal welfare impacts), costs and effectiveness, and side effects. Each measure assessment was reviewed by at least two additional experts. The individual detailed measure assessments are presented in **Appendices 1 to 32**, and are summarised in this manual. Guidance on the information in the assessments is presented in **Section 7** of this manual (see **Box 4** for summary).

The information provided in this manual, particularly in relation to animal welfare, is a guide only and we recommend that a full ethical review should be undertaken and local conditions, available resources, legal frameworks, and capacity need to be considered before implementing any of the measures described.

Box 4. Information included for each measure assessed:

- Measure name in English (and other EU languages, if available)
- Intended lethality (lethal, non-lethal, both)
- Measure description. Summarising methods of application, noting different types and changes in application in relation to different species, and any legal restraints
- Integration with other measures
- Availability of the measure for the different vertebrate IAS of Union concern (available, under development, potential) for different management objectives to their population(s) (rapid eradication, eradication, control, containment)
- Application of the measure in EU Member States
- Humaneness assessment
- Costs and effectiveness case studies
- Side effects
- Conclusion
- References

An important point to note is the ways in which 'humaneness' and 'costs and effectiveness', two key aspects of these assessments, have been addressed:

Humaneness/animal welfare impact

An individual measure can lead to a range of possible humaneness/welfare impact outcomes, depending upon the different 'types' of the measure being applied (e.g. different type of cage trap), and the species it is applied to. Each measure was assessed in relation to its likely impact on an individual animal, assuming that its application followed best practices, as available. In addition, the assessments also note where common misapplication may lead to unnecessary pain or suffering.

To assess humaneness, the welfare impact categories set out by Sharp and Saunders (2011) have been adopted (**Appendix 33**). A justification for the selection of this framework is provided in **Section 2.3**. However, these categories were only used as a guide, as the project did not have the capacity to replicate the full assessment process described by Sharp and Saunders (2011) which included the establishment of an expert-panel, extensive literature search and review, and the running of expert assessment workshops.

The humaneness/welfare assessment is split into two separate sections; (A) the '*overall welfare impact'* which assesses the humaneness impact of a measure, excluding the actual killing of the animal (if the measure involves killing); and (B) the '*mode of death*' which assesses the humaneness impact of the killing method (if the measure involves killing). For example, if a measure captures and then kills an animal, the measure will be assessed within both sections.

Under '*overall welfare impact'*, the measure was assessed according to five separate welfare domains: 1. Water deprivation, food deprivation, malnutrition; 2. Environmental challenge; 3. Injury, disease, functional impairment; 4. Behavioural, interactive restriction; and 5. Anxiety, fear, pain, distress, thirst, hunger, etc. The fifth domain is usually a cumulative effect of the other four domains and is generally, but not always, equivalent to the most extreme potential impact.

Under '*mode of death*', the measure was assessed considering the time taken for the target animal to reach irreversible unconsciousness and any suffering, which includes (but is not limited to) fear, anxiety, pain, distress, apprehension, sickness, fatigue, thirst and hunger.

The results of the humaneness assessments are summarised in **Section 5**, but for detailed results please see the individual measure assessments (**Appendices 1-32**).

Costs and effectiveness

As costs and effectiveness depend upon many factors such as the spatial scale of the measure's implementation and its objective, this information has been assessed through evidence provided in individual case studies. Note that **a full cost-effectiveness, or cost-benefit analysis has not been undertaken**, but rather a qualitative assessment which considers long-term costs and effectiveness for the stated objectives. The conclusions drawn on costs and effectiveness for the application of measures to the different species are presented in **Section 6**, whereas the costs and effectiveness case studies and more detailed discussions are available in the individual measure assessments (**Appendices 1-32**).

1.4. How to use this manual

In **Section 2**, the manual presents an overview of current international standards and EU rules on animal welfare of relevance to the management (eradication, control and containment) of vertebrate IAS populations. The aim is to provide context on humaneness considerations, including legal requirements and minimum standards, for managing IAS. It provides a justification for the criteria adopted to select measures, and the framework used to assess their humaneness (**Section 2.3**). It also discusses why the application of an objective or quantitative threshold below which an activity might be considered 'inhumane' *per se*, and therefore never acceptable, is not possible.

Section 3 provides a brief summary of the measures not selected for assessment, briefly noting any implications for animal welfare and costs and effectiveness.

The remaining sections of the manual present information on the measures for managing the vertebrate IAS of Union concern:

- **Section 4. Toolbox.** A matrix of measures that are available, under development, or potentially available to be applied to the vertebrate IAS of Union concern, for different management objectives.

- **Section 5. Humaneness summaries.** The humaneness assessment for each measure is summarised according to the overall welfare impacts, and mode of death. These accounts, when accompanied by the effectiveness assessments (**Section 6**), should be used to guide the user to the relevant measure assessment for detailed information (**Section 7** and the **Appendices**).

- **Section 6**. **Species accounts.** For each of the 22 vertebrate IAS of Union concern, a brief summary of the costs and effectiveness of the measures that are [potentially] available for different objectives are presented. These accounts, when accompanied by the humaneness summaries (**Section 5**), should be used to guide the user to the relevant measure assessment for detailed information (**Section 7** and the **Appendices**).

- **Section 7 & Appendices 1-32. Measure assessments.** Detailed information on each measure, including on their methods of application and available best practices. Also includes the full assessments of humaneness, costs and benefits, and side effects.

- **Section 8 & Appendices 34-40. Regional conditions.** These present information collated through the regional engagement activities for each Member State including: the species presence; an overview of the legislation, standards and guidance regarding management of IAS of Union concern; and any restrictions and/or bans on the application of the measures (and corresponding legislation).

- **Section 9. References.** Lists the references for this manual – excluding the references for the individual measure assessments, which are listed in the assessments themselves.

2. Animal welfare and the management of IAS

2.1. Overview of international and EU standards, regulations and guidance

In this section, international and EU standards, regulations, and guidance documents that contain, to a greater or lesser extent, provisions in relation to animal welfare that could be applied to the eradication, control, or containment of populations of vertebrate IAS are identified and discussed (listed in **Box 5**). For each standard/regulation/guidance, their main provisions on animal welfare that are relevant to IAS and their management are identified, and their legal and ethical requirements are highlighted.

It is important to note that standards and regulations at the international and EU level are constantly being updated and, therefore, information presented in this manual may soon become outdated. Note that the information presented in this manual was collated up to late 2021.

Box 5. Standards, regulations, and guidance with provisions relevant to animal welfare for the management of IAS

International standards:

- Agreement on International Humane Trapping Standards (AIHTS)
- Bern Convention on the Conservation of European Wildlife and Natural Habitats; and Bonn Convention on the Conservation of Migratory Species of Wild Animals.

European legislation:

- EEC Council Regulation 3254/91 (Leghold Trap)
- Birds Directive (Directive 2009/147/EC)
- Habitats Directive (Council Directive 92/43/EEC)
- Treaty establishing the European Community
- Council Regulation (EC) No 1099/2009 on the protection of animals at the time of killing
- Regulation (EU) 1143/2014 on invasive alien species
- Biocidal Products Regulation (Regulation EU 528/2012)
- EU Directive 2010/63/EU on the protection of animals used for scientific purposes

Guidance documents:

- International consensus principles for ethical wildlife control
- World Organisation for Animal Health (OIE) standards animal welfare
- Sharp and Saunders model for assessing the relative humaneness of pest animal control methods.
- Trapping and marking terrestrial mammals for research

2.1.1. Agreement on International Humane Trapping Standards (AIHTS)

The AIHTS[1] was negotiated between the EU, Canada and the Russian Federation (with a similar agreement with the USA) to establish international standards of humane trapping (restraining and kill traps), and to lay down harmonised technical standards offering a sufficient level of protection to the welfare of certain species of trapped animals (detailed below). The Agreement was ratified by the EU in 1998, the Government of Canada in 1999, and the Russian Federation in 2008, which allowed the Agreement to enter into force in July 2008. In July 2004, the European Commission attempted to harmonise the implementation of the AIHTS within the EU by adopting a proposal for a Directive introducing humane trapping standards for certain animal species (COM (2004)532). However, a parliamentary report raised serious objections to the use of the word 'humane' for this was deemed highly misleading. Following the rejection by the European Parliament in 2004 of the Commission's proposal and its withdrawal in 2012, the Commission took action aimed at facilitating cooperation and sharing of lessons learned amongst the relevant national competent authorities[2]. In particular, the Commission reminded the Member States of their responsibility to comply with the Agreement even in the absence of common EU rules. In this context, enforcement is pursued on a case-by-case basis and taking into account evidence brought by complainants that the prohibition of specific traps is not enforced by the Member States' authorities.

In a recent review of mammal trapping standards (including the AIHTS), Proulx et al. (2020) concluded that it is clear that mammal trapping standards need to be revisited to implement state-of-the-art trapping technology and improve capture efficiency and species selectivity.

2.1.2. EEC Council Regulation 3254/91 (Leghold Trap)

Leghold traps as a means of restraining animals are not permitted in the EU, for any purpose. Council Regulation (EEC) no. 3254/91 of 4 November 1991 prohibits the use of leghold traps in the Community, as well as regulating the import of pelts and manufactured goods of certain wild animal species from outside of Europe. The regulation defines a leghold trap as "*a device designed to restrain or capture an animal by means of jaws which close tightly upon one or more of the animal's limbs, thereby preventing withdrawal of the limb or limbs from the trap*". There are very few countries world-wide which still allow the use of this type of trap.

2.1.3. Bern Convention and CMS

The Bern convention (the Convention on the Conservation of European Wildlife and Natural Habitats, 1979) is a binding international instrument covering many European and some African states, as well as the EU, providing principles or specifying measures to support the conservation of species and habitats. Special attention is given to endangered and vulnerable species, including endangered and vulnerable migratory species. The Convention on Migratory Species (CMS), also called Bonn Convention (1979), covers over 133 Parties around the world including the EU and focuses on international co-operation to ensure the viability of species undertaking transboundary migrations as part of their natural behaviour. However, the conventions themselves may require consultation when considering extensive (e.g. trans-continental) measures, which might threaten either species or habitats specified in either convention. The Bern convention prohibits the use of a variety of means and methods of killing and capture (Appendix IV of the convention; **Table 3**) of protected fauna species

1 Council Decision (98/142/EC) of 26 January 2998 concerning the conclusion of an Agreement on international humane trapping standards between the European Community, Canada and the Russian Federation https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31998D0142

2 Question for written answer E-002254/18 to the Commission Keith Taylor (Verts/ALE) 23 April 2018. https://www.europarl.europa.eu/RegData/questions/reponses_qe/2018/002254/P8_RE(2018)002254_EN.pdf

listed in Appendix III of the Convention. Whilst Parties can licence specific exemptions to these prohibitions for specified purposes it seems unlikely that the Convention foresaw the application of prohibited measures at continental scales in a co-ordinated fashion. The list of prohibitions might help guide thinking on measures which might be considered unacceptable in a modern wildlife management programme.

Table 3. Means and methods prohibited for killing and capture of protected fauna under the Bern Convention

Methods	Mammals	Birds	Freshwater fish
Snares	✓	✓	
Live animals used as decoys which are blind or mutilated	✓	✓	
Tape recorders	✓	✓	
Electrical devices capable of killing and stunning	✓	✓	
Artificial light sources	✓	✓	✓
Mirrors and other dazzling devices	✓	✓	
Devices for illuminating targets	✓	✓	
Sighting devices for night shooting comprising an electronic image magnifier or image converter	✓	✓	
Explosives	✓	✓	✓
Nets	✓*	✓	
Traps	✓*	✓	
Poison and poisoned or anaesthetic bait	✓	✓	✓
Gassing or smoking out	✓	✓	✓
Semi-automatic or automatic weapons with a magazine capable of holding more than two rounds of ammunition	✓	✓	
Aircraft	✓	✓	
Motor vehicles in motion	✓	✓	
Limes		✓	
Hooks		✓	
Firearms			✓
Electricity with alternating current			✓

*If applied for large scale or non-selective capture or killing
Source: Adaptated from Bern Convention Appendix IV – Prohibited means and methods of killing, capture and other forms of exploitation'

2.1.4. Birds Directive (Directive 2009/147/EC)

The Birds Directive provides a framework for the conservation and management of wild birds in Europe, including methods used to manage them. This Directive is one of the key instruments through which the EU and its Member States meet their obligations under the Bern and Bonn Conventions concerning wild birds. It sets broad objectives for a wide range of activities, although the precise legal mechanisms for their achievement are at the discretion of each Member State. It aims to protect all European wild birds and the habitats of listed species. As a long established mechanism across EU Member States, it has set the expectations for the types of measures applied to protect biodiversity and the environment.

2.1.5. Habitats Directive (Council Directive 92/43/EEC)

The aim of the Habitats Directive is to ensure the conservation of rare, threatened or endemic animal and plant species and characteristic

habitat types in the EU. This Directive is one of the key instruments through which the EU and its Member States meet their obligations under the Bern and Bonn Conventions, and their associated instruments. This is the primary legislative tool limiting the use of measures prohibited under the Bern or Bonn Conventions. Prohibitions in **Table 3** are specified here, in relation to application to species listed in Annex V (a) and with derogations for species listed in Annex IV (a), and transposed into the national legislations of Member States. This Directive also provides the concept of '*Favourable Conservation Status*' when considering the viability of a population of a threatened species. Threats to the viability of populations of species listed in Annex IV of the Directive may be produced directly by IAS on the Union list, or may arise as a consequence of action to manage IAS (e.g. where threatened species may occur as non-target casualties of management action). Thus, the Habitats Directive may contribute to the justification of management action, and may also constrain considerations on the selection of tools for proposed management action (i.e. where tools may produce considerable non-target effects).

2.1.6. Treaty establishing the European Community

Protocol (No 33) on protection and welfare of animals (1997) is annexed to the main treaty establishing the European Community. This document recognises animals in Europe as sentient, and requires the protection of their welfare as a fundamental principle: *In formulating and implementing the Community's agriculture, transport, internal market and research policies, the Community and the Member States shall pay full regard to the welfare requirements of animals, while respecting the legislative or administrative provisions and customs of the Member States relating in particular to religious rites, cultural traditions and regional heritage*.

2.1.7. Council Regulation (EC) no. 1099/2009 on the protection of animals at the time of killing

This Regulation, which builds on OIE standards (discussed below), specifies the principles and details of stunning and killing livestock, but some of the welfare minima are useful for humaneness assessments of management programmes. Key concepts transferable to this context include the principles that:

> "*...any person involved in the killing of animals should take the necessary measures to avoid pain and minimise the distress and suffering of animals during the slaughtering or killing process, taking into account the best practices in the field and the methods permitted*"

> "*...pain, distress or suffering should be considered as avoidable when ... operators or any person involved in the killing of animals breach one of the requirements of this Regulation or use permitted practices without reflecting the state of the art, thereby inducing by negligence or intention, pain, distress or suffering to the animals*"

> "*The protection of animals at the time of slaughter or killing is a matter of public concern....*"

The Regulation is founded in the practical context of agricultural practice or the killing of animals for disease control purposes, whereas the killing of wild or stray animals for population control purposes explicitly falls outside its scope. However, the standards set out in the Regulation (and OIE guidance documents) represent a potentially useful source when considering the killing or euthanasia of wild animals in the field. Destruction of the brain using a free bullet (shooting) is a commonly advocated method for larger species, whilst the use of a field portable captive bolt (also to instantly render the animal unconscious and destroy the brain) is often advocated for smaller species such as geese. Requirements to respect

humane standards during management operations according to the EU IAS Regulation should focus on humane methods that are appropriate to be used in the field and on the competence of the operators who should ensure their consistent application.

2.1.8. Regulation (EU) 1143/2014 on invasive alien species

The EU IAS Regulation requires assessment of the humaneness and practicability of measures which might be deployed against IAS in the EU. The preambles of the Regulation also include some principles of operation which are relevant here:

- Prevention is the preferred approach (Recital 15)
- The most effective and cost efficient response is often to eradicate the population as soon as possible while the number of specimens is still limited (Recital 24)
- "*Animals are spared any avoidable pain, distress or suffering*" when implementing rapid eradication, control or containment measures (Recital 25, Article 17.2, 19.3)
- "*minimising the impact on non-targeted species and their habitats*" (preamble 25; Article 3.14, 3.17, 17.2, 17.3, 19.3, 19.4, 24.1e)
- When applying eradication measures, Member States shall ensure that the methods used are effective in achieving the complete and permanent removal of the population of the invasive alien species concerned (Article 17.2)

These principles might be understood to imply that the most humane option should be preferred when selecting between effective measures. In this context, the most humane approach is to remove the requirement to effect the eradication or control of an IAS population by preventing its entry. Should measures to remove animals from the environment be required, measures should apply to the smallest number of animals by ensuring a timely intervention and prevent the establishment of a substantial population of species of IAS in the EU, and where eradication of IAS on the Union list is planned the requirement to ensure success of the program of measures is explicit. We note that this combination of fundamental principles aligns well with a recent consensus on the principle of ethical welfare control (Dubois et al., 2017). Whenever there is a choice of alternative (and effective) measures to eradication or control, the most humane should be selected. Article 19.3 (Management measures) states:

> "*When applying management measures and selecting methods to be used, Member States shall have due regard to human health and the environment, especially non-targeted species and their habitats, and shall ensure that, when animals are targeted, they are spared any avoidable pain, distress or suffering, without compromising the effectiveness of the management measures*."

The form of the requirement "*... animals are spared any avoidable pain, distress or suffering....*" suggests that this is uunconditional, bearing in mind potential constraints (costs and benefits referred to in Art. 19 of the IAS Regulation), such as resources, capacity, costs, etc. Finally, the IAS Regulation encourages the selection of measures to minimise the effects on non-target species and the environment. Here, the form of the principle is less emphatic.

2.1.9. Biocidal Products Regulation (Regulation EU 528/2012)

Toxins for use against animals are regulated within the EU by the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012), which came into force in September 2013 (repealing the Biocidal Products Directive 98/8/EC). Any biocidal product requires authorisation before it can be used, and the active substances contained in that biocidal product also need to be approved under the BPR. All active substances and products are categorised (and assessed/authorised) according to their targeted application into 22 Product Types (PT)

grouped into four categories. Within the group 'Pest Control' there are four PTs relevant to this assessment: PT 14 Rodenticide, PT 15 Avicide, PT 17 Piscicide, and PT 20 Control of other vertebrates. This therefore covers products which might be used as part of measures used to manage IAS and subsequently permits their authorisation for use in Member States. According to the BPR (Article 19(1)(b) criterion ii and common principles point 49 and 76 in Annex VI) biocidal products should cause no unacceptable effects on the target organisms, including unnecessary suffering and pain for vertebrates (humaneness) (ECHA, 2018). This criterion is relevant for biocides in the Pest Control PTs14, 15, 17, 19 (repelling or attracting vertebrates) and PT20. Guidance on the assessment of active substances and products (for seeking authorisation) (ECHA, 2018) states that "*for these biocides an assessment must be made to demonstrate that the biocidal product does not cause unnecessary suffering in its effect on target vertebrates. This must include an evaluation of the mechanism by which the effect is obtained and the observed effects on the behaviour and health of the target vertebrates; where the intended effect is to kill the target vertebrate, the time necessary to obtain the death of the target vertebrate and the conditions under which death occurs must be evaluated*." Importantly, the Regulation implemented by Member States specifies precisely the formulation and method of delivery for the authorised toxicants, permitting little opportunity to deviate from their registered purpose.

2.1.10. EU Directive 2010/63/EU on the protection of animals used for scientific purposes

This Directive protects live non-human vertebrates and live cephalopods used for scientific purposes. It requires the application of an *a-priori* harm/benefit evaluation to determine the ethical value of a proposed study; the consultation of professionals whose primary duty is the welfare of animals; ensures the competence of operators undertaking every procedure or assessment related to the welfare of animals; requires the strict specification of every protocol and adherence to those plans; and requires retrospective reviews of the harms produced to all of the animals it regulates. Importantly, it applies the principle of the '3Rs' to continuously improve the welfare of animals used in scientific procedures (3Rs; Replacement of the use of live animals; Reduction in the number harmed; Refinement of their experience = reducing harms and distress in procedures and husbandry). This principle of formalising the continuous improvement of the scientific process with respect to the use of animals and their welfare has produced a dramatic improvement in the 'efficiency' of scientific research using live animals (reductions in the number of animals used, the harms they are subjected to; EU (2020)) and importantly has driven a revolution in efforts to improve the husbandry of animals in research (principally their welfare and euthanasia), as well as very many improvements to scientific protocols removing un-necessary harms. This has been broadened in some institutions to become a requirement to foster a general 'culture of care' for animals used in a scientific context which includes a detailed evaluation of every aspect of the animal's experience and a drive to continuously improve it from the ground up.

Those responsible for the application of measures to manage IAS could adopt a similar requirement to demonstrate continuous improvement of measures as good/best practice. Especially in cases where this might improve the humaneness of measures and the number of non-target species affected , it might establish a similar enthusiasm in the field of wildlife control to professionalise the inception and delivery of measures where animals are killed. Importantly, where control operations are likely to be lengthy, it assures decision-makers and society that every effort will be made to refine the experience of animals subject to control and ensure that their welfare is an ever-present consideration in every plan and action.

2.1.11. OIE standards on animal welfare

The World Organisation for Animal Health (OIE) publishes a series of guidance documents on aspects of animal husbandry. These guides are regularly updated as scientific knowledge evolves, and new standards are developed to cover different aspects of welfare. Like all OIE standards, these texts are science based and include brief guides on the killing and slaughter of livestock and production fish. Livestock includes examples for small ruminant species (analogous to some of the larger mammalian IAS; e.g. *Muntiacus reevesi* Reeve's muntjac), large poultry species (analogous to *Alopochen aegyptiaca* Egyptian goose). As noted for Regulation (EC) No 1099/2009 above (which builds on the OIE guides), the guides are founded in the practical context of agricultural practice or the killing of animals for disease control purposes, and represent a potentially useful source when considering the killing or euthanasia of wild animals in the field.

2.1.12. International consensus principles for ethical wildlife control

These principles, developed through an international expert workshop, and published in a peer-reviewed journal (Dubois et al., 2017), consist of seven sequential processes that should be considered when undertaking the management of wildlife, including by extension the eradication or control of IAS populations. These are:

1. Modifying human practices
2. Justification for the eradication/control of the population
3. Clear and achievable outcome-based objectives
4. Minimise animal welfare harms
5. Social acceptability
6. Systematic planning
7. Decision-making by specifics rather than labels

Of these, items 2, 3, 5, 6 and 7 all refer to the establishment of an ethical plan to control or eradicate IAS populations, ensuring that any activity undertaken is justified, proportionate and importantly carries with it a social and political will to ensure it achieves its purpose. The paper identifies that characteristics of a successful management programme include the clarity of its objectives and that it is planned to be achievable, its progress is monitored and systems of evidence-led adaptive or dynamic management are used.

The paper highlights that methods applied should cause the least animal welfare harm to the least number of animals present. The authors point out that when decisions are made on the methods to be applied, the predictability of the welfare outcome and effectiveness (rate of welfare outcome success) are important criteria to be considered. This should include adequate consideration of the indirect impact of management methods such as starvation of dependent young, disruption of social groups, and disruption of ecological systems. The review also states that while non-lethal methods may usually be considered to cause less severe harm than lethal methods, this is not always the case. Although exclusion and short-distance relocation may cause relatively mild and short-lived negative effects on some animals, relocation can result in severe welfare problems and even death if animals cannot secure shelter, food, water, safety, and territory in the new environment. The paper also stresses that methods that result in the least welfare harm when used by knowledgeable and competent professionals may be more harmful when used by untrained individuals. Finally, the authors emphasise that decisions about management should be based on the specifics of the situation rather than negative labels such as 'pest' or 'over-abundant'.

2.1.13. A model for assessing the relative humaneness of pest animal control methods

A comparative model was devised to compare the humaneness of a broad range of methods and measures used to remove invasive species from the environment in Australia including bringing

into captivity, shooting, trapping and poisoning (Sharp and Saunders, 2011). There is no reason why this model cannot be used in a European context, and indeed this has been done for assessing the relative welfare impacts of wildlife management methods in the UK (Baker et al., 2016).

The tool was the product of an extended sequence of committee tasks, workshops and publications with contributions from a wide range of stakeholders and experts. The process was supported by state agencies and key stakeholders. This eventually produced a revised model framework for comparing and selecting wildlife management methods, with a specific goal of improving the description of the relative humaneness of alternative approaches.

The tool deliberately sacrifices some quantitative power in order to maintain a broad scope. The aim was therefore to produce a practical, general model of assessment that can be applied to any pest control method, and permit the comparison of lethal and non-lethal methods. As Sharp and Saunders (2011) note, "*whilst most methods are lethal; some are not (without further intervention), so to produce a list of 'humaneness criteria' that would be applicable to every technique and for every species did not seem to be a viable option. …. The model should allow a judgement to be made about the humaneness of a method and then methods can be ranked based on this judgement*". The design of the tool deliberately allows the methodology to account for the many deficiencies in evidence or understanding inherent in the discussion of the humaneness of pest management methodologies and established a series of core principle to guide assessors when making evaluations:

- The benefit of the doubt – in cases where there is doubt or lack of knowledge about whether an animal will suffer very severely, one should assume it will do so;
- The worst case – one should assume that the worst case will happen; and
- Equal weight of the different dimensions of suffering – suffering due to pain, illness, or stress is equal.

The tool uses a two-part evaluation, examining (Part A) the overall welfare impact of a method, excluding the impact of any killing method involved; and (Part B) the welfare impact of the killing method itself. A measure that includes non-lethal and lethal components (e.g. restraint followed by killing) would include an assessment under both parts A and B, whilst for a non-lethal method only Part A assessment would be used (e.g. for bringing animals into captivity, the cumulative harms produced by the initial restraint, transport into captivity, followed by the welfare outcomes of the captivity itself could be assessed). Each part of the evaluation adapts a pre-existing methodology (Mellor and Reid, 1994, Broom, 1999). Importantly, the experience of animals subjected to non-lethal approaches, or the non-lethal components of lethal measures (e.g. restraint before killing) uses the 5 domains approach whereby the suffering and distress of the animal are considered across 5 dimensions of their experience (**Figure 2**).

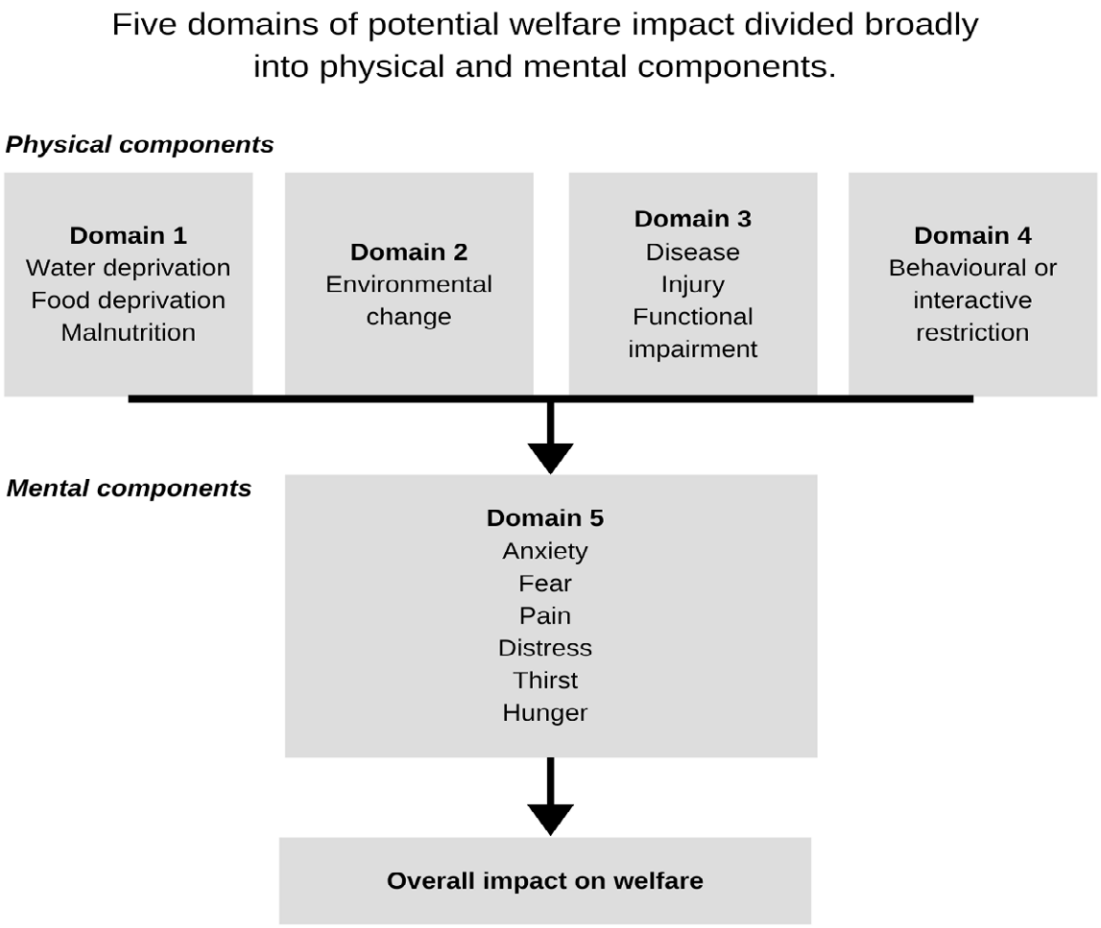


Figure 2. The 5 Domains used to assess the overall welfare impact experienced by animals during non-lethal methods.

Source: Adapted from Sharp and Saunders (2011), itself modified from Mellor (2004)

An essential requirement for using the model, is that assessment assumes that the method in question is applied according to a Standard Operating Procedure (SOP) - a previously defined best-practice methodology - so that the harms intrinsic to the method are evaluated rather than the inadequacies of its deployment. Thus, the assumption must be made that the most refined possible methodology is being deployed by staff demonstrating competence in the tasks involved and with sufficient experience to ensure methods used will minimise the exposure of non-target species. In the case of the 60 method/species combinations scored by Sharp and Saunders (2011), they undertook a lengthy consultation exercise to establish an agreed best practice methodology for each species before undertaking the comparative assessment. Importantly, each evaluation considered the potential for a method to fail (i.e. the likelihood of a severe harm being produced).

2.1.14. Trapping and marking terrestrial mammals for research: Integrating ethics, performance criteria, techniques, and common sense.

Powell and Proulx (2003) reviewed and discussed aspects of decision-making around the selection of trapping and marking vertebrates for research, in the context of North American mammals. Whilst the review is aimed at research scientists, it often lumps management activity into the same basket of purposes.

More positively they propose two criteria that can be used to evaluate the humaneness of different traps or methods; one for kill traps, and one for restraining traps. Both are based on a statistical description of trap tests. Criterion 1 used for killing traps is that there should be 95% confidence that ≥70% of trap-strikes will produce irreversible unconsciousness within 3 minutes (compare to the AIHTS criteria, see section 2.2.). Under Criterion 2, a permissible restraining trap should score <50 injuries (from a list of injuries) for ≥70% of restraints (also with a 95% confidence). For comparison with criteria for restraining traps under the AIHTS see next section. Powell and Proulx's review summarised the extensive experience of the authors in testing traps against these criteria and recommending the least harmful methods for each species or species group.

Powell and Proulx (2003) emphasise that minimisation of harms and maximisation of success are often achieved by combining many small factors and details into a methodology, combined with the skill and competence of the operatives. This suggests that worthwhile comparisons between measures should be based on an agreed optimum methodology. For example, cage or box traps are often suggested as the most appropriate and least harmful methods to restrain a range of mammals, especially if checked daily. Daily checking is also necessary to ensure that some foot-hold traps meet humaneness criteria for catching small canids, with the implication being that the same devices used in another way would fail to meet the humaneness criteria. Again, this illustrates that the device may have the potential to deliver a humane outcome if its use is appropriate or constrained by an appropriate SOP and the use of experienced operatives. The authors generalize that foot-hold traps and snares are difficult to set without being indiscriminate and can directly and severely harm non-target species where they are restrained, especially smaller non-targets. Similarly, any restraining traps relying on an anchor to hold an animal (primarily foot hold traps, body-hold traps and snares) must be set so that they are not carried off by larger animals. In this scenario, mis-targeted or mis-fired restraint traps catching a larger species may not only cause injury directly, but can also interfere with normal behaviour such that lengthy extended stress and suffering is produced.

2.1.15. A proposed framework for assessing welfare impacts of shooting

Shooting is one of the most widely used tools to manage wildlife. It provides a selective method that can kill animals at a distance, which is a unique characteristic of this measure. This feature makes it particularly useful for species that may not be readily trapped or captured, or those animals within a population that are trap-shy. However, shooting has a much greater human interaction than many other wildlife management methods such as trapping, and therefore 'human factors' such as shooter proficiency play a large role in the welfare outcome (Hampton et al. 2021). Following the approach adopted internationally to test the welfare impacts of kill-traps, Hampton et al. (2021) propose a four step standardised testing approach for shooting (and darting) in order to improve the welfare outcomes, and transparency of shooting programmes. This proposed four stage testing process involves: (1) range and field testing to confirm accuracy and precision, the delivery of appropriate kinetic energy levels and projectile behaviour; (2) post-mortem assessment of ballistic injury in cadavers; (3) small-scale live animal pilot studies with predetermined threshold pass/fail levels; and (4) broad-scale use with reporting of the frequency of adverse animal welfare outcomes. They conclude that currently animal ethics committees are operating in a knowledge vacuum, and that application of such a process, especially to newly developed technologies, would be beneficial.

2.2. Minimum expectations for animal welfare

In this section, the minimum expectations for animal welfare taken, when available, from the standards, regulations, and guidance above are discussed in the context of general measures used for the eradication, control, and containment of populations of the 22 vertebrate IAS which are the focus of this project.

2.2.1. Traps

AIHTS - kill traps and restraining traps

The AIHTS establishes requirements for trapping certain species (listed in AIHTS Annex 1) for the purposes of wildlife management including pest control, obtaining fur, skin or meat, and the capture of mammals for conservation (AIHTS, Article 3). The Standards set out minimum thresholds which a kill-trap or restraining-trap must meet in order to achieve the standard. In this context, the agreement ensures that animals of the species listed are not exposed to the less humane methods previously practiced, and represents a step towards ensuring that trapping uses more humane methods. This Agreement is implemented across Europe by legislation in each EU Member State. The AIHTS relates specifically to the following species (listed in AIHTS Annex 1), with those that are IAS of Union concern highlighted in **red** (shown here in order of decreasing mass/size):

Wolf	*Canis lupus*
Coyote	*Canis latrans*
Beaver (North American)	*Castor canadensis*
Beaver (European)	*Castor fiber*
Lynx (European)	*Lynx lynx*
Lynx (North American)	*Lynx canadensis*
Bobcat	*Felix rufus*
Otter (North American)	*Lutra canadensis*
Otter (European)	*Lutra lutra*
Badger (European)	*Meles meles*
Raccoon	***Procyon lotor***
Badger (North American)	*Taxidea taxus*
Raccoon dog	***Nyctereutes procyonoides***
Fisher	*Martes pennanti*
Pine Marten	*Martes martes*
Sable	*Martes zibellina*
American Marten	*Martes americana*
Muskrat	***Ondatra zibethicus***
Ermine/stoat	*Mustela erminea*

The AIHTS defines separate requirements for acceptable restraining and kill trap methods (summarised in **Table 4**). The core principles embodied by the Agreement are that the pain and suffering of animals should be limited and that as new methods become available, standards are progressively refined. For methods of restraint, the standard is not particularly demanding and permits relatively substantial and, by extension, distressing and painful injuries to occur in up to 20% of trapped animals (**Table 4**). For kill traps, a strict and statistically coherent approach to assessing the humaneness of a trap is mandated, requiring scientific testing of traps using live animals. We note that, since 2013, such tests will have been undertaken through studies regulated by Directive 2010/63/EU. For a regulatory purpose, each scientific study requires the use of the minimum number of animals given in **Table 4** to satisfy the assessment criteria, and would proscribe suffering beyond that required for the purpose. Thus, the minimum sample sizes described in **Table 4** will be those used for most recent

assessment studies in Europe and it is unlikely that any tests would have permitted the suffering of experimental animals beyond the stated time limit. This limits the additional inference that can be drawn from the results of trap testing to support the AIHTS. Limits on the use of more animals confound confident estimation of the proportion of trap strikes which may fail to produce timely irreversible insensitivity, whilst the requirement to terminate tests at the 300 second limit confound any assessment of whether unsuccessful strikes produce irreversible insensitivity after 305 seconds or if left unmitigated would produce a slow death.

Traps demonstrating compliance with the AIHTS represent one of the few objective assessments of the humaneness of management measures, and also represent a case study in how considerations of humaneness may be applied in wildlife management. Whilst the AIHTS permit suffering beyond that considered acceptable by some, its application ensures that for some species unacceptably inefficient designs or measures are prohibited from being used. Most other measures assessed in this manual have not been subjected to similar objective and scientific scrutiny with respect to measures of humaneness and cannot be purported as being any better than the AIHTS in promoting humane outcomes.

In this context, both the Agreement and regulatory functions contributing to its regulation (i.e. trap testing) are of interest here, especially where they might be used to compare measures; for example, the proportion of animals which may suffer extended or unmitigated distress. If scientific methods are used to measure the humaneness of diverse measures, then Directive 2010/63/EU will become pertinent in shaping why and how this work is undertaken.

The AIHTS definition of restraining traps covers all traps that are not intended to kill, which includes box traps, cage traps, multi-catch traps, and snares etc.. Once restrained, captured animals can be approached by an operator, dispatched (if a target species, or an unacceptably injured non-target species) or released (if an uninjured non-target species). The presence of an operator and use of a humane method of dispatch permit management methods using restraining traps to ensure a reliable and humane death (a rapid death can be more or less assured once the restrained animal is discovered by the operator, assuming a humane method of dispatch is employed by a skilled individual). However, unlike some other methods, the use of restraining traps always produces harm. If the restraint is brief (measured in minutes) and the trap produces no injury, this harm may be relatively small. However, if the restraint is prolonged, animals may suffer a number of stressors, for example, the inability to express their natural behaviour, exposure to extreme environment conditions, isolation from their social group, and exposure to predators (or even just the fear produced by potential exposure) (see Baker et al. (2022) which examines these live-trapping impacts for rats). If the method of restraint also produces the potential for injury, then the harms produced by restraint alone may become substantial. Further, some methods of restraint may also permit animals to escape before they can be approached by an operator. In these cases, animals may suffer prolonged pain and distress from unmitigated injuries caused by the method of restraint.

Table 4. AIHTS requirements for restraining and kill trapping method

	Restraining traps	Kill traps
Definition	Traps designed and set with the intention of not killing the trapped animal, but restraining its movements to such an extent that a human can make direct contact with it	Traps designed and set with the intention of killing a trapped animal of the target species
Parameters	Assessment of **behaviour** and **injury**	**Time of occurrence of unconsciousness** and insensibility (monitored by checking corneal and palpebral reflexes)
Indicators	**Behavioural** indicators recognised as indicators of poor welfare in trapped wild animals are: (a) self-directed biting leading to severe injury (self-mutilation); (b) excessive immobility and unresponsiveness. **Injuries** recognised as indicators of poor welfare in trapped wild animals are: (a) fracture; (b) joint luxation proximal to the carpus or tarsus; (c) severance of a tendon or ligament; (d) major periosteal abrasion; (e) severe external haemorrhage or haemorrhage into an internal cavity; (f) major skeletal muscle degeneration; (g) limb ischemia; (h) fracture of a permanent tooth exposing pulp cavity; (i) ocular damage including corneal laceration; (j) spinal cord injury; (k) severe internal organ damage; (l) myocardial degeneration; (m) amputation; (n) death	Time limit to loss of corneal and palpebral reflexes: • 45 seconds (*Mustela erminea*) • 120 seconds (*Martes americana, Martes martes, Martes zibellina*) • 300 seconds (all other listed species)
Thresholds	At least 80 % (from a minimum of 20) of these animals show none of the indicators listed	At least 80 % (from a minimum of 12) of these animals are unconscious and insensible within the time limit, and remain in this state until death

Source: Compiled by authors from AIHTS

There are two principle indicators when assessing welfare performance of restraining traps; behavioral and physical injuries suffered by restrained individuals including mortality (target and non-target species; **Table 4**). In the testing of restraining traps in >80% of at least 20 trials there must be no incidence of any of the indicators being present in trapped animals (there is no upper limit on the harms experienced for the remaining <20%). Some of the physical injury indicators are likely to be apparent only in post-mortem examination and hence will not be recorded in most field use. In addition, while behavioural and physical indicators help to assess injury, they do not necessarily help in assessing variables such as pain. Anxiety caused by confinement and physical exertion related to struggling will also affect the welfare of the animal (Marks, 2010, Marks et al., 2004). When prolonged, this distress can have a deleterious effect on an animal's health and subsequent survival (Moberg, 2000). Longer periods of time spent in the trap are often associated with greater exertion and more serious injuries (Powell and Proulx, 2003). Most European countries and some North American states require traps (both killing and restraining) to be checked daily (Iossa

et al., 2007). This should be considered as a minimum standard; however, reducing the time in traps by either checking more frequently (Powell and Proulx, 2003) or monitoring traps with electronic devices can reduce the number of serious injuries (Kaczensky et al., 2002, Potoçnik et al., 2002, Larkin et al., 2003).

The AIHTS states that kill (spring/jawed) traps must lead to death or irreversible insensibility within a time limit which varies between species (**Table 4**). For most species the time limit is 300 seconds, although for selected smaller Mustelid species it is recognised that traps are available which permit a lower time threshold of 120 seconds for *Martes americana*, *Martes martes*, and *Martes zibellina*; and only 45 seconds for *Mustela erminea*. Generally, these traps comprise a trigger, and a killing bar usually powered by a spring, with a rapid death ideally produced by the bar striking the head/skull, or neck of the animal with sufficient force to either produce fatal damage to the brain (destruction of the brain) or severely damage the spinal cord (cervical dislocation). Insensibility and death can often be instantaneous (a humane death), and even if death is not immediate as long as it follows the immediate onset of unconsciousness, without recovery, it is considered not to negatively impact animal welfare. However, kill traps are prone to two general failings. Animals may be struck and injured (failed strike) but may subsequently recover consciousness before death. Failed strikes may produce substantial injuries, especially if they strike a limb, or hind quarters of an animal. Failed strikes may pin an animal in a trap, permitting an operator to discover the animal in a routine trap check; in this scenario the suffering of the animal is then ended by the operator using a humane method of euthanasia/killing. Much more problematically, failed strikes may produce substantial injuries but also allow the animal to escape. In this case the substantial harms produced by the trap continue until the animal either dies of, or recovers from its injuries following an extended period of unmitigated suffering.

Under the AIHTS, the traps are tested under laboratory conditions for all species with insensibility measured using the lack of a palpebral (blink) and/or corneal reflex. The thresholds established mean that conditions must be met in at least 80% of the 12 test trials. It should be noted that there is no upper limit to the degree or duration of the harm permitted in the 20% of trials that fail to produce irreversible unconsciousness under the AIHTS. In addition, the limit of 300 seconds was set despite the fact that a European Commission committee of experts defined a humane killing trap as "a trap which renders an animal insensible to pain instantaneously, or at least within a few seconds" and proposed – amongst other things - that the maximum time-limit should be set at 30 seconds[3]. The European Parliament's report[4] confirmed that the five-minute (300 seconds) time limit can in no way, shape or form be considered as 'humane'. Finally, the agreement focuses exclusively on the physical injury inflicted by traps and thus fails to adequately take into account the pain and stress, which animals suffer as a result of being trapped.

For kill traps for aquatic species (e.g. muskrat), differences between the principle and details of national regulation between signatories and the assessments which underpin them becomes more confused. Some countries (e.g. Canada) adopt the stance that a jawed trap that has been approved on land can also be used under water. However, it does not appear that these traps are tested in both types of scenarios, and the proportion of animals caught but not killed within 300 seconds by body-grip traps set underwater might

3 Opinion of the European Economic and Social Committee on the 'Proposal for a Directive of the European Parliament and of the Council introducing humane trapping standards for certain animal species' (COM(2004) 532 final — 2004/0183(COD))

4 Karin Scheele's report (A6-3004/2005), adopted by the Committee on the Environment, Public Health and Food Safety on 11th October 2005

be considered to eventually die from drowning whilst conscious.

Drowning traps are considered by some as inhumane, provoking an acute physiological crisis in all of the animals subjected to drowning (hypoxia; suffocation), which can persist beyond the 300 second threshold for terrestrial killing traps, combined with the fear that the inhalation of water is an extremely stressful experience (Talling & Inglis 2009). In addition, hypoxia is not considered a humane method of euthanasia by both veterinarians and laboratory researchers (Harris et al., 2005).

Due to concerns about the welfare standards established under the AIHTS, and its test procedures, Proulx et al. (2020) undertook a review of the AIHTS. They found that the AIHTS standards do not reflect ongoing advances in trapping technology, and concluded that the AIHTS assessment protocols should be updated to include trap components and sets, animal handling and dispatching, and trap visit intervals. These authors propose that the list of trap types and species included in the standards should be updated, and the concepts of capture efficiency and trap selectivity should also be developed and included in the standards.

Kill traps - Non AIHTS species

Despite the general wish for the period to irreversible insensitivity achieved by kill traps to be as short as possible, and the suggestions by some authors that 180 seconds might be an appropriate benchmark (Powell and Proulx, 2003), the threshold applied to the majority of larger species in the AIHTS (i.e. > 2 kg) is 300 seconds, and this situation persists because of the absence of trap designs which assure irreversible insensibility in a shorter time. Similarly, where a number of countries (e.g. UK, New Zealand, and Germany) have applied the principles of the AIHTS in trap testing methodologies for non-AIHTS species, a 300 second threshold is generally used and very few reports and or published papers regarding the IAS species refer to actual time to death. England adopted the AIHTS criteria as the standard for all new traps considered for inclusion onto the Spring Trap Approval Order 2018[5] (which lists the approved traps for use with each species in England) using 300 seconds as the threshold for irreversible unconsciousness. Where trap-testing has been applied to IAS currently on the Union list (e.g. Eastern grey squirrel, *Sciurus carolinensis*), or to similar species (e.g. Edible dormouse, *Glis glis* which might compare to the Siberian chipmunk, *Tamias sibiricus*), few tested traps pass the 300 second threshold, suggesting that even fewer would pass a shorter interval.

The humaneness of traps used in the field is rarely measured and it is highly unlikely that they are observed sufficiently rigorously to determine the realised time to irreversible unconsciousness. Some traps have been tested and are known not to meet the criteria for IAS on the Union list (e.g. Fenn IV trap and the Eastern grey squirrel); these should not be used.

Snares

Both killing and restraining snares are allowed under the AIHTS as long as they meet the relevant criteria. However, most countries in the EU have banned the use of snares, and others that permit snares impose a number of restrictions on their useuse. For example Spain allows snares for capture of birds but not mammals; the UK does not allow self-locking snares; Finland allows snares for foxes only in winter periods (see League Against Cruel Sports (2017)). Snares, depending on the type, set and target species may cause a diverse range of injuries (e.g. lacerations, pressure necrosis) and are often considered to be more indiscriminate in their interaction with non-target species. Further work is needed to examine the long-term welfare impact of leg-hold snares and to fully understand the risks they pose when they snare other parts of the animal (e.g. body or

5 The Spring Traps Approval (England) Order http://www.legislation.gov.uk/uksi/2018/1190/made

neck) and how different species respond to this restraint.

2.2.2. Toxins

As discussed above, in relation to animal welfare, an active substance or product shall be authorised under the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012) when "*the biocidal product has no unacceptable effects on the target organisms, in particular unacceptable resistance or cross-resistance or unnecessary suffering and pain for vertebrates*" (Article 19(1)(b) criterion ii). Further guidance is provided by ECHA (2018), which states that "*a biocidal product intended to control vertebrates must not normally be regarded as satisfying criterion (ii) under point (b) of Article 19(1) unless:*

- *death is synchronous with the extinction of consciousness, or*
- *death occurs immediately, or*
- *vital functions are reduced gradually without signs of obvious suffering*."

Fisher et al. (2010) (cited in Dubois et al. 2017) focus on toxins for possum population control. They found that cyanide had the lowest welfare impact, sodium fluoroacetate had intermediate harm, and cholecalciferol and anticoagulants had the greatest harm. With toxins the assessed level of pain and the duration of that pain are the deciding factors on humaneness. Cyanide is relatively quick whereas anticoagulants can take a number of days with pain associated with the majority of the duration. Baker et al. (2022) also found that anticoagulants and cholecalciferol cause rats severe to extreme welfare impacts for days.

2.2.3. Hunting with dogs

Although there is currently no EU wide ban on hunting with dogs, the majority of EU Member States no longer allow this as a lethal management method (with the exception of France). Many countries allow 'flushing out' of birds or mammals with dogs, but the use of dogs to injure or kill is illegal.

2.2.4. Methods of killing and euthanasia

Here we distinguish between killing and euthanasia when applied to IAS in the course of management. Killing is the death of an otherwise healthy animal to achieve the purpose of the management measure. In this context death may be produced without any behavioural change or sign of distress (e.g. successful head shot of free-ranging animal unaware of the marksman), or it may occur to a restrained animal showing mild signs of distress consistent with the approach of a human. Euthanasia is specifically limited to the relief of pain and substantial suffering and often represents the most rapid, secure, and effective means to resolve its suffering. Here the distress will usually comprise the pain of a physical injury inflicted by an ineffective application of a measure (gun or trap) or a moribund animal discovered following the use of a toxin. Whilst field deployments of measures against IAS may use the same tools for both killing and euthanasia, the very different cultural roots of the two approaches (killing wildlife in the field and euthanasia as a veterinary act in a controlled environment) need to be considered when reviewing the evidence here.

Even the most humane of measures (e.g. headshot, effective kill trap) may produce scenarios where animals must be euthanised. Indeed, best-practise for the hunting of large species (deer and wild boar; where even well placed shots may fail to kill a large ungulate instantly) encourages avoidance of potentially inhumane outcomes. Shooting deer should strive for a clean shot, appropriately targeted at head or heart/lung. It must be ensured that injured animals can be followed, discovered and dispatched promptly ensuring the rapid and permanent end to the animal's suffering (e.g. Deer Act 1991 for England). Similarly, where kill traps are used, regulation requires their regular inspection by an operator, so that pinned

and injured animals may be promptly found and dispatched (euthanasia) in order to rapidly and permanently end the animals' suffering (e.g. Animal Welfare Act 2006 in England).

Euthanasia of animals used for scientific purposes in the EU

Directive 2010/63/EU[6] is only applicable to animals used in research (all vertebrates and cephalopods), but some of the welfare minima are useful for humaneness assessments of management programmes. It states that animals are killed with minimum pain, suffering and distress and must be killed by a competent person (Article 6). It also states specific methods (under Annex IV) which are acceptable for different classes of animals. **Table 5** shows which methods would be acceptable for the 22 IAS if following the criteria under this directive. It must be noted that not all these techniques will be applicable or practical in a field situation or when controlling large numbers but does give a basis for relative humaneness for the type of management given. It should also be noted that in some instances there may be more humane methods available in a field situation than those referred to in this table.

6 Directive 2010/63/EU on the protection of animals used for scientific purposes https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0063

Table 5. Acceptability of 'humane' methods of killing under **Directive 2010/63/EU for animals used for scientific purposes**

Species		Anaesthesia	Electrical stunning	Cervical dislocation	Cranial concussion	Captive bolt	Free shooting	Carbon dioxide (gradual fill)
Common myna	*Acridotheres tristis*	✓	✓	✓	✓			
Egyptian goose	*Alopochen aegyptiaca*	✓	✓		✓			✓
Pallas' squirrel	*Callosciurus erythraeus*	✓		✓(with sedation)	✓			✓
Indian house crow	*Corvus splendens*	✓		✓ (with sedation)				✓
Small Indian mongoose*	*Herpestes javanicus*	✓					✓ (in field with competent marksman)	
Pumpkinseed	*Lepomis gibbosus*	✓	✓		✓			
American bullfrog	*Lithobates catesbeianus*	✓	✓		✓			
Reeve's muntjac	*Muntiacus reevesi*	✓				✓	✓ (in field with competent marksman)	
Coypu	*Myocastor coypus*	✓				✓?		✓?
Coati*	*Nasua nasua*	✓					✓ (in field with competent marksman)	
Raccoon dog*	*Nyctereutes procyonoides*	✓					✓ (in field with competent marksman)	
Muskrat	*Ondatra zibethicus*	✓		✓ (with sedation if <1kg)	✓ (if <1kg)			✓

Species		Anaesthesia	Electrical stunning	Cervical dislocation	Cranial concussion	Captive bolt	Free shooting	Carbon dioxide (gradual fill)
American ruddy duck	*Oxyura jamaicensis*	✓		✓ (with sedation)				✓
Amur sleeper	*Perccottus glenii*	✓	✓		✓			
Striped eel catfish	*Plotosus lineatus*	✓	✓		✓			
Raccoon*	*Procyon lotor*	✓					✓ (in field with competent marksman)	
Stone moroko	*Pseudorasbora parva*	✓	✓		✓			
Grey squirrel	*Sciurus carolinensis*	✓		✓ (with sedation)	✓			✓
Fox squirrel	*Sciurus niger*	✓		✓ (with sedation)	✓			✓
Siberian chipmunk	*Tamias sibiricus*	✓		✓	✓			✓
Sacred ibis	*Threskiornis aethiopicus*	✓						✓
Red-eared, yellow-bellied, and Cumberland sliders	*Trachemys scripta*	✓			✓	✓ (when large)	✓ (in field with competent marksman)	

*Source: Adapted from Annex IV of Directive 2010/63/EU on the protection of animals used for scientific purposes. Decapitation and the use of inert gases were not included as they would be considered inappropriate for wildlife management. * indicates species of IAS sufficiently similar to the category 'Dogs, cats, ferrets and foxes' to assume direct transposition*

However, a survey of scientists, vets and animal technologists which examined attitudes to rodent euthanasia reported that physical methods, particularly concussion, were regarded as distressing to operators (National Research Council (US) Committee on Pain and Distress in Laboratory Animals, 1992). Therefore, these techniques should not be included in research from a welfare perspective, particularly for killing animals in the field, as there will likely be more of a risk that errors will be made if the operator is not in a controlled environment, or is reluctant to apply the method and distressed as a result.

American Veterinary Medical Association guidelines

The American Veterinary Medical Association guidelines (AVMA) lists euthanasia methods which it deems acceptable (**Table 6**) and unacceptable (**Table 7**) on welfare grounds (Underwood and Anthony, 2020). The Association advocates for the veterinary profession in the USA and maintains recommendations for a variety of activities and behaviours across the veterinary profession. It is important to note that these guidelines come from the perspective of vets in the US, and based on their cultural expectations and the perceptions of their clients, which is a very different perspective to the state mandated eradication of a wildlife species in rural Europe. They should therefore not be used as an authoritative source for the purposes of this manual. Here they describe the suggested approaches to euthanise kept animals (those kept for a variety of purposes, including science, but under the control of an owner or keeper). Of particular interest here is that whilst many of the methods are specific to acts of veterinary surgery and may be proscribed for use in the management of wildlife populations, the guidelines also include additional information about animals' physiologic and behavioral responses to euthanasia (specifically, pain, stress, and distress), euthanasia's effects on observers, and the economic feasibility and environmental impacts of various approaches.

Table 6. Acceptable methods of euthanasia (AVMA) for relevant taxa groups

Species	Acceptable	Acceptable with conditions
Amphibians	As appropriate by species—Injected barbiturates, dissociative agents and anaesthetics as specified, topical or injected buffered MS 222 or topical benzocaine hydrochloride	As appropriate by species—Inhaled anaesthetics as specified, CO2, PCB or firearm, manually applied blunt force trauma to the head, rapid freezing of small (< 4 g [0.1 oz]) individuals where immediate death occurs
Avians (excl. Poultry)	S5: IV barbiturates	S5: Inhaled anaesthetics, CO2, CO, N2, Ar, cervical dislocation (small birds and poultry), decapitation (small birds) S7.6: Gunshot (free-ranging birds)
Fish	Immersion in buffered benzocaine or benzocaine hydrochloride, isoflurane, sevoflurane, quinaldine sulfate, buffered MS 222, 2-phenoxyethanol, injected pentobarbital, rapid chilling (appropriate species), ethanol	Eugenol, isoeugenol, clove oil, CO2-saturated water, decapitation/cervical transection/manually applied blunt force trauma followed by pithing or exsanguination, maceration (research setting), captive bolt (large fish)
Reptiles	As appropriate by species—Injected barbiturates/ MS 222, dissociative agents with adjunctive method and anaesthetics as specified	As appropriate by species–Inhaled anaesthetics as specified, CO2, PCB or firearm, manually applied blunt force trauma, rapid freezing for animals < 4 g where immediate death occurs, spinal cord severance/destruction of brain (crocodilians)
Rodents	Injected barbiturates and barbiturate combinations, dissociative agent combinations	Inhaled anaesthetics, CO2, CO, tribromoethanol, ethanol, cervical dislocation, decapitation, focused beam microwave irradiation

Source: The AVMA Guidelines for the Euthanasia of Animals: 2020 Edition

Table 7. Unacceptable methods of euthanasia (AVMA)

Agent or method	Comments
Air embolism	Air embolism may be accompanied by convulsions, opisthotonos, and vocalisation. If used, it should be done only in anaesthetised animals.
Asphyxiation	Physically preventing respiration (smothering, strangulation, dewatering) is unacceptable.
Burning	Chemical or thermal burning of an animal is not an acceptable method of euthanasia.
Chloral hydrate	Unacceptable in dogs, cats, and small mammals.
Chloroform	Chloroform is a known hepatotoxin and suspected carcinogen and, therefore, is extremely hazardous to personnel.
Cyanide	Cyanide poses an extreme danger to personnel and the manner of death is aesthetically objectionable.
Decompression (excluding low atmospheric pressure stunning when it can be demonstrated that it achieves euthanasia)	Decompression is unacceptable for euthanasia because of numerous disadvantages. (1) Many chambers are designed to produce decompression at a rate 15–60 times as fast as the recommended optimum for animals, resulting in pain and distress attributable to expanding gases trapped in body cavities. (2) Immature animals are tolerant of hypoxia, and longer periods of decompression are required before respiration ceases. (3) Accidental recompression, with recovery of injured animals, can occur. (4) Bleeding, vomiting, convulsions, urination, and defecation, which are aesthetically unpleasant, may develop in unconscious animals.
Drowning	Drowning is not a means of euthanasia and is inhumane.
Exsanguination	Because of the anxiety associated with extreme hypovolemia, exsanguination as a sole method of killing should be used only on unconscious animals.
Formaldehyde	Direct immersion of an animal into formalin, as a means of euthanasia, is inhumane with the exception of Porifera.
Household products and solvents	Acetone, cleaning agents, quaternary compounds (including CCl4), laxatives, pesticides, dimethylketone, quaternary ammonium products, antacids, and other toxicants not specifically designed for therapeutic or euthanasia use are not acceptable.
Hypothermia	Hypothermia is not an appropriate method of euthanasia.
Insulin	Insulin causes hypoglycemia, which can lead to considerable distress (behavior changes, irritability, and disorientation) before onset of hypoglycemic seizures, which may or may not result in death.
Magnesium sulfate and potassium chloride	Unacceptable for use as euthanasia agents in conscious vertebrate animals.
Manually applied blunt force trauma to the head	Generally unacceptable for most species excluding piglets and small laboratory animals. Replace, as much as possible, manually applied blunt force trauma to the head with alternate methods.
Neuromuscular blocking agents (nicotine, magnesium sulfate, potassium chloride, and all curariform agents)	When used alone, these drugs all cause respiratory arrest before loss of consciousness, so the animal may perceive pain and distress after it is immobilised.
Rapid freezing	Rapid freezing as a sole means of euthanasia is not considered to be humane with the exception of small (< 4 g) reptiles, amphibians, and < 5-day-old rodent neonates where immediate death occurs. In all other cases animals should be rendered dead or unconscious prior to freezing.
Strychnine	Strychnine causes violent convulsions and painful muscle contractions.
Thoracic compression	Not acceptable for use on a conscious animal.

Source: The AVMA Guidelines for the Euthanasia of Animals: 2020 Edition

Euthanasia of reptiles (OIE)

In the case of reptiles (OIE Terrestrial Animal Health Code, Chapter 7.14[7]), the killing process should involve either stunning followed by a killing method or direct killing. It states that the choice of methods used may be influenced by a number of criteria including the species and size of the reptile, and that the killing process should:

- minimise agitation, fear, stress and pain to the reptiles;
- be appropriate for the species, size, age and health of the reptile;
- be reliable and reproducible;
- include the use of a stunning method (in accordance with Article 7.14.2.) followed by a killing step; or alternatively
- a one-step direct killing method; and
- when it includes a stunning step, ensure that death occurs during unconsciousness.

The Code, then provides criteria (or measurables of consciousness, e.g. eye movement) to assess the outcome of the stunning or killing, that are useful indicators of animal welfare.

Below, taken directly from the Code, lists the various killing methods outlined in the Code along with their recommendations for effective use.

Penetrative captive bolt

The aim of this method is to produce a state of unconsciousness and cause severe damage to the brain by the impact and penetration of a captive bolt using a mechanical device.

- reptiles should be effectively restrained;
- the device should be correctly positioned on the head to result in the penetration of the brain by the bolt;
- the bolt should be of appropriate mass, length, diameter and shape;
- cartridge or compressed air specifications should be determined to deliver the correct bolt velocity;
- equipment and charge should be selected to suit the species, size and type of the reptile;
- equipment should be cleaned, maintained and stored, following manufacturer's recommendations.

Non-penetrative captive bolt

The non-penetrative captive bolt method is sometimes called 'concussive stunning', although concussion is the underlying principle for both penetrative and non-penetrative methods. The concussion may result in both unconsciousness and death.

- reptiles should be effectively restrained;
- the device should be correctly positioned on the head to allow optimum transfer of energy to the brain;
- the bolt should be of mass, diameter and shape appropriate to the anatomy of the cranium and brain;
- the equipment should be appropriately selected and maintained and adjusted for the species, size and type of the reptile;
- cartridge or compressed air specifications should be determined to deliver the correct bolt velocity;
- equipment and charge should be selected to suit the species, size and type of the reptile;
- equipment should be cleaned, maintained and stored, following manufacturer's recommendations.

Percussive blow to the head

A percussive blow to the head to induce cerebral concussion can be achieved manually. A concussive state is normally associated with a sudden loss of consciousness with associated loss of reflexes. Inducing unconsciousness requires

7 OIE Terrestrial Animal Health Code, Chapter 7.14 https://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_aw_reptiles.htm

the transfer of sufficient energy into the brain to disrupt normal neural function. If the severity of the blow is sufficient then it will ultimately result in the *death* of the animal.

Recommendations for effective use of percussive blow to the head in relation to animal welfare are:

- reptiles should be effectively restrained;
- the blow should be correctly applied to result in optimum transfer of energy to the brain;
- the tool should be of appropriate size and weight, and the blow of sufficient force to induce concussion;
- equipment and method should be selected to suit the species, size and type of the reptile.

Gunshot

An effective gunshot, where the projectile enters the brain, can cause immediate unconsciousness and death. A gunshot to the heart or neck does not immediately render a reptile unconscious and therefore should not be used. If death does not occur following the gunshot, then an additional killing method should be used immediately to ensure death.

- accurate targeting of the brain should be ensured;
- selected firearm and projectile should be suitable for the species, size and type of the reptile;
- equipment should be cleaned and stored following manufacturer's recommendations.

Pithing

Pithing is an adjunct method used to ensure death by destruction of brain tissue. It is carried out by inserting a rod or probe through the foramen magnum or shot hole from a penetrative captive bolt or gunshot, into the brain. After insertion of the rod or probe it should be promptly turned a minimum of four times in a centrifugal motion to ensure destruction of the brain tissue. Recommendations for effective use of pithing in relation to animal welfare are:

- pithing should only be used in unconscious reptiles;
- movement of the pithing implement should ensure maximum destruction of brain tissue.

Decapitation or spinal cord severance

Decapitation involves cutting the neck of the animal, between the skull and the first cervical vertebra using a sharp instrument (guillotine, axe or blade) leading to severance of the head. For some reptile species, decapitation is not anatomically feasible. For severance of the spinal cord, complete separation of the head from the neck is not necessary. Some reptiles may remain conscious for over an hour after decapitation or spinal cord severance, which makes decapitation or severance of the spinal cord acceptable only in stunned and unconscious reptiles and when followed by immediate destruction of the brain. Recommendations for effective use of decapitation or spinal cord severance in relation to animal welfare are:

- decapitation or spinal cord severance should only be used on unconscious reptiles;
- decapitation or spinal cord severance should always be followed immediately by physical intervention to destroy the brain, i.e. immediate crushing of the brain or pithing.

Chemical agents

There are a number of chemical agents that, subject to relevant regulatory approvals, can be used for the restraint or killing of reptiles. If death does not occur following administration of the agent, then an additional killing method should be used.

2.3. Framework for evaluating humaneness of measures

Here we present a framework to support decision-making associated with pursuing the IAS Regulation. Where this regulation requires Member States to manage free-living populations of invasive alien species (IAS), alternative approaches may be considered, which may include the use of different measures. However, measures may vary in the animal welfare impacts that they cause for either the target IAS, or non-target species. Different measures may also vary in terms of practicality, and independently in their likelihood of success or cost. This tool is intended to support decision-makers in making reasoned choices between alternative measures where issues of humaneness are duly considered alongside issues of practicality, effectiveness, and cost.

The international standards and EU rules on animal welfare pertinent to the subject are outlined above. Most do not apply directly to individual vertebrate species considered here (the exceptions being bird species and those listed in the AIHTS). However, the basket of international rules on related species, or derived from related disciplines do inform the expectations stakeholders may have regarding which measures are permissible/impermissible and the level of welfare impact might be acceptable. From these we define a series of principles which form the basis for the criteria used to triage the measures identified here that are [potentially] available for the eradication, control and containment of populations of vertebrate IAS of Union concern.

In addition, we outline a framework of criteria to assess humaneness as part of the overall assessment of individual measures selected and presented in this manual.

2.3.1. Humaneness and its dependence on the ethical context

Humaneness is a poorly defined concept relating to the acceptability of the pain and distress we may cause animals in pursuit of our policies or goals (Hampton et al., 2020). Most problematically, it is often reduced to a binary state, with activities considered to be either 'humane' or 'inhumane'. Oversimplification of this complex field of thought may discourage operators from continually striving for the approach with the lowest welfare impact, on the basis that all 'humane' approaches are equally 'humane'. In this manual, the use of the binary expressions, 'humane/inhumane' or 'acceptable/unacceptable' is therefore avoided. The aim is rather to describe measures along an axis of welfare impact to permit decision-making that selects the methods producing least welfare impacts as a matter of principle.

Users of the manual are strongly encouraged to adopt the method with the lowest welfare impact, without compromising the effectiveness of the management measures, so that control measures cause the least animal welfare harms to the least number of animals, taking into account other considerations such as costs, needs, benefits, feasibility and public perception, a moral position adopted by many working in this field (Powell and Proulx, 2003, Sharp and Saunders, 2011, Dubois et al., 2017, Sharp et al., 2011).

Whilst a measure to manage IAS that is guaranteed to be free of pain or distress and therefore having no welfare impact would be ideal, it may be unachievable in the practice of wildlife management. Methods permitting the instantaneous insensibility and death of free-ranging wildlife in their natural state (i.e. before the introduction of any anthropogenic stressor associated with management) often produce a risk of unmitigated injury and extended periods of pain before death. For example, even the most experienced and well equipped marksman may fail to place a headshot and may therefore maim an animal which then escapes injured; similarly, a failed strike from a 'humane' kill-trap may seriously injure an animal but fail to pin it, permitting it to escape and endure a slow death over many days. Methods

which guarantee a certain death (i.e. a time-limited end to unmitigated or continuing harms) usually involve restraining animals with traps or snares, which may produce a degree of harm (e.g. stress, injury) to all animals (including non-target species). Furthermore, ongoing development and evaluation of methods are needed because methods that cause the least harm at a given time may be superseded by less harmful methods in the future. As proposed by Littin et al (2004), as well as using the most humane management methods that achieve the aims in any given situation, people should aim to maximise the humaneness of existing methods and to identify new methods that are more humane.

In order to minimise the impact of invasive alien species, the IAS Regulation identifies three broad goals of management measures, i.e. eradication, population control or containment, a choice to be made by the Member States as appropriate to their specific circumstances. As the total animal welfare impact of a particular management operation will depend on the level of impact on an individual as well as on the number of individuals involved, the decision of the measures to be taken and the goal to be achieved should be described and communicated as unambiguously as possible. In particular, both the value of purpose (i.e. the conservation benefit and the goal's achievability) and the number of animals that may be harmed must be clear.

In this sense, **only eradication could represent a specific unambiguous outcome in terms of animals to be harmed**, albeit one which might be produced in varied ways across varied timescales. The specification of the programme of work which might deliver even this outcome is therefore uncertain and adaptive management approaches are often needed to guide management as eradications proceed. An understanding of the extent of the target population, demography, ecology, behaviour, and reproductive capacity, and the effectiveness of the chosen method are then required to judge the likelihood of success (Dubois et al. 2017). In a review of large mammalian eradications, Robertson et al. (2017) observe that understanding the area over which a population has established is a more useful metric when planning eradications than attempting to estimate population size.

The advantages of well-planned eradication programmes, also in terms of the impact on animal welfare, should be adequately communicated to increase public support. If the population is effectively eradicated at an early stage of the invasion, this may avoid the suffering of a larger number of animals being harmed in the long term through perpetual population control or containment efforts across extensive areas. When selecting methods to achieve rapid eradication, and without disregarding the impact on animal welfare, this places the emphasis on those with high effectiveness to minimize the number of animals need to be controlled. This may influence the balance between humaneness and effectiveness when considering the choice of suitable methods. Conversely, goals seeking either population control or containment of a species require a more detailed specification still, especially regarding the purpose, scope and scale of operations.

In defining a programme of work (including allocation of resources and timescale), selecting the methods to apply and setting the management goals, it is also important to assess the potential of failure. The ethical risks of failure include outcomes where a potentially large number of animals, both target and non-target species, will have suffered without having achieved the desired conservation benefit.

It is only in this context that the ethical harm/benefit calculation for the project as a whole, and the contribution the selected measures make to producing harm can be evaluated. As such, it is impossible to discuss and identify a consistent and general lower limit of humaneness applicable to all goals, but only to projects which relate to well specified programmes of work. It is therefore more useful to consider the position of each measure along a single axis of humaneness

so that methods might be compared, and to support decision-makers who should choose, in principle, the most humane method available (while considering all other factors).

2.3.2. Approach taken for evaluating measures against minimum standards

Basic principles of the management of invasive alien vertebrate species involve the deployment of management measures to permanently remove animals from the environment. The most certain and sustainable approaches are to remove animals, either by killing them, or bringing them into captivity. Alternatively, management that aims to limit or contain populations might involve approaches such as building barriers to the movement of some IAS, or fertility control; although the difficulties of achieving practical use of either of these approaches for vertebrate IAS included on the Union list under the IAS Regulation make their use experimental and restricted to very specific scenarios. Successful projects are likely to be those which combine different approaches at different phases of operations with the appropriate coordination by the competent authorities being an important factor for success.

Approaches to managing IAS will themselves often comprise combinations of sub-measures. For example, some approaches to deliver lethal management, as well as those bringing animals into captivity, and currently those delivering fertility control, all require animals to be caught and restrained so that they can be approached by an operator. For some species, various methods of restraint might be available which vary in the welfare impacts that they produce. It is therefore possible to assess and promote / proscribe individual sub-measures for particular species (e.g. specific methods of restraint or dispatch).

However, some approaches may use methods which are considered inappropriate for use in a modern programme for managing or controlling free-living wildlife, including the IAS of Union concern. Such methods might include those for which social objection is likely (e.g. use of broadcast toxicants in inhabited areas, bringing a large number of animals into captivity), are considered to be unnecessarily harmful to animal welfare (e.g. use of indiscriminate kill-trapping; use of live animal decoys; traps or snares checked at intervals longer than 24 hrs), or for which no objective evidence will dissuade stakeholders that there are not moral concerns (e.g. drowning traps) and which might otherwise provoke interference from sections of society. As such, the measures identified were classified into one of three tiers in order to exclude some measures before they were assessed in detail (see 'feasibility' criteria **Section 1.3**). These are:

1. Removed from consideration because of insurmountable pan-European regulatory barriers (i.e. they are strictly illegal across Europe, or likely to be illegal in most countries);
2. Removed from consideration because they are considered to be inappropriate as part of a modern IAS management programme (i.e. no longer in use, or unlikely to be used to manage IAS);
3. Retained for assessment.

Justification for inclusion in tier 1 is self-explanatory and includes by way of example the use of leg-hold traps to restrain animals. Justification for inclusion in tier 2 reflects the authors' consensus opinion that some measures should not be considered because they are likely to produce significant problems wherever they are deployed; because they are likely to breach the principles established in the IAS Regulation (Art. 19(3)); or are likely to receive overwhelming objections from wider society. An example for inclusion in tier 2 would be hunting and killing animals with dogs.

2.3.3. Approach taken for assessing humaneness of measures

Comparing all measures along a single axis of humaneness requires that we integrate the pain, fear and distress inherent in the typical operation

of a measure into a single framework. For lethal methods this would include the pain, fear and distress produced by its intended function, as well as the likelihood of failures which might cause harm, and the severity of the harm they might produce. Therefore, the principles used by Sharp and Saunders (2011) (itself based on Mellor and Reid (1994), and Broom 1999) which are discussed in detail above, have been adopted and used to assess measures in terms of their likely impact on an individual animal and assumed the measure is applied using any available best practice. Component considerations used to compare measures or sub-measures include:

- Time to death/irreversible unconsciousness;
- Pain level and duration;
- Anxiety, fear, distress incurred;
- Reliability/effectiveness;
- Long-term implications of failure of management method (e.g. sub-lethal dose, injuries from trapping etc.).

For measures which encompass a number of subtypes, each sub-type has been evaluated independently where evidence is available. An example would be for the measure *Aquatic barriers* (**Appendix 2**), where the different 'types', including electric, acoustic, light, physical, CO_2, etc, are discussed and assessed separately.

All measures have been scored using the Sharp and Saunders (2011) impact categories across the 5 welfare impact domains (detailed in **Appendix 33,** summarised in **Figure 2**). The degree of impact in each domain is rated on a three-step scale (compressing the 5-step scale used by the authors): i. no impact, ii. mild or moderate impact, iii. severe or extreme impact. Note that the score given to domain 5 is usually considered the 'overall impact' since this represents the outcome of the impacts in the other four domains and is generally, but not always, equivalent to the most extreme potential impact given in the other 4 domains. It is important, when considering the relative scores of non-lethal methods that the duration of the harms be taken into account appropriately. For example, harms may persist over the animals lifetime (e.g. bringing them into captivity) or be produced indirectly by maintaining artificially high densities of wild animals (erection of barriers, or landscapes managed to lower the carrying-capacity of habitats, receiving locations in translocation projects).

For measures that are lethal, the mode of death has been assessed separately and again uses a compressed version of the impact scale developed by Sharp and Saunders (detailed in **Appendix 33**) which assesses suffering and duration to irreversible unconsciousness, i. immediate death (i.e. no suffering), ii. not immediate death (mild - moderate suffering), iii. not immediate death (severe - extreme suffering).

2.4. International and EU standards, regulations and guidance - conclusions

With respect to management, there are very few pieces of legislation that ban outright the use of specific methods for invasive alien species. Even where some methods are prohibited or restricted in principle, exemptions, permits or licenses to undertake such activities can often be allowed by the competent authorities for necessary purposes. Most of the conservation legislation does not offer any protection for non-native animals or birds. The AIHTS only covers three of the species on the EU IAS list of Union Concern – although inferences on humaneness and welfare criteria could be read across to other species on the list.

Legislation and scientific information can be used as a guide to identify potential welfare impacts;

however, circumstances, urgency, targeted species, and numbers of individuals will also have a major effect on the type of management used and then on animal welfare. For example, kill trapping or cage trapping and dispatch of rodents are accepted as having a smaller welfare impact than the use of anticoagulant rodenticides (Baker et al. 2022), but for island eradications (e.g. non-native mice on islands) the latter is often used as the only practical solution.

2.5. Overview of standards, regulations and guidance within EU Member States

The standards, regulations and guidance from the EU Member States relevant to the welfare of animals during their management are presented in a series of regional Appendices to this manual (**Appendices 34-41**). The information in these appendices **should not be taken as legal guidance** to identify if a measure can or cannot be used, or what restrictions are placed on their use, but rather as a general overview to inform the user. As already noted, standards and regulations are constantly being updated, and this is particularly true within Member States. Therefore, information presented in this manual and its Appendices will become outdated as new legislation is enacted across the EU. **It is therefore essential that anyone planning on undertaking any of the measures set out in this manual should first contact their relevant National Authorities to understand the legal frameworks that they need to operate within**.

3. Measures not assessed

This manual does not include the assessment of measures used for detection alone, and/or for objectives that are not eradication, control or containment of IAS populations (e.g. prevention, or methods to exclude animals from sensitive areas). These measures usually have a lower impact on animal welfare compared to direct management methods, and they can be particularly cost-effective in minimising the IAS impacts on biodiversity, related ecosystems services and, where applicable, on human health or the economy. Without aiming at providing an exhaustive description, these measures are shortly presented below noting their cost-effectiveness and potential animal welfare impacts when relevant.

3.1. Exclusion measures

Fences and barriers used to contain the spread of IAS are assessed as two separate measures in this manual, as aquatic barriers, and physical terrestrial barriers. However, fences and barriers are also a useful tool to prevent IAS accessing sensitive or protected areas, or for supporting management or eradication actions in restricted areas (i.e. prevention of escape). Electric fences could be useful alone or in combination with conventional fences (Orueta and Ramos, 2001). For example, fences have been used frequently in Australia for dingoes and rabbits, helping to reduce the species density in some protected areas (Gregory et al., 2014). A 4-km fence was constructed in Okinawa island to separate a *Herpestes auropunctatus* control area (about 30,000 ha) where the species was cage-trapped from the uncontrolled area (Barun et al. 2011). During a management programme, a pond was fenced to avoid dispersal of adult and sub-adult American bullfrogs and to drive individuals toward pitfalls (large buckets of 20 litre) where they could be trapped (Goverse et al. 2010). Fencing has been used also in the Danish island of Fano to protect nesting seabirds from foxes (Dansk Ornitologisk Forening, 2020). This technique has particular potential for IAS that are predators such as *Nyctereutes procyonoides, Procyon lotor,* and *Nasua nasua* and for *Muntiacus reevesi*. However, as all exclusion methods, fencing must be monitored and managed closely in order for it to be effective and the fencing design should be specific to the target species. While fencing may cause occasional injuries and behavioral/interactive restrictions to the animals, it is in general considered highly humane when used as a non-lethal method to prevent IAS accessing sensitive or protected areas. It must also be stressed that fencing will potentially have impacts upon non-target species, depending upon the type of fence/barrier used, leading to behavioural/interactive restrictions and possible injury. When fencing is followed by lethal measures, the additional impact of these on animal welfare should be considered.

Repellents and deterrents are effective only in conjunction with other measures to avoid local spread and damage (Orueta and Ramos, 2001). An example is Capsaicin, which is a repellent used to deter mammalian predators from bird nests: it has been shown to be effective with little to no welfare impacts, as it only provides an unpleasant

taste to mammals, and it is not harmful to birds (Bayliss et al., 2012).

Guard dogs can be used to protect certain species from IAS in specific situations. An example of its success was the introduction of Maremma guard dogs in Middle Island, Australia, to protect a breeding colony of Little Penguins (*Eudyptula minor*) from fox predation (King et al., 2015). It has been suggested that this technique could be very effective for the conservation of some threatened seabird populations. Furthermore, it has been evaluated as a more humane way to protect penguins compared to killing foxes with other measures such as shooting, poison, fumigation and traps.

3.2. Preventive measures

Education and public-awareness-oriented programmes. The establishment of education and public awareness programmes can engage local communities and relevant stakeholder groups to change behaviours to prevent the purchase, release, and spreading of alien animals. Public engagement can also be used to mitigate conflict and build support for management actions (Crowley et al., 2017) and to support enforcement of legislative measures. General consultation could serve not only to gather evidence of support/opposition to the management proposals, but also to gather information to help make the key decisions, e.g. by seeking information on possible impacts or management costs to particular sectors.

3.3. Detection measures

In order to implement effective prevention, eradication, control or containment of invasive alien species populations, accurate and timely species' identification is required. The following methods have been applied to detect IAS of Union concern:

Citizen science programmes provide data that are highly valued (Pescott et al. 2015) and are widely used to report on introductions and ranges of alien species. There are a wide range of international (e.g. eBird) and country specific (e.g. BirdTrack) data portals that contain real time data on IAS occurrence. They are dependent on (often lay) members of the public who collect and upload data, and the majority of data are gathered through opportunistic sampling, meaning that there is no underlying scientific survey design (Boakes et al. 2010). This means data-quality issues need to be addressed and data collected by the public must be validated whenever possible. However, the use of information technology can be used to rapidly convert citizen science data to information that can support policy decision making (Groom et al., 2019).

Professional monitoring using field experts and dogs, field cameras and laboratory genetic determination (incl. eDNA). Automatic cameras with motion sensors can be set where there are possible sightings or suspicious traces (e.g. excrement or signs of presence).

4. Toolbox of measures

Here a 'toolbox of measures' is presented to support the identification of which measures are (potentially) available to eradicate, control and contain populations of the 22 vertebrate IAS of Union concern (**Table 8**). It lists the species against the individual measures, identifying the availability of each measure (available, under development, or potential) and the objective it can be applied for (rapid eradication, eradication, control, or containment of populations). Note that some measures are identified as being applied for 'Unknown [other]' objective; these are mostly in relation to their use in surveys, detection or research (e.g. for electrofishing). The availability of many of the measures are identified as 'Potential' for some of the species; this is often based on expert opinion where no evidence could be readily mobilised and usually based on the fact that the measure has been applied to a similar species.

It must be stressed that if a measure is listed for a species, it does not mean it should be used, but rather that there is evidence that it can be [potentially] used. Many other aspects need to be taken into consideration before implementing a measure to manage a species, including: resource and expertise availibility; legal restrictions; welfare impacts; costs and effectiveness; side effects; and stakeholder support. In order to support this decision making process once the species of interest has been identified, the user should then view the humaneness summaries of the individual measures (**Section 5**), and the relevant species account which summarises the effectiveness and costs of the available measures (**Section 6**). These sections, when considered together, will help inform the user which of the detailed measure assessments to refer to for more information (**Section 7 and Appendices 1-32**). These appendices provide detailed information for each measure, including their methods of application to all species, and available best practices. They also include the full assessments of humaneness, costs and effectiveness. Finally, information on the legal frameworks and any restrictions or bans upon the application of the measures in EU Member States are provided in the regional conditions appendices (**Section 8 and Appendices 34-41**).

Table 8. Toolbox of measures

Measures that are (potentially) available to eradicate, control and contain populations of the 22 vertebrate IAS of Union concern.
Availability: *A = Available, U = Under development, P = Potential.*
Objective:
Un = Unknown = *Objective is unknown or other, e.g. monitoring or detection.*
RE = Rapid eradication *= Measures to achieve eradication (permanent removal) of the population of the IAS, at an early stage of invasion, after an early detection of a new occurrence (cf. Article 17).*
Er = Eradication *= Measures to achieve eradication (permanent removal) of the species once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19).*
Cl = Control *= Measures to achieve population control of the species once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19).*
Ct = Containment *= Measures to achieve containment of a population of the species once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19).*

Category	Measure name	Objective	*Acridotheres tristis*	*Alopochen aegyptiaca*	*Callosciurus erythraeus*	*Corvus splendens*	*Herpestes javanicus*	*Lepomis gibbosus*	*Lithobates catesbeianus*	*Muntiacus reevesi*	*Myocastor coypus*	*Nasua nasua*	*Nyctereutes procyonoides*	*Ondatra zibethicus*	*Oxyura jamaicensis*	*Perccottus glenii*	*Plotosus lineatus*	*Procyon lotor*	*Pseudorasbora parva*	*Sciurus carolinensis*	*Sciurus niger*	*Tamias sibiricus*	*Threskiornis aethiopicus*	*Trachemys scripta*
Biological control	Native predators	Unknown																						
		Rapid erad.																						
		Eradication																						
		Control						P	A							A			A					P
		Containment						P	A							A			A	P				
Habitat manipulation	Aquatic barriers – physical & non-physical	Un																						
		RE						P	A							P			P					
		Er																						
		Cl						P	A							P			P					
		Ct						P	A							A&P			A					
	Aquatic habitat management - Pond drying/ draining	Un						A	A							P			P					P
		RE						A	A							A			A					P
		Er																						A
		Cl						A	A							A			A					P
		Ct						P	A							P			A					P
	Physical terrestrial barriers	Un							P															P
		RE																						
		Er																						
		Cl																						
		Ct							P															P

Category	Measure name	Objective	*A. tristis*	*A. aegyptiaca*	*C. erythraeus*	*C. splendens*	*H. javanicus*	*L. gibbosus*	*L. catesbeianus*	*M. reevesi*	*M. coypus*	*N. nasua*	*N. procyonoides*	*O. zibethicus*	*O. jamaicensis*	*P. glenii*	*P. lineatus*	*P. lotor*	*P. parva*	*S. carolinensis*	*S. niger*	*T. sibiricus*	*T. aethiopicus*	*T. scripta*
Hand removal	Hand removal	Un	P	P		P		P	A	A		A			P	P	P						P	P
		RE				A			A						P				A				P	A
		Er		P		A			A						A				A				A	A
		Cl		A					A						A								A	A
		Ct		A					A						P								P	A
	Physical fishing methods	Un						A	P							P			A					P
		RE						P	A							P			A					A
		Er																						P
		Cl						A	A							P	P		A					A
		Ct						A	A							P			A					A
Other	Egg oiling	Un																						
		RE	P			P																	P	
		Er	P	P											A								P	
		Cl	P	A		A									A								A	
		Ct	P	A											A								P	
	Electrofishing	Un						A	P							A			A					
		RE						P	A							A			A					
		Er																						
		Cl						P	P							A			A					
		Ct						P	P							P			P					
	Fertility Control - chemical (in bait) & injection	Un																						
		RE																						
		Er							U															
		Cl			P				U	P		P	P	P				P		A	P	P		
		Ct							U				P					P						
	Hunting dogs (tracking/ baying)	Un			P		A			P	A	P	P	P				P		P	P	P		
		RE			P						P	P	A	P				A		P	P	P		P
		Er			P					P	P	P	A	P				A		P	P	P		P
		Cl			P		P			P	P	P	A	P				A		P	P	P		A
		Ct			P		P			P	P	P	A	P				A		P	P	P		
	Judas animals	Un	P			P	P			P	U	P	A	P				U					P	U
		RE				P							A											
		Er								P			A											
		Cl								P			A											
		Ct								P			A											

Category	Measure name	Objective	*A. tristis*	*A. aegyptiaca*	*C. erythraeus*	*C. splendens*	*H. javanicus*	*L. gibbosus*	*L. catesbeianus*	*M. reevesi*	*M. coypus*	*N. nasua*	*N. procyonoides*	*O. zibethicus*	*O. jamaicensis*	*P. gleni*	*P. lineatus*	*P. lotor*	*P. parva*	*S. carolinensis*	*S. niger*	*T. sibiricus*	*T. aethiopicus*	*T. scripta*
Poisoning or toxicants	Stupefying bait	Un								P														
		RE																						
		Er	U			U																	A	
		Cl	U	P		U																		
		Ct																						
	Chemical treatment of the habitats	Un							P		P													
		RE						P						P		P			A					
		Er						P								P			A					
		Cl						P								P			P					
		Ct																						
	Poisons and toxins in bait	Un																						
		RE					P																	
		Er					P													A				
		Cl					P							P						A				
		Ct					P																	
Shooting	Shooting	Un																						
		RE	A	A	A	A			P	A	A	A	A	A	A			A		A	P	P	A	P
		Er	P	A	A	A			A	A	A	A	A	A	A			A		A	P	P	A	P
		Cl	A	A	A	P	A		A	A	A	P	A	A	A			A		A	P	P	A	A
		Ct	P	A	A		A		A	A	A	P	A	A	A			A		A	P	P	A	A
Trapping	Drowning traps	Un									A			A										
		RE																						
		Er																						
		Cl									A			A										
		Ct									A													
	Goodnature self-resetting traps	Un			P		P													A	P	P		
		RE			P		P													P	P	P		
		Er			P		P													P	P	P		
		Cl			P		A													P	P	P		
		Ct			P		P													P	P	P		

Category	Measure name	Objective	*A. tristis*	*A. aegyptiaca*	*C. erythraeus*	*C. splendens*	*H. javanicus*	*L. gibbosus*	*L. catesbeianus*	*M. reevesi*	*M. coypus*	*N. nasua*	*N. procyonoides*	*O. zibethicus*	*O. jamaicensis*	*P. glenii*	*P. lineatus*	*P. lotor*	*P. parva*	*S. carolinensis*	*S. niger*	*T. sibiricus*	*T. aethiopicus*	*T. scripta*
Trapping	Spring traps	Un			P		A				A	P	A	A				A		A	P	P		
		RE			P													P		P	P	P		
		Er			P		P					P	P	A				P		P	P	P		
		Cl			P		P					P	P	A				A		A	P	P		
		Ct			P		P					P	P	A				P		P	P	P		
	Cage traps	Un	A	A	P	P	P			A	A	P	A					A		A	A	A	P	A
		RE	A	A	P	A	A				A	A	A		A			A		A	A	A	P	P
		Er	A	A	A		A			A	A	A	A	A	A			A		A	A	A	P	A
		Cl	A	A	A		A			A	A	A	A	A	A			A		A	A	A	P	A
		Ct	A	A	A		A			A	A	A	A	A	A			A		A	A	A	P	A
	Neck-hold traps, and snares	Un					P				P	P	P					P						
		RE											P											
		Er					P					P	P					A						
		Cl					P					P	P					A						
		Ct					P					P	P					A						
	Live decoy traps	Un	A	A		P																		
		RE	A	A		P																		
		Er	A	A		P																		
		Cl	A	A		P																		
		Ct	A	A																				
Dispatch/ removal only once captured	Cervical dislocation		P	P	A	P	P	P	P						P	P	P		P	A	A		P	P
	Cranial depression		A	A	U	P	P	P	A	A	P	P	P	P	P	P		P	P	A	A		P	P
	Decapitation		P	P	P	P		P	P							P	P		P	P	P	P	P	P
	Electrocution		P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	Freezing							A	A										P					A
	Injection euthanasia		P	P	P	P	P	P	A	P	P	P	P	P	P	P		P	P	A	A	P	P	A
	Keeping in captivity		P	P	A	P	P	P	P	P	P	P	P	P	P	P		A	P	P	P	P	P	A
	Modified atmospheres		A	A	A	P	P				A	A	P	P	P			P		A	A	P	P	P
	Shooting - dispatch restrained animals		P	P	P	P	P			P	A	A	P	P	P			A		A	A	P	P	A
	Slaughter (knife)		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	Surgical sterilisation		P	P	P	P	P			P	A	P	P	P	P			A		A	P	P	P	A

Source: Compiled by authors

5. Humaneness summaries

Each measure has been assessed in terms of its likely impact on an individual animal and assuming the measure is applied using any available best practices. The impact categories for the humaneness assessment for each measure according to their 'overall welfare impact' (using the 5 domains), and where relevant for 'mode of death' (see **Table 9**) are presented, and a rationale is provided to support the assessment. The full details of the impact categories as provided by Sharp and Saunders (2011) are presented in **Appendix 33**. As an individual measure can lead to a range of possible welfare impacts/outcomes depending upon the different types of the measure being applied, and the species it is applied to, often more than one category is assigned for each measure. Please see the individual measure assessments for more information on the humaneness assessments (**Section 7 and Appendices 1-32**), including where common misapplication of the measure may lead to unnecessary welfare impacts.

This section, when used alongside the species accounts (**Section 6**), is designed to help users quickly understand the key aspects in relation to the effectiveness and welfare impacts of the available measures for the capture/restraint or removal from the wild, and for the dispatch/removal once captured. It is intended that the user should then refer to the relevant individual measure assessments for more detailed information (**Section 7** and **Appendices 1-32**).

Table 9. Humaneness assessment impact categories

	Overall welfare impact (5 domains) Assesses the humaneness impact of a measure, excluding the actual killing of the animal (if the measure involves killing)			**Mode of death** Assesses the humaneness impact of the killing method (if the measure involves killing)		
Impact categories	No impact	Mild – Moderate impact	Severe – Extreme impact	Immediate death (i.e. no suffering)	Not immediate death (Mild – Moderate suffering)	Not immediate death (Severe – Extreme suffering)

Source: Adapted from Sharp and Saunders (2011)

5.1. Biological control

Measure	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Native predators	No impact	No impact	Mild – Moderate to Severe – Extreme impact	No impact	Mild – Moderate to Severe – Extreme impact	No suffering to Mild – Moderate suffering
	Native predators select prey (including those with dependent young) and hunt according to their own requirements and capabilities, without any reference to human expectation. Kills may not be swift, and hunts may injure prey without always killing them but predation in most contexts will produce a very short period of extreme fear (pursuit) and a short period of suffering (seconds).					

5.2. Habitat manipulation

Measure	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Aquatic barriers – physical	No impact	No impact to Mild – Moderate impact	No impact	No impact	No impact	Not applicable
	Physical barriers have little or no welfare impact upon the aquatic IAS of Union concern.					
Aquatic barriers - non-physical	No impact	No impact to Mild – Moderate impact	No impact to Severe – Extreme impact	No impact to Mild – Moderate impact	No impact to Severe – Extreme impact	Severe – Extreme suffering
	Non-physical barriers that work as deterrents, have little or no welfare impact upon the aquatic IAS of Union concern. Electric and CO_2 barriers have the potential for more serious welfare impacts. Ozone is the only barrier that is intentionally lethal, and exposure to non-lethal doses can lead to serious injury.					

Measure	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Aquatic habitat management - Pond drying/draining	Mild – Moderate impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate impact	Mild – Moderate impact to Severe – Extreme impact	Severe – Extreme suffering
	Depending on how long after draining, and under which circumstances, the target species is removed from the water body, this measure can expose aquatic animals to extreme conditions, i.e. acute exposure to air and lack of water. Therefore when applying this measure, it is important to ensure that all target aquatic animals are removed from the water body before it is completely devoid of water and later euthanised appropriately, in order to guarantee that the measure is applied avoiding unnecessary welfare impacts. When this measure is used to kill animals, i.e. through acute exposure to air and lack of water, it will lead to a slow death with severe/extreme levels of suffering.					
Physical terrestrial barriers	No impact to Mild – Moderate impact	No impact	Mild – Moderate impact	Mild – Moderate impact	No impact to Mild – Moderate impact	Not applicable
	The impact on the animals' welfare may be limited to occasional injuries and behavioural/interactive restrictions. The additional impact of neutering the contained animals should be considered if relevant.					

5.3. Hand removal

Measure	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Hand removal	No impact	No impact	No impact to Mild – Moderate impact	No impact	Mild – Moderate impact	Not applicable
	Hand removal is generally fast and does not involve particular severe impacts on animals. However, handling and restraint of animals almost certainly will produce fear in wild species, and could potentially lead to some injuries. The duration of fear will depend to the time it takes to euthanize.					
Physical fishing methods	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate impact	Severe – Extreme impact	Not applicable
	Most types of aquatic nets used to capture animals usually involve some degree of environmental challenge (lack of oxygen), behavioural restrictions (inability to swim or hide from predators), distress and injury. The severity of injuries depends on the specific method used, the species in question and how the technique is undertaken.					

5.4. Other

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Egg oiling	No impact	No impact	No impact	Mild – Moderate impact	No impact to Mild – Moderate impact	No suffering to Mild – Moderate suffering
	Egg oiling causes the death of the developing embryo in the egg through asphyxiation. Young embryos are not considered able to feel pain so in these cases the method is considered to lead to little welfare impact. However, embryos in the last 20% of incubation can experience pain and in these cases they may experience suffering before death.					
Electrofishing	No impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Not applicable
	If properly used, electrofishing should not lead to the death of the animal. However, depending on many different factors, including the environmental conditions of the site being treated and the target species, the application of this method can have varying degrees of harmful effects on the animals targeted (as well as to bycatch).					
Fertility Control - chemical (in bait) & injection	No impact	No impact	No impact to Mild – Moderate impact	No impact	No impact to Mild – Moderate impact	Not applicable
	The measure in general is considered to have a mild welfare impact, although repeated treatments may have a cumulative effect. Further details on the impact of this measure for many of the vertebrate IAS of Union concern are needed. In relation to the use of triploidy in American bullfrogs it can be considered to have no impact on welfare. Although little information is available on the sensory capacity of amphibian eggs at the stage of development, given that the procedure takes place 10 minutes after fertilisation, negligible impacts are to be expected.					
Hunting dogs (tracking/ baying)	No impact	No impact	No impact to Mild – Moderate impact	No impact	No impact to Mild – Moderate impact	Not applicable
	Mild – Moderate impact is expected for the hunted animals (and the tracking/baying hunting dogs), given the use of appropriately trained dogs, or dogs that are wearing a muzzle. Time between finding the animal and death/handling/capture of the animal is short with dogs (minutes), for example compared with non-lethal trapping, where animals can be restrained for hours or more.					
Judas animals	No impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Not applicable
	Capture/recapture of Judas animals and culling of disclosed animals causes stress of varying severity to the Judas animals themselves. Their welfare may also be affected by surgical sterilisation, being introduced in new areas, being isolated and having to find other conspecifics. The severity of the stress is exacerbated by the repetition of these actions.					

5.5. Poisoning or toxicants

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	**Environmental challenge**	**Injury, disease, functional impairment**	**Behavioural, interactive restriction**	**Anxiety, fear, pain, distress, thirst, hunger etc.**	**Suffering before irreversible unconsciousness**
Chemical treatment of habitats	No impact	No impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate impact	Mild – Moderate impact to Severe – Extreme impact	Mild – Moderate suffering to Severe – Extreme suffering
	For the fish species and *Lithobates (Rana) catesbeianus*, different chemical treatments result in different degeres of humaneness impact, for example Rotenone leads to observable behavioural stress and death occurs between 24-36 hours (though time to death is heavily affected by water temperature). For the mammals, aluminium phosphide has a moderate impact (based on studies on rabbits), which cannot automatically be assumed to be the same for *Myocastor coypus* or *Ondatra zibethicus*.					
Poisons and toxins in bait	No impact	No impact	No impact	No impact	No impact	Mild – Moderate suffering to Severe – Extreme suffering
	For methods involving toxic baits it is likely that there will be no welfare impact prior to the animal ingesting the bait. However, anticoagulant rodenticides take days to cause irreversible insensibility before death and suffering is likely to range between moderate/severe/extreme. No approved poison product is available for *S. carolinensis* since approval for warfarin for use against this species lapsed in 2014. There are also no approved poison products in the EU for the other potential target species discussed here - *H. javanicus* and *O. zibethicus*. Until such time that regulatory approval of a substance with relatively low target and non-target welfare impacts emerges, the overall recommendation of this assessment is that the use of poisons and toxins in bait to manage IAS of Union concern is unsuitable. The use of baits also has the potential for non-specific killing of other animals through ingestion of toxin/bait directly or ingestion of poisoned animals.					
Stupefying bait	Mild – Moderate impact	No impact	No impact to Severe – Extreme impact	Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate suffering to Severe – Extreme suffering
	The welfare impacts of treatment with Alphachloralose depends critically on the operator's ability to quickly retrieve the animals that have taken the bait and humanely dispatch them, and also ensure the welfare of non-target species pending recovery. This, in turn, is dependent on dosage of the stupefacient received by each animal, which may be hard to control, and the extent to which the treated animals disperse.					

5.6. Shooting

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Shooting	No impact	No impact	No impact to Severe – Extreme impact	No impact	No impact to Severe – Extreme impact	No suffering to Severe – Extreme suffering
	If used appropriately, shooting should result in a rapid instantaneous death for the majority of animals, with no consequences for their welfare. However, shooting carries the risk of wounding with potentially severe consequences for the welfare of the animal concerned. This risk can be reduced by the selection of appropriate firearms and ammunition, detection devices and scopes, the training of the shooters, and measures to ensure wounded animals are followed and quickly dispatched with a second shot.					

5.7. Trapping

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Cage traps	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate impact	Not applicable
	If used appropriately by trained personnel, cage traps offer a flexible and relatively humane method of animal capture and restraint. If traps are checked at intervals appropriate for the species and are used correctly (e.g. avoiding extreme conditions and unsuitable locations), mortality rates associated with cage traps approach zero. Use of trap alarms is recommended to minimize time in the trap.					
Drowning traps	No impact	No impact	Mild – Moderate impact	Severe – Extreme impact	Severe – Extreme impact	Severe – Extreme suffering
	The use of drowning traps causes severe suffering in target and non-target animals. Death by drowning induced hypoxia is not considered an acceptable method of euthanasia by veterinary and laboratory researchers.					

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Goodnature self-resetting traps	No impact	No impact	No impact	No impact	No impact	No suffering to Severe – Extreme suffering
	No impact occurs before the killing method (trap triggering) is applied, and the manufacturer reports claim that these traps can cause irreversible unconsciousness instantly. However, the only data available on time to irreversible unconsciousness are unable to support such claims for Goodnature traps with ship rats, brushtail possums and stoats because of the practicalities of testing unconsciousness instantly after trap triggering. Goodnature traps for *S. carolinensis* have been approved in the UK indicating that in tests most squirrels were irreversibly unconscious in ≤300 seconds (exact times were not recorded). As individuals of *S. niger* can be much heavier than *S. carolinensis*, traps would need to undergo welfare testing for this particular species. The A18 Mongoose Goodnature trap is currently undergoing welfare testing but manufacturer reports claim that it can kill mongoose instantly. While these traps have the potential to cause only relatively limited suffering, severe to extreme suffering cannot yet be ruled out in some cases.					
Live decoy traps	Mild – Moderate impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate to Severe – Extreme impact	Not applicable
	Individuals used as the decoy will have their welfare impacted, and they must be provided with food, water, perches, space to stretch and shelter and protected from severe weather. Captured animals should be removed quickly based on regular inspection of the traps. Care is needed, for example in the placement of traps, to reduce the risks of predation.					
Neck-hold traps, and snares	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate to Severe – Extreme impact	Severe – Extreme impact	Severe – Extreme impact	Not applicable
	Animals caught in snares and snare traps (neck-hold traps/snares, and non-lethal stop-snares) commonly suffer moderate injuries, including damage to tendons or ligaments and amputation of a digit. Severe to extreme injuries also sometimes occur, with luxation or fractures of the limbs or amputation and snared animals may be severely injured or strangled. Sometimes animals chew or bite their own feet and limbs, or exhaust themselves trying to escape. Captured animals are potentially exposed for hours to environmental conditions outside their normal range and to attack by predators. Use of trap alarms is recommended to minimize time in the trap.					
Spring traps	No impact	No impact	No impact	No impact	No impact	No suffering to Severe – Extreme suffering
	No impact occurs under any domain before the killing method (trap triggering) is applied. The welfare impact of spring traps is likely to vary widely among species, trap model and the way the trap is used. When deployed according to best practise, they have the potential to produce instantaneous and irreversible insensibility and death, however potentially severe-extreme suffering cannot be ruled out. Traps must be checked regularly so that injured animals can be killed quickly. While traps that have passed AIHTS or NAWAC standards are expected to cause irreversible unconsciousness within 5 or 3 minutes respectively, other traps have not been tested in this way.					

5.8. Measures to dispatch/remove once captured

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Cervical dislocation	No impact	No impact	No impact	Mild – Moderate impact	Mild – Moderate impact	No suffering
	When performed correctly by well-trained individuals, cervical dislocation appears to be a method of euthanasia with a low welfare impact, which may induce rapid loss of consciousness and ensures a rapid death. It is feasible and effective in small fish but should be confirmed by exsanguination or destruction of the brain.					
Cranial depression	No impact	No impact	No impact	Mild – Moderate impact	Mild – Moderate impact	No suffering
	Cranial depression can represent one of the most humane methods of dispatch for restrained animals when applied by a trained operative. The animal is likely to experience fear for a very short period while being removed from the trap and presented for dispatch. Insensibility (and usually death) are instantaneous when cranial depression is applied by a competent operator. Generally, penetrating captive bolts are more appropriate for euthanasia of medium and large mammals. However, adequate restraint is important to ensure proper placement of captive bolts, and this becomes progressively more challenging with larger wild animals. Cranial depression is then not recommended for animals above 3 kg.					
Decapitation	No impact	No impact	No impact	Mild – Moderate impact	Mild – Moderate impact	No suffering
	While decapitation is considered a humane method of dispatching animals particularly in laboratories and farms, the method is not widely used in wildlife management.					
Electrocution	No impact	No impact	No impact	Mild – Moderate impact	Severe – Extreme impact	Mild – Moderate suffering
	The method is used for farmed animals and sometimes also with wild animals. Since animals do not lose consciousness for 10 to 30 seconds the method should not be applied without ensuring a rapid unconsciousness by passing a current through the brain before the animal is electrocuted. However, 'electrical and electronic devices capable of killing or stunning' are prohibited under Annex VI of the Habitats Directive (Council Directive 92/43/EEC).					

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	**Environmental challenge**	**Injury, disease, functional impairment**	**Behavioural, interactive restriction**	**Anxiety, fear, pain, distress, thirst, hunger etc.**	**Suffering before irreversible unconsciousness**
Cooling then freezing	No impact to Mild – Moderate impact	Mild – Moderate to Severe – Extreme impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	No suffering to Severe – Extreme suffering
	Rapid freezing of small amphibians and reptiles (<4g) will result in almost immediate death. Some amphibians, reptiles, and fishes can be euthanised through hypothermia (cooling followed by freezing) where the cooling acts as an anesthetic before freezing to ensure there is no suffering as the formation of ice crystals in the body could lead to pain (note that drugs, e.g. MS 222 can also be used to anesthetise). The appropriateness of the measures depends upon temperatrure tolerance, with species inhabiting areas where ambient (or water) temperatures fall to very low levels may maintain neural activity at lower temperatures compared to those found in warmer climates.					
Injection euthanasia	No impact	No impact to Mild – Moderate impact	No impact	No impact to Mild – Moderate impact	No impact to Mild – Moderate impact	No suffering to Mild – Moderate suffering
	This technique does not lead to suffering and is considered one of the most rapid and reliable methods of performing euthanasia. Sedation or anaesthesia is required, unless in case of direct intravenous administration, either to facilitate the handling of animals or to avoid fear and pain. Injection euthanasia is applied to restrained animals; therefore pain and stress are related to the technique employed to capture the animals (e.g. trapping) and to handle them before sedation. This measure also includes the (non-injection) application of use of drugs applied via water in order euthanize fish species. For this, welfare impacts can arise due to animals being kept in containers while the drug is administered. There is also evidence that some fish species exhibit stress before the animals lose consciousness.					
Keeping in captivity	No impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Not applicable
	The impact of captivity on a non-domestic animal is considered mild-moderate, depending on species-specific characteristics and scientific knowledge supporting best practices. In addition to the captivity itself, captured animals destined for a life in captivity will be confined in transport cages, transported and potentially quarantined, the cumulative welfare impacts of which should also be taken into account. Further research is needed to quantify the welfare outcomes associated with captivity on wild-caught individuals of the 22 vertebrate IAS of Union concern.					

Measures	Overall welfare impact (5 domains)					Mode of death
	Water deprivation, food deprivation, malnutrition	Environmental challenge	Injury, disease, functional impairment	Behavioural, interactive restriction	Anxiety, fear, pain, distress, thirst, hunger etc.	Suffering before irreversible unconsciousness
Modified atmospheres	No impact	Severe – Extreme impact	No impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate suffering to Severe – Extreme suffering
	Euthanasia using modified atmospheres is not as quick as most other methods of dispatch, with animals subjected to the method experiencing periods of distress lasting for some time (a number of 10s of seconds). In addition, it has the potential to be applied incorrectly and produce much greater suffering, especially where it is applied in field settings.					
Shooting - dispatch restrained animals	No impact	No impact	No impact	Mild – Moderate impact	Mild – Moderate impact	No suffering
	Shooting in a cage with a properly placed gunshot can cause immediate insensibility and humane death, making this one of the quickest methods of dispatch for restrained animals when applied by trained operatives. Personnel should be trained in correct and safe use of firearms and the anatomy of the species involved, in order to correctly target vital areas.					
Slaughter (knife)	No impact	No impact	No impact	Mild – Moderate impact	Mild – Moderate impact	No suffering
	Animals are slaughtered using a transverse cut across the throat, close to the head, causing exsanguination. The length of time between making the cut and loss of consciousness remains controversial. There are different opinions on whether the animal feels pain during the neck cut and if the resulting drop in blood pressure causes discomfort or distress. Therefore, slaughter with a knife should be considered a terminal procedure to be used only in stunned or anaesthetised animals and this assessment assumes that either stunning or anaesthesia has been applied prior to slaughter.					
Surgical sterilisation	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Mild – Moderate impact	Not applicable
	Assuming best practice application of this technique, this measure would rank as having mild-moderate humaneness impact. Despite surgical sterilisation being a one-off procedure to render permanent infertility, the long-term welfare impacts of sterilising on non-domestic species is still lacking research (i.e. behavioural changes, sociability, survival).					

6. Species accounts

This section presents individual species accounts for each of the 22 vertebrate IAS of Union concern. For each species, the measures [potentially] available to eradicate, control and contain their populations, as summarised in the 'toolbox of measures' (**Table 8**) are briefly discussed for their effectiveness. This section is intended to be used alongside the humaneness assessments (**Section 5**), to help users understand the key aspects in relation to the effectiveness and welfare impacts of the available measures. It is important to note that these sections (**5** and **6**) present a summary only, and the user should refer to the relevant individual measure assessments for more detailed information (**Section 7** and **Appendices 1-32**).

Key:

Objective and availability. For each of the 22 vertebrate IAS of Union concern a summary table presents each measure that is available for application to the species for the different management objectives (see toolbox for definitions). For each species the measures are listed with those that are 'available' first, and those that are only 'potential' last:

- Availability =
  A – Available;
  U – Under development;
  P – Potential.
- Objective =
  Un – Unknown/other objective;
  RE – Rapid eradication;
  Er – Eradication;
  Cl – [Population] Control;
  Ct – Containment.

When availability of a measure is identified as 'Potential', this is often based on the known application of the measure to a similar species, or in the case of measures used for dispatch based on use within veterinary sector.

Effectiveness and costs. Brief notes on the effectiveness and where available costs (though no cost-effectiveness assessments have been undertaken) of the measure's application to the species are also included. For measures used to dispatch/remove the species once captured, only information on their availability is presented.

The species are listed in alphabetical order of their scientific name:

Scientific name	English name
Acridotheres tristis	Common myna
Alopochen aegyptiaca	Egyptian goose
Callosciurus erythraeus	Pallas' squirrel
Corvus splendens	Indian house crow
Herpestes javanicus (=H. auropunctatus)	Small Indian mongoose
Lepomis gibbosus	Pumpkinseed
Lithobates catesbeianus	North-American bullfrog
Muntiacus reevesi	Muntjac deer
Myocastor coypus	Coypu
Nasua nasua	Coati
Nyctereutes procyonoides	Raccoon dog
Ondatra zibethicus	Muskrat
Oxyura jamaicensis	Ruddy duck
Perccottus glenii	Amur sleeper
Plotosus lineatus	Striped eel catfish
Procyon lotor	Raccoon
Pseudorasbora parva	Stone moroko
Sciurus carolinensis	Grey squirrel
Sciurus niger	Fox squirrel
Tamias sibiricus	Siberian chipmunk
Threskiornis aethiopicus	Sacred ibis
Trachemys scripta	Red-eared, yellow-bellied and Cumberland sliders

6.1. *Acridotheres tristis* (Linnaeus, 1766)

Acridotheres tristis (Common myna) © Budak CC BY-NC-ND 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Обикновена майна
Hrvatski	Croatian	obična mina
Čeština	Czech	majna obecná
Dansk	Danish	almindelig mynah
Nederlands	Dutch	treurmaina
English	English	common myna
Eesti	Estonian	mainakuldnokk
Suomi	Finnish	pihamaina
Français	French	martin triste
Deutsch	German	Hirtenmaina
ελληνικά	Greek	Κοινή μάινα
Magyar	Hungarian	pásztormejnó
Gaeilge	Irish	míona coiteann
Italiano	Italian	maina comune
Latviskiski	Latvian	parastā maina
Lietuviškaiškai	Lithuanian	paprastoji maina
Malti	Maltese	il-majna
Polski	Polish	majna brunatna
Português	Portuguese	mainá-indiano
Română	Romanian	myna indiană
Slovenčina (Slovenský jazyk)	Slovak	škorec hnedý
Slovenščina (Slovenski Jezik)	Slovenian	žalostna majna
Español	Spanish	miná común
Svenska	Swedish	brun majna

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting – dispatch restrained animals	A	A	A	A	A	Cage trapping is a frequently used and successful method to support the management of IAS. The requirement for regular checking brings significant implications for cost and their cost-effectiveness can be low in situations where the rate of animal capture is poor. Although the method is known to be available for the target species, further details are needed on its effectiveness and costs.
Live decoy traps	Cage traps, noose traps	A	A	A	A	A	The use of decoy traps requires initial decoy birds to be caught using another method. Decoy traps are the most widely used and cost-effective method for the eradication and population control of *Acridotheres tristis*. They are relatively cheap and the main costs are the manpower required for their placement and checking. In Europe, decoy trapping has been successfully used to rapidly eradicate this species from the Spanish islands of Tenerife, Gran Canaria and Mallorca during the early stages of establishment.
Shooting	Trapping, Judas animals		A	P	A	P	Shooting is widely used as a wildlife management tool. This reflects its selective nature, ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Although the method is known to be available for the target species (e.g. in Spain), further details are needed on its effectiveness and costs.
Egg oiling			P	P	P	P	The effectiveness of the measure in terms of population control is more dependent on the ease of locating and accessing nests, and the ability to treat a vast majority of nests.
Stupefying bait				U	U		At present there are no stupefying chemicals approved for general use in the EU. In a case study of its application in the Seychelles, the use of stupefying baits was not effective at all because of non-target species risks and dosage problems. Shooting was used to eradicate the birds instead. Although the method is known to be under development for the target species, further details are needed on its effectiveness and costs.
Hand removal	Trapping	P					Hand removal is considered effective for eradication or population control only when combined with other removal techniques. Bird eggs can be removed or destroyed to reduce productivity as a single method or in combination with a reduction of adults. In some instances, removed eggs can be replaced by dummy eggs to prevent replacement with a new clutch. Although the method is known to be (potentially) available for the target species, further details are needed on its effectiveness and costs.
Judas animals	Shooting	P					The Judas animal technique is considered as potentially applicable to birds. The Judas animal method is most cost-efficient at very low densities of the target population. When only few animals are left in a population for eradication, Judas animals can provide a valuable method to help find the last few individuals. Although the method is known to be potentially available for the target species, further details are needed on its effectiveness and costs.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cranial depression	**A**
Modified atmospheres	**A**
Cervical dislocation	**P**
Decapitation	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterlisation	**P**

6.2. *Alopochen aegyptiaca* (Linnaeus, 1766)

Alopochen aegyptiaca (Egyptian goose) © Roland zh CC BY-SA 3.0.

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Египетска гъска
Hrvatski	Croatian	egipatska guska
Čeština	Czech	husice nilská
Dansk	Danish	nilgås
Nederlands	Dutch	nijlgans
English	English	Egyptian goose
Eesti	Estonian	vaaraohani
Suomi	Finnish	afrikanhanhi
Français	French	ouette d'Égypte
Deutsch	German	Nilgans
ελληνικά	Greek	Αιγυπτιακή χήνα
Magyar	Hungarian	nílusi lúd
Gaeilge	Irish	Gé Éigipteach
Italiano	Italian	oca egiziana
Latviskiski	Latvian	Ēģiptes zoss
Lietuviškaiškai	Lithuanian	egiptinė žąsis
Malti	Maltese	il-wiżża tal-Eġittu
Polski	Polish	gęsiówka egipska
Português	Portuguese	ganso-do-Egipto
Română	Romanian	gâscă egipteană
Slovenčina (Slovenský jazyk)	Slovak	húska štíhla
Slovenščina (Slovenski jezik)	Slovenian	nilska gos
Español	Spanish	ganso del Nilo
Svenska	Swedish	nilgås

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting restrained animals; Keeping in captivity; Modified atmospheres; Injection euthanasia	A	A	A	A	A	Cage traps have provided a cost-effective method to support a number of large-scale population control and eradication programmes. Where the objective is eradication, cage traps are best used in combination with another method to remove any trap shy members of the population, and to locate animals when capture rates are low. Ongoing resources required and regular trap checking. Although the measure is available for the target species, further details are needed on its effectiveness and costs.
Live decoy traps	Live trapping; Modified atmospheres; Shooting restrained animals; Keep in captivity; Injection euthanasia	A	A	A	A	A	Live decoy traps are relatively cheap and the main costs are the manpower required for their placement and checking. They offer an alternative method to shooting to support the eradication and population control of *Alopochen aegyptiaca*, although they have not yet been deployed in large numbers for this species. Decoy traps for Egyptian geese have only been used in trials and have proven effective in removing small breeding groups of the species in Belgium.
Shooting	Traps; Judas animals		A	A	A	A	Shooting is widely used as a wildlife management tool. This reflects its selective nature, ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Although the method is known to be available for the target species, further details are needed on its effectiveness and costs. In addition, the species is often found in urban areas where shooting will likely be prohibited
Egg oiling				P	A	A	The effectiveness of the measure in terms of population control is more dependent on the ease of locating nests and the ability to treat a vast majority of nests as it has been estimated that 88% of nests need to be detected in order to revert population growth.
Hand removal	Live trapping; Shooting	P		P	A	A	Hand removal is considered effective for eradication or population control only when combined with other removal techniques. Bird eggs can be removed or destroyed (perforation, shaking) to reduce productivity as a single method or in combination with a reduction of adults. In some instances, removed eggs can be replaced/exchanged with dummy eggs to prevent birds from laying a new clutch. Further details are needed on its effectiveness and costs.
Stupefying bait	Shooting; Hand removal				P		The method (using alphachloralose) can potentially be used for this target species, as it was effective in capturing and either dispatching or relocating Canadian geese. Stupefying baits can be highly cost-effective when used in a situation that minimises the problems of dosage and non-target species.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cranial depression	**A**
Modified atmospheres	**A**
Cervical dislocation	**P**
Decapitation	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterilisation	**P**

6.3. *Callosciurus erythraeus (Pallas, 1779)*

Callosciurus erythraeus (Pallas' squirrel) © 57 Andrew CC BY-NC-ND 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Катерица на Палас
Hrvatski	Croatian	Pallasova vjeverica
Čeština	Czech	veverka Pallasova
Dansk	Danish	Rødbuget egern
Nederlands	Dutch	Pallas' eekhoorn
English	English	Pallas' squirrel
Eesti	Estonian	puna-kabeorav
Suomi	Finnish	oliiviselkäorava
Français	French	écureuil de Pallas
Deutsch	German	Pallas-Schönhörnchen
ελληνικά	Greek	Σκίουρος του Pallas
Magyar	Hungarian	csinos tarkamókus
Gaeilge	Irish	-
Italiano	Italian	scoiattolo di Pallas
Latviskiski	Latvian	Sarkanvēdera krāšņvāvere
Lietuviškaiškai	Lithuanian	Palaso voverė
Malti	Maltese	-
Polski	Polish	wiewiórczak rdzawobrzuchy
Português	Portuguese	esquilo-de-Pallas
Română	Romanian	-
Slovenčina (Slovenský jazyk)	Slovak	veverica červenkavá
Slovenščina (Slovenski jezik)	Slovenian	Pallasova veverica lepotka
Español	Spanish	ardilla de Pallas
Svenska	Swedish	rödmagad trädekorre

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Shooting	Traps; Hunting dogs (tracking/ baying)		A	A	A	A	Shooting has been used to supplement the population control of small IAS such as squirrels. Although the method is known to be available for this target species, further details are needed on its effectiveness and costs.
Cage traps	Shooting; Chemical fertility control	P	P	A	A	A	The method is available and has been used for the local eradication of this target species, but further details are needed on its effectiveness and costs. In general, cage traps provide a cost-effective method to support large scale population control and eradication programmes of different species.
Hunting dogs (tracking/ baying)	Shooting	P	P	P	P	P	The method can potentially be used for this target species, as squirrels can potentially be hunted with dogs e.g. those traditionally used for squirrel hunting in Sweden and Finland. It may be used to help locate individuals where population numbers are low. Further details are needed on the effectiveness and costs of the measure for this particular species.
Goodnature self-resetting traps		P	P	P	P	P	The measure could potentially be used for this species, as the A18 Goodnature® traps are available for killing *S. carolinensis*. The capital outlay of buying self-resetting traps is greater than for traditional traps, but since traps do not need to be reset regularly there should be a reduction in field effort and overall costs over time compared to more labour-intensive methods.
Spring traps		P	P	P	P	P	The method can potentially be used for this target species. Kill trapping grey squirrels is generally less efficient than live trapping, but spring traps were identified as better than live cage and leghold traps for fox squirrels due to their moderate efficiency, low relative cost, high selectivity and relative humaneness. Further details are needed on the effectiveness and costs of the measure for this particular species.
Fertility Control - chemical (in bait) & injection	Any type of live-capture measure				P		The method can potentially be used for this target species, as immunocontraceptive injections and oral contraceptives are effective at inhibiting reproduction in grey squirrels. The costs of injections are much higher than those of oral contraceptives, but both methods are more expensive and less effective than lethal eradication measures for squirrels.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	A
Keeping in captivity	A
Modified atmospheres	A
Cranial depression	U
Decapitation	P
Electrocution	P
Injection euthanasia	P
Shooting - dispatch restrained animals	P
Slaughter (knife)	P
Surgical sterilisation	P

6.4. *Corvus splendens* Viellot, 1817

Corvus splendens (Indian house crow) © Shanthanu Bhardwaj CC BY-SA 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Индийска домашна врана
Hrvatski	Croatian	indijski gavran
Čeština	Czech	vrána domácí
Dansk	Danish	Indisk huskrage
Nederlands	Dutch	huiskraai
English	English	Indian house crow
Eesti	Estonian	õuevares
Suomi	Finnish	intianvaris
Français	French	corbeau familier
Deutsch	German	Glanzkrähe
ελληνικά	Greek	-
Magyar	Hungarian	indiai varjú
Gaeilge	Irish	-
Italiano	Italian	corvo indiano delle case
Latviskiski	Latvian	Indijas vārna
Lietuviškaiškai	Lithuanian	indinė varna
Malti	Maltese	-
Polski	Polish	wrona orientalna
Português	Portuguese	corvo-indiano
Română	Romanian	-
Slovenčina (Slovenský jazyk)	Slovak	vrana lesklá
Slovenščina (Slovenski jezik)	Slovenian	domača vrana
Español	Spanish	cuervo indio
Svenska	Swedish	huskråka

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Hand removal	Trapping	**P**	**A**	**A**			Hand removal is considered effective for eradication or population control only when combined with other removal techniques. Bird eggs can be removed or destroyed to reduce productivity as a single method or in combination with a reduction of adults. In some instances, removed eggs can be replaced by dummy eggs to prevent replacement with a new clutch. In Socotra (Yemen), this management programme was successful in keeping the population under control and below 15 birds by the time it was fully operating. Eradication was achieved by shooting the last adults.
Shooting	Traps; Judas animals		**A**	**A**	**P**		Shooting is widely used as a wildlife management tool. This reflects its selective nature, its ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. This method has been used successfully on this species, but further details are needed to assess its effectiveness and costs if widely used..
Cage traps	Shoooting; Shooting - dispatch restrained animals	**P**	**A**				Cage traps have provided a cost-effective method to support a number of large-scale population control and eradication programmes. Where the objective is eradication, cage traps are best used in combination with another method to remove any trap shy members of the population, and to locate animals when capture rates are low. Ongoing resources and regular trap checking are required. Although the measure is available for the target species, further details are needed on its effectiveness and costs.
Egg oiling	Trapping; Shooting		**P**		**A**		Egg oiling is a method of population management whereby bird eggs are coated with a substance such as mineral or corn oil. For example, in Israel, none of the oiled nests (91) had hatched. 45% of the nests that were oiled were abandoned, with the other 55% of treated nests being incubated for three weeks or more. This approach resulted in a 19% decrease to the population. Most of the costs associated with the measure of egg oiling relate to the labour costs, which will be directly impacted by the size of the populations managed, the distribution and the ability to locate and treat nests (hence some studies indicate that this measure is not cost effective for larger population control in comparison to culling methods).
Stupefying bait				**U**	**U**		At present there are no stupefying chemicals approved for general use in the EU. Although the method is known to be under development for the target species, further details are needed on its effectiveness and costs.
Judas animals	Shooting	**P**	**P**				Judas animal technique is based on the use of tagged individuals to find conspecifics, in species that are known to aggregate. It is considered as potentially applicable to birds. The Judas animal method is most cost-efficient at very low densities of the target population. When only few animals are left in a population up for eradication, Judas animals can provide a valuable method to help find the last few individuals. Although the method is known to be potentially available for the target species, further details are needed on its effectiveness and costs.
Live decoy traps	Cage traps; Mist nets; Noose traps	**P**	**P**	**P**	**P**		The use of decoy traps requires initial decoy birds to be caught using another method, or captive birds. They are relatively cheap and the main costs are the manpower required for their placement and checking. Decoy traps have been used in a small number of cases to assist the population eradication and control of *Corvus splendens*, but when used alone they are not considered suitable to achieve total eradication as a proportion of birds become wary and trap-shy.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Cranial depression	**P**
Decapitation	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Modified atmospheres	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterilisation	**P**

6.5. *Herpestes javanicus* (É. Geoffroy Saint-Hilaire, 1818)

Herpestes javanicus (Small Asian mongoose) © Carla Kishinami CC BY-NC-ND 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Малка индийска мангуста
Hrvatski	Croatian	mali indijski mungos
Čeština	Czech	promyka malá
Dansk	Danish	Java mangust
Nederlands	Dutch	Indische mangoeste
English	English	small Indian mongoose
Eesti	Estonian	täpikmangust
Suomi	Finnish	pikkumungo
Français	French	mangouste de Java
Deutsch	German	Kleiner Mungo
ελληνικά	Greek	Μικρή ασιατική μαγκούστα
Magyar	Hungarian	jávai mongúz
Gaeilge	Irish	-
Italiano	Italian	mangusta indiana
Latviskiski	Latvian	mazais Āzijas mangusts
Lietuviškaiškai	Lithuanian	javinė mangusta
Malti	Maltese	-
Polski	Polish	mangusta złocista
Português	Portuguese	mangusto-pequeno-asiático
Română	Romanian	mangustă javaneză
Slovenčina (Slovenský jazyk)	Slovak	mungo geoffroyov
Slovenščina (Slovenski jezik)	Slovenian	mali indijski mungo
Español	Spanish	mangosta pequeña asiática
Svenska	Swedish	javanesisk mungo

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting; Methods for treatment or humane dispatch	P	A	A	A	A	Cage traps are a widely used method for rapid eradication, eradication, control and containment for populations of many different species. However, cost-effectiveness can be compromised when capture rates are low, by trying to capture trap-shy individuals and where there are limits to the sites where they can be set. They are often used with shooting where the strengths and weaknesses of the two methods often complement each other.
Shooting	Trapping; Hunting dogs				A	A	Shooting can be highly cost-effective, reflecting its selective nature, its ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Shooting can provide the main population control method or be applied in combination with other methods, such as traps, given the restrictions on the use of shooting on some sites, and the changing cost-effectiveness of different methods as animal density changes.
Hunting dogs (tracking/ baying)	Shooting	A			P	P	The measure is very useful for animals dispersed across extensive and difficult to work landscapes. Although the measure is available for the target species, further details are needed on its effectiveness and costs. In general, hunting with tracking/baying dogs can be very cost-effective.
Goodnature self-resetting traps	Spring traps	P	P	P	A	P	No independent evidence is available on cost-effectiveness. Manufacturer reported a short study in which Goodnature traps were used to reduce *H. javanicus* numbers over a short period. The capital outlay of buying self-resetting traps is greater than for traditional traps, but since traps do not need to be reset regularly there should be a reduction in field effort and overall costs over time compared to more labour-intensive methods.
Spring traps	Live cage traps	A		P	P	P	Spring trapping has not yet been used entirely successfully to eradicate *H. javanicus*, but it has been used to reduce populations to a few individuals at which stage it might prove more effective to switch to or incorporate other methods. Multiple trap and bait/ scent types should be considered for use in eradication, as wariness or aversion to one combination may not be transferable to others. Spring trapping is very labour-intensive and can be difficult in some terrains. It does not seem to be the main method used with *H. javanicus*. Numerous strategies for the mechanical removal of mongoose are in use with no standardised measure to evaluate efficacy. DOC 250 spring traps set in best practice boxes were more effective than Tomahawk live cage traps in Hawaii, while a cost-benefit analysis indicated that DOC 250 traps were more cost-effective than live traps in Fiji. The effectiveness of spring traps for mongoose population control depends on bait type, trap spacing, the area trapped and the skill of the trapper in trap placement and setting.
Poisons and toxins in bait	Shooting; Trapping		P	P	P	P	Diphacinone is effective at killing mongoose but expensive due to a variety of factors and its US registration was allowed to lapse. The approach is thus also unlikely to be viable for controlling populations of the mongoose in the EU. In the EU, PAPP offers the best prospect for a poison that is relatively safe and humane for use against mongoose, but the registration costs of PAPP as a novel active substance in the EU would be considerable and currently unrealistic.
Neck-hold traps, and snares	Other types of live trap, e.g., cage traps	P		P	P	P	Snare traps are rarely used in Europe to manage IAS. Their use is legal only in four Member States and no useful data were identified on cost-effectiveness.
Judas animals	Shooting	P					A Judas animal is a wild individual of the target species that is caught and fitted with a radio-tracking device and then re-released into its normal habitat. It will then seek out members of the same species. Hunters radio-track and locate the Judas animal and then remove the other individuals of the target species using another method (e.g. shooting). Judas animals can potentially be used for this species, to help detect and locate individuals, particularly in low density populations. Cost and its effectiveness on this species and in the area of its distribution still need to be studied.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Cranial depression	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Modified atmospheres	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterlisation	**P**

6.6. *Lepomis gibbosus* (Linnaeus, 1758)

Lepomis gibbosus (Pumpkinseed) © Matt Tillett CC BY-NC-ND 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Слънчева риба
Hrvatski	Croatian	sunčanica
Čeština	Czech	slunečnice pestrá
Dansk	Danish	solaborre
Nederlands	Dutch	zonnebaars
English	English	pumpkinseed
Eesti	Estonian	harilik päikeseahven
Suomi	Finnish	aurinkoahven
Français	French	perche soleil
Deutsch	German	Sonnenbarsch
ελληνικά	Greek	Ηλιόψαρο
Magyar	Hungarian	naphal
Gaeilge	Irish	iasc síl puimcín
Italiano	Italian	persico sole
Latviskiski	Latvian	soletschnaja pyba
Lietuviškaiškai	Lithuanian	paprastasis saulešeris
Malti	Maltese	il-pixxisol
Polski	Polish	bas słoneczny
Português	Portuguese	perca-sol
Română	Romanian	biban soare
Slovenčina (Slovenský jazyk)	Slovak	slnečnica pestrá
Slovenščina (Slovenski jezik)	Slovenian	sončni ostriž
Español	Spanish	percasol
Svenska	Swedish	solabborre

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Aquatic habitat management - Pond drying/ draining	Physical fishing; Electrofishing; Hand removal	A	A		A	P	Drainage combined with seine netting (see physical fishing below, could also be supported by electrofishing and hand removal) has been shown to be effective at eradicating *L. gibbosus* populations. Only likely to be feasible and cost-effective in small and isolated waterbodies.
Physical fishing methods	Electrofishing (potentially native predators)	A	P		A	A	Fishing using gill nets combined with electrofishing has been shown to be effective at reducing *L. gibbosus* populations in a lake in Spain. Costs will be ongoing as such measures need to be repeated, and is therefore only really cost effective for small isolated water bodies. Recreational fishing can also play a key role for early detection.
Electrofishing	Hand removal; Physical fishing	A	P		P	P	Effective as a sampling tool, more effective for larger individuals and can be combined with physical fishing (e.g. fyke nets). The measure requires specialist equipment and training, and costs increase and effectiveness decreases as the size of the treated area gets larger.
Native predators					P	P	One study has shown that the introduction of pike (*Esox lucius*) did not systematically inhibit natural colonisation by *L. gibbosus.* However another found that *L. gibbosus* was more abundant in ponds where pike were not present compared to ponds where pike were present.
Aquatic barriers - physical & non-physical			P		P	P	Permeable barriers on the outflows of lentic habitats could be used to prevent spread, and be used to support rapid eradication measures. Require ongoing maintenance costs. Non-physical in-stream barriers could potentially be used to prevent spread. However they are not yet 100% effective, and more suited to deterrent for entering hydroelectric plants etc. Require continuous costs for running and maintenance, and vulnerable to power outages.
Chemical treatment of habitats			P	P	P		Further details are needed on its effectiveness and costs. In general the measures is most effective in enclosed waterbodies. However, none of the chemical piscicides that are known to be effective (e.g. rotenone) or under development (e.g. CO2), are currently approved for use in the EU under the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012). Costs vary according piscicide used and will increase with size of the spatial area being treated.

Measures to dispatch/remove once captured	
Measure	**Availability**
Freezing	A
Cervical dislocation	P
Cranial depression	P
Decapitation	P
Electrocution	P
Injection euthanasia [directly into water]	P
Keeping in captivity	P
Slaughter (knife)	P

6.7. *Lithobates (Rana) catesbeianus* (Shaw, 1802)

Lithobates catesbeianus (American bullfrog) © Katja Schulz CC BY 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Американска жаба бик
Hrvatski	Croatian	sjevernoamerička žaba bukača
Čeština	Czech	skokan volský
Dansk	Danish	Amerikansk oksefrø
Nederlands	Dutch	Amerikaanse stierkikker
English	English	American bullfrog
Eesti	Estonian	härgkonn
Suomi	Finnish	härkäsammakko
Français	French	grenouille-taureau
Deutsch	German	Nordamerikanischer Ochsenfrosch
ελληνικά	Greek	Αμερικανικός βουβαλοβάτραχος
Magyar	Hungarian	amerikai ökörbéka
Gaeilge	Irish	Tarbhfhrog Meiriceánach
Italiano	Italian	rana toro americana
Latviskiski	Latvian	vērša varde
Lietuviškaiškai	Lithuanian	jautinė varlė
Malti	Maltese	-
Polski	Polish	żaba ryczęca
Português	Portuguese	rã-touro-americana
Română	Romanian	-
Slovenčina (Slovenský jazyk)	Slovak	skokan volský
Slovenščina (Slovenski jezik)	Slovenian	volovska žaba
Español	Spanish	rana toro
Svenska	Swedish	oxgroda

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Hand removal	Trapping; Passive netting; Electrofishing; Pond fencing	A	A	A	A	A	Hand removal is considered effective for eradication or population control only when combined with other removal techniques. A handheld net is used when sampling shallow waters or in combination with other techniques, such as electrofishing, where they are used to scoop stunned fish and amphibians, from the water. Trident pole spears outfitted with rubber sling were used to capture *L. catesbeianus*. A first successful eradication of bullfrogs on a landscape level was carried out in the USA. The work highlights that the removal of bullfrogs was possible by targeting breeding populations, using a variety of mechanical removal methods (incl. hand removal), and monitoring via traditional (visual surveys and audio recording devices) and eDNA survey techniques.
Physical fishing methods	Electrofishing; Hand removal; Spearing/ gigging; Shooting; Biocontrol; Pond draining	P	A		A	A	This measure refers to the use of passive fishing methods, including a variety of aquatic nets and traps, through which animals are caught by actively swimming or moving into the net or trap. Seine nets, fyke nets, funnel traps, multiple capture traps, hook and line are all physical fishing methods used for American bullfrogs. For example, seine nets have been successfully used in management actions to capture *Lithobates catesbeianus.* Also fishing with a hook and line has been used in eradication efforts of *L. catesbeianus.* Fyke nets and Gee traps have proven highly effective in capturing *L. catesbeianus* larvae and can also be used to remove adults, largely contributing to the population control or even eradication of this species, especially in small and isolated populations. A multiple capture trap, which has been developed to control invasive cane toad populations in Australia, modified to float and lured, has also shown promise in helping to control population of *L. catesbeianus*.
Aquatic habitat management - Pond drying/ draining	Hand removal; Trapping; Netting; Spearing; Shooting; Electrofishing		A		A	A	Given that breeding populations of *Lithobates catesbeianus* have been found to disappear following natural pond drying, draining of water bodies at least every two years has been suggested as an effective management strategy for largely reducing populations of this species. These operations are mostly effective for the stages dependent on permanent waters (eggs and tadpoles). Draining has been used to eradicate or control populations of *L. catesbeianus* in Germany, France, Belgium, the Netherlands, the UK, and the USA. In Germany, spread of the population was prevented and the success of the eradication measures was still being discussed, but there have been no further reports of the species in the area.
Shooting	Traps; Pond-draining; hand removal		P	A	A	A	Shooting is widely used as a wildlife management tool. This reflects its selective nature, ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Although the method is known to be available for targeting adults of the species it is applied in combination with other measures (e.g. hand removal, egg removal, trapping etc.), and further details are needed on its effectiveness and costs.

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Aquatic barriers – physical & non-physical			A		A	A	Physical mesh screens have been used to prevent spread of *L. catesbeianus* tadpoles during pond drainage actions in Belgium, and could be used to support rapid eradication or other pond drainage actions to control the species.
Native predators	Many other non-lethal measures				A	A	The measure might include introducing predators where they have recently been absent, or enhancing the predatory activity of existing native predators. In Belgium, a replicated randomised study was undertaken exploring the effects of introducing pike and drawdown on the abundance of *L. catesbeianus* and other fish in an aquaculture pond system. Whilst an annual drawdown had no effect on the biomass of *L. catesbeianus* adults or tadpoles, the presence of pike did substantially reduce the abundance (biomass) of *L. catesbeianus* tadpoles by the end of the study (though the biomass of adult frogs was unaffected). However, it was not clear if the observed effects would play a significant role in regulation or control of the bullfrog population, as tadpole mortality and the recruitment and productivity of adult frogs are not linked.
Electrofishing	Fencing; Seine netting; Fyke netting; Pond drainage; Hand netting; Shooting	P	A		P	P	Based on the evidence provided it is a cost-effective measure to eradicate populations of bullfrogs from small isolated ponds/lakes and streams/rivers, though repeated applications are needed, sometimes in combination with other methods. Costs increase and effectiveness decreases as the size of the treated area gets larger. However, the measure requires specific equipment for its application as well as duly trained skilled staff which can ensure its proper use depending on the target species. Within the EU, the only specific experience of eradication of *L. catesbeianus* with electrofishing was in Germany and the Netherlands. In Canada, electrofishing equipment was successfully used to capture and remove *L. catesbeianus* from streams and lakes, which were then euthanised using a separate protocol (freezing). Some basic experiments on eggs of *L. catesbeianus* showed no effects of electroshocking on them.
Fertility control - chemical (in bait) & injection	Any type of live-capture measure			U	U	U	Research has found that sterile triploid males of *L. catesbeianus* can be produced at sufficient numbers to eradicate a small target population. This approach, combined with traditional management (e.g. fish traps) is now being applied through the LIFE 3n-Bullfrog project which began in late 2019 with the aim of population control and containment in Belgium. However, the use of triploidy requires construction of a dedicated facility to rear sterile triploid bullfrogs in sufficient numbers for release.

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Physical terrestrial barriers	Trapping; Pond draining	**P**				**P**	Construction of fences to intentionally fragment river or land habitats may be used for invasive alien species management, to prevent their spread. The use of this method on the cane toad in Australia suggests that water exclusion devices could be potentially used to prevent bullfrog invasion and control their populations in European semi-arid habitats. Although the method is known to be potentially available for the target species, further details are needed on its effectiveness and costs (physical barriers have been used to facilitate the capture and eradication of bullfrog).
Chemical treatment of habitats		**P**					The only evidence for *L. catesbeianus* is for the use of rotenone, ammonia and CO^2. They are most cost-effective in small lentic (enclosed) systems, though there is evidence of their effective use in larger lakes and in lotic systems. One key drawback is that none of these measures are currently approved for use in the EU under the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012).

Measures to dispatch/remove once captured	
Measure	**Availability**
Cranial depression	**A**
Freezing	**A**
Injection euthanasia	**A**
Cervical dislocation	**P**
Decapitation	**P**
Keeping in captivity	**P**
Slaughter (knife)	**P**

6.8. *Muntiacus reevesi* (Ogilby, 1839)

Muntiacus reevesi (Muntjac deer) © Andrew-M-Whitman CC BY-NC-ND 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Китайски мунтжак
Hrvatski	Croatian	jelen mutjak
Čeština	Czech	muntžak malý
Dansk	Danish	muntjak
Nederlands	Dutch	Chinese muntjak
English	English	muntjac deer
Eesti	Estonian	hiina muntjak
Suomi	Finnish	kiinanmuntjakki
Français	French	muntjac de Chine
Deutsch	German	Chinesischer Muntjak
ελληνικά	Greek	-
Magyar	Hungarian	kínai muntyákszarvas
Gaeilge	Irish	Muinseac
Italiano	Italian	muntjak della Cina
Latviskiski	Latvian	Ķīnas mundžaks
Lietuviškaiškai	Lithuanian	kininis muntjakas
Malti	Maltese	-
Polski	Polish	mundżak
Português	Portuguese	muntjac-chinês
Română	Romanian	-
Slovenčina (Slovenský jazyk)	Slovak	mundžak malý
Slovenščina (Slovenski jezik)	Slovenian	muntjak
Español	Spanish	muntíaco de Reeves
Svenska	Swedish	röd muntjak

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Shooting	Judas animals; Hunting dogs		A	A	A	A	Standard Operating Procedures (SOPs) for shooting should specify the most appropriate method, as well as firearms and ammunition. Shooting in areas where animals have recently been observed is important, using either trusted sources or reports from surveillance/ monitoring programmes for the species. In many cases shooting provides a cost-effective method of population control. Shooting has been widely used for the population control of large alien mammals such as deer.
Cage traps	Methods of dispatch	A		A	A	A	Capture and restraint of animals in the wild, for subsequent removal, dispatch, or management (e.g. fertility control). Developing and investing in optimal trap designs and deployments (humane SOPs) can be expensive, as are the maintenance of trap lines across extensive areas. However, the method has proven effective, having been the primary tool in a number of successful IAS eradications for many species.
Hand removal		A					Hand nets can be used to capture individuals, e.g. in urban settings.
Hunting dogs (tracking/ baying)	Methods of restraint and removal	P		P	P	P	Used to locate and corral animals resistant to capture using other methods. Requires other methods to restrain and remove animals from the environment. Very useful for animals dispersed across extensive and difficult to work landscapes. Although the measure can potentially be used for the target species, further details are needed on its effectiveness and costs.
Judas animals	Methods of restraint or removal	P		P	P	P	A Judas animal is a wild individual of the target species that is caught and fitted with a radio-tracking device and then re-released into its normal habitat. It will then seek out members of the same species. Hunters radio-track and locate the Judas animal and then remove the other individuals of the target species using another method (e.g. shooting). Judas animals can potentially be used for this species, to help detect and locate individuals, particularly in low density populations. Although the measure can potentially be used for this species, further details are needed on its effectiveness and costs.
Fertility Control - chemical (in bait) & injection	Any live capture measure				P		The measure is in principle available for this species, as drug and vaccine contraceptives have been demonstrated to be effective in other deer species.
Stupefying bait	Methods of dispatch	P					Baits intended to immobilise animals (restraint) for subsequent removal or dispatch. The measure can potentially be used for the target species, although use with Australian deer is experimental and has not been attempted with muntjac.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cranial depression	A
Electrocution	P
Injection euthanasia	P
Keeping in captivity	P
Shooting - dispatch restrained animals	P
Slaughter (knife)	P
Surgical sterilisation	P

6.9. *Myocastor coypus* (Molina, 1782)

Myocastor coypus (Coypu) © Stanze CC BY-SA 2.0

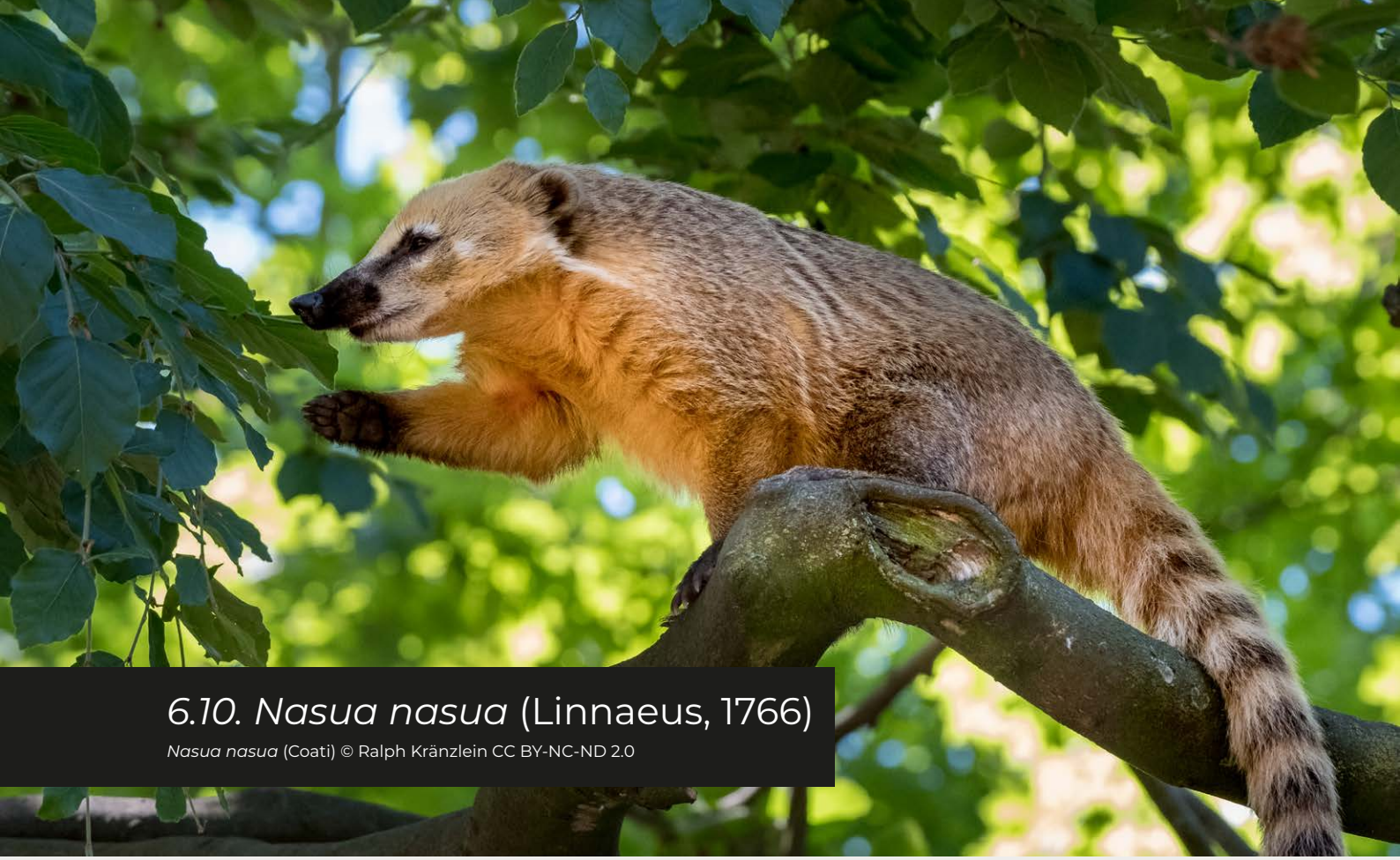
Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Нутрия
Hrvatski	Croatian	barska nutrija
Čeština	Czech	nutrie říční
Dansk	Danish	sumpbæver
Nederlands	Dutch	beverrat
English	English	coypu
Eesti	Estonian	nutria
Suomi	Finnish	nutria
Français	French	ragondin
Deutsch	German	Nutria
ελληνικά	Greek	Μυοκάστορας
Magyar	Hungarian	nutria
Gaeilge	Irish	Francach abhann
Italiano	Italian	nutria
Latviskiski	Latvian	nūtrija
Lietuviškaiškai	Lithuanian	nutrija
Malti	Maltese	-
Polski	Polish	amerykańska
Português	Portuguese	ratão-d'água
Română	Romanian	nutrie
Slovenčina (Slovenský jazyk)	Slovak	nutria riečna
Slovenščina (Slovenski jezik)	Slovenian	nutrija
Español	Spanish	coipú
Svenska	Swedish	sumpbäver

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting	A	A	A	A	A	This measure has provided the main method used to achieve the widescale eradication of this species from large areas. However, its use has not always proven effective for the ongoing control of populations of this species.
Shooting	Traps; Judas animals		A	A	A	A	Shooting has been widely used as the main method of population control for large alien mammals, such as coypu. Further details are needed on the effectiveness and costs of the measure for this target species.
Drowning traps	Shooting; Other traps	A			A	A	While the method can be used for this target species, there is little experience reported of its use. In general, drowning traps are more efficient if used in situations with small ranging water levels.
Spring traps	Shooting; Drowning traps	A					The method is available for this target species. The Conibear® trap (no. 220-2) is the most commonly used body-gripping trap for controlling coypu populations and Conibear® traps nos. 160-2 and 330-2 can also be used. Further details are needed on the effectiveness and costs of the measure for this particular species, but in general body-gripping traps (such as Conibear) are extremely effective when set in runs.
Hunting dogs (tracking/ baying)	Shooting	A	P	P	P	P	The measure has been effectively used for this species. In general, hunting with tracking/baying dogs can be very cost-effective, but further details are needed on the costs for this target species. Detection dogs which detect, but never hunt or come in direct contact with the IAS, have been used to track coypu in the USA.
Judas animals	Hunting dogs; Shooting; Sterilisation of the Judas animal	U					The method is under development for this target species. Further details are needed on the actual use, effectiveness and costs of the measure for this particular species.
Chemical treatment of habitats		P					The active substance aluminium phosphide releasing phosphine can potentially be used for this target species. However, its use is not authorised in the EU on any of the vertebrate IAS of Union concern, and only approved for use in the outdoor management of pest rodents. In addition, further details on its efficacy (and costs) against this particular species are needed.
Neck-hold traps, and snares	Cage traps; Any dispatch method	P					The method can potentially be used for this target species, but further details are needed on its effectiveness and costs. Furthermore, snare traps are permitted only in four Member States (Ireland, France, Spain and Belgium).

Measures to dispatch/remove once captured	
Measure	**Availability**
Modified atmospheres	A
Shooting - dispatch restrained animals	A
Surgical sterilisation	A
Cranial depression	P
Electrocution	P
Injection euthanasia	P
Keeping in captivity	P
Slaughter (knife)	P



6.10. *Nasua nasua* (Linnaeus, 1766)

Nasua nasua (Coati) © Ralph Kränzlein CC BY-NC-ND 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Южноамериканско носато мече (коати)
Hrvatski	Croatian	nosati rakun
Čeština	Czech	nosál červený
Dansk	Danish	næsebjørn
Nederlands	Dutch	rode neusbeer
English	English	coati
Eesti	Estonian	ninakaru
Suomi	Finnish	koati
Français	French	coati roux
Deutsch	German	Roter Nasenbär
ελληνικά	Greek	Κοάτι της νότιας Βραζιλίας
Magyar	Hungarian	vörösorrú ormányosmedve (koáti)
Gaeilge	Irish	-
Italiano	Italian	coati rosso
Latviskiski	Latvian	Dienvidamerikas degunlācītis
Lietuviškaiškai	Lithuanian	paprastasis koatis
Malti	Maltese	-
Polski	Polish	ostronos rudy
Português	Portuguese	quati-de-cauda-anelada
Română	Romanian	-
Slovenčina (Slovenský jazyk)	Slovak	nosáľ červený
Slovenščina (Slovenski jezik)	Slovenian	nosati medvedek
Español	Spanish	coatí
Svenska	Swedish	vanlig näsbjörn

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Chemical sterilisation; Surgical sterilisation; Shooting restrained animals; Keeping in captivity	P	A	A	A	A	Cage traps have provided a cost-effective method to support a number of large-scale population control and eradication programmes. Where the objective is eradication, cage traps are best used in combination with another method to remove any trap shy members of the population, and to locate animals when capture rates are low. Ongoing resources required and regular trap checking. The method is available for this target species, but further details are needed on its effectiveness and costs.
Shooting	Traps; Judas animals		A	A	P	P	Shooting has been widely used as the main method of population control for large alien mammals. The method is available for this target species, but further details are needed on its effectiveness and costs.
Hunting dogs (tracking/ baying)	Shooting; Live traps; Judas animals	P	P	P	P	P	Hunting with tracking/baying dogs can be very efficient to reduce high density populations of IAS in combination with shooting. In low density populations tracking/ baying dogs are very efficient combined with other measures, such as game cameras or Judas animals. The method can potentially be used for this target species, but further details are needed on its effectiveness and costs.
Spring traps		P		P	P	P	Spring traps can potentially be used and may be suitable for coati, subject to appropriate testing. In general, spring trapping is very labour-intensive and can be difficult in some terrains.
Neck-hold traps, and snares	Shooting restrained animals; Injection euthanasia	P		P	P	P	The method can potentially be used for this target species, as the coati is closely related to the raccoon, and neck hold traps and leg hold snares have both been used for capturing raccoons. However, modified neck-hold snares are not recommended to manage animal populations due to welfare concerns. In general, information and data on the use of these traps is very poor, so it is not possible to draw conclusions on cost effectiveness.
Judas animals	Hunting dogs; Live traps; Shooting; Surgical sterilisation	P					The Judas animal method is most cost-efficient at very low densities of the target population. When only few animals are left in a population up for eradication, Judas animals can provide a valuable method to help find the last few individuals. The method can potentially be used for this target species, but further details are needed on its effectiveness and costs.
Fertility Control - chemical (in bait) & injection	Any type of live-capture measure				P		The method can potentially be used for this target species, but further details are needed on its effectiveness and costs. In general, oral delivery of a contraceptive, formulated in bait or feed, is likely to be substantially less costly than methods requiring capture, treatment and release of individual animals, although this increases the risk of non-target uptake.

Measures to dispatch/remove once captured	
comune	**Availability**
Modified atmospheres	A
Shooting - dispatch restrained animals	A
Cranial depression	P
Electrocution	P
Injection euthanasia	P
Keeping in captivity	P
Slaughter (knife)	P
Surgical sterilisation	P

6.11. *Nyctereutes procyonoides* (Gray, 1834)

Nyctereutes procyonoides (Raccoon dog) © Dennis Irrgang CC BY 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Енотовидно куче
Hrvatski	Croatian	-
Čeština	Czech	psík mývalovitý
Dansk	Danish	mårhund
Nederlands	Dutch	wasbeerhond
English	English	raccoon dog
Eesti	Estonian	kährik
Suomi	Finnish	supikoira
Français	French	chien viverrin
Deutsch	German	Marderhund
ελληνικά	Greek	Νυκτερευτής
Magyar	Hungarian	nyestkutya
Gaeilge	Irish	-
Italiano	Italian	cane procione
Latviskiski	Latvian	jenotsuns
Lietuviškaiškai	Lithuanian	mangutas
Malti	Maltese	-
Polski	Polish	jenot azjatycki
Português	Portuguese	cão-guaxinim
Română	Romanian	câine enot
Slovenčina (Slovenský jazyk)	Slovak	psík medvedíkovitý
Slovenščina (Slovenski jezik)	Slovenian	rakunasti pes
Español	Spanish	perro mapache
Svenska	Swedish	mårdhund

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting; Keeping in captivity; Sterilisation; Immuno-contra-ceptive vaccines by injection	A	A	A	A	A	Although the method is available for the target species, further details are needed on its effectiveness and costs for different objectives. In general, where the objective is eradication, cage traps are best used in combination with another method to remove any trap shy members of the population, and to locate animals when capture rates are low. Where the objective is population control, care is needed to ensure that effort is sufficient to achieve the stated objectives.
Judas animals	Shooting; Hunting dogs; Sterilisation (of the Judas animal)	A	A	A	A	A	In Sweden some Judas animals have been found to be very efficient, while others have never paired up with a new mate. However, an estimation of costs and effectiveness is hard, since the measure has been integrated with other measures. In a medium sized population other measures have been more efficient, but when the population is getting very small, the Judas animals show increased efficiency.
Shooting	Live and kill traps; Judas animals; Hunting dogs		A	A	A	A	Although the method is available for the target species, further details are needed on its effectiveness and costs. Hunting is often integrated with other measures.
Hunting dogs (tracking/ baying)	Shooting; Judas animals; Live or killing traps	P	A	A	A	A	Although the method is available for the target species, further details are needed on its effectiveness and costs. Detection dogs which detect, but never hunt or come in direct contact with the IAS, have been used to detect raccoon dog tracks in Norway. Tracking/baying hunting dogs have been used with integrated measures for population control of raccoon dogs in Sweden. The whole project has been very effective and costed approx. 800 000 Euros/year in 2010-2020, which incorporates all integrated measures.
Spring traps	Shooting; Habitat modifica-tion; Exclu-sion meas-ures such as fencing	A		P	P	P	Although the method is available or potential for the target species, further details are needed on its effectiveness and costs for eradication, population control and containment projects. In general, spring trapping is very labour-intensive and can be difficult in some terrains.
Neck-hold traps, and snares	Cage traps	P	P	P	P	P	Although the method is potentially available for the target species, further details are needed on its effectiveness and costs.
Fertility Control - chemical (in bait) & injection	Live-capture measures (e.g. cage traps); Keeping in captivity				P	P	Although the method is potentially available for the target species, further details are needed on its effectiveness and costs. In captive raccoon dogs, GnRH agonist implants (Suprelorin), progestin-implants (MGA), and oral progestins (Megace) have been used and all records were effective at preventing reproduction. In general, non-oral contraceptives are best utilised in isolated and small wild populations due to immigration and emigration that might affect the proportion of contracepted animals. The availability of chemical fertility control that could be delivered orally via species-specific baits would potentially greatly increase the scope for the application of these agents as an IAS management tool.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cranial depression	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Modified atmospheres	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterilisation	**P**

6.12. *Ondatra zibethicus (Linnaeus, 1776)*

Ondatra zibethicus (Muskrat) © Tom Koerner/USFWS CC BY 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Ондатра
Hrvatski	Croatian	bizamski štakor
Čeština	Czech	ondatra pižmová
Dansk	Danish	bisamrotte
Nederlands	Dutch	muskusrat
English	English	muskrat
Eesti	Estonian	piisamrott
Suomi	Finnish	piisami
Français	French	rat musqué
Deutsch	German	Bisamratte
ελληνικά	Greek	Μοσχοπόντικας
Magyar	Hungarian	pézsmapocok
Gaeilge	Irish	muscfhrancach
Italiano	Italian	topo muschiato
Latviskiski	Latvian	-
Lietuviškaiškai	Lithuanian	ondatra
Malti	Maltese	-
Polski	Polish	Piżmak amerykański
Português	Portuguese	rato-almiscarado
Română	Romanian	bizam
Slovenčina (Slovenský jazyk)	Slovak	ondatra pižmová
Slovenščina (Slovenski jezik)	Slovenian	pižmovka
Español	Spanish	rata almizclera
Svenska	Swedish	bisam

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Keeping in captivity; Sterilisation; Application of immuno-contraceptive vaccines by injection			A	A	A	This method has been widely used for the control of this species, including successful eradication programmes. However, further details are needed on its effectiveness and costs. In general, where the objective is eradication, cage traps are best used in combination with another method to remove any trap shy members of the population, and to locate animals when capture rates are low. Where the objective is population control, care is needed to ensure that effort is sufficient to achieve the stated objectives.
Shooting	Trapping		A	A	A	A	Shooting is widely used as a wildlife management tool. This reflects its selective nature, ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Although the method is known to be available for the target species, further details are needed on its effectiveness and costs. The species can be the object of hunting in Poland, Bulgaria and Romania.
Drowning traps	Body-gripping; Bait traps and Conibear traps	A			A		Drowning traps are more efficient if used in situations with small ranging water level. Trapping affects muskrat population's density only if the levels of investment are in adequate proportion to population size.
Spring traps	Drowning traps; Exclusion measures, such as fencing	A		A	A	A	Although the method is available for the target species, further details are needed on its effectiveness and costs for eradication projects. In general, spring trapping is very labour-intensive and can be difficult in some terrains.
Hunting dogs (tracking/ baying)	Judas animals; Live or killing traps	P	P	P	P	P	Although the method is potentially available for the target species, further details are needed on its effectiveness and costs.
Fertility Control - chemical (in bait) & injection	Live-capture measures (e.g. cage traps); Keeping in captivity				P		Although the method is potentially available or under development for the target species, further details are needed on its effectiveness and costs. In general, non-oral contraceptives are best utilised on isolated and small wild populations due to immigration and emigration that might affect the proportion of contracepted animals. The availability of chemical fertility control that could be delivered orally via species-specific baits would potentially greatly increase the scope for the application of these agents as an IAS management tool.
Judas animals	Hunting dogs; Sterilisation of the Judas animal	P					Although the method is potentially available for the target species, further details are needed on its effectiveness and costs.
Chemical treatment of habitats			P				The active substance aluminium phosphide releasing phosphine can potentially be used for this target species. However, its use is not authorised in the EU on any of the vertebrate IAS of Union concern, and only approved for use in the outdoor management of pest rodents. Zinc phosphide concentrate, which releases phosphine, is the only toxicant registered in the US for use on aquatic rodents including the muskrat. Further details on the efficacy and costs of the measure against this particular species are needed.
Poisons and toxins in bait	Trapping; Shooting				P		The use of poison baits against muskrats in Europe has mainly involved the FGAR chlorophacinone and the SGARs difenacoum and bromadiolone. However, chlorophacinone, bromadiolone and difenacoum are no longer approved for use in the EU. Factors such as the geography, topography, and accessibility of the terrain, the density of watercourses in the area, and the density of the target muskrat population, can greatly influence the effort required. As such, the measure is only applicable to sporadic population control efforts aimed at particularly intractable local populations. No successful eradications of muskrat are known to have been achieved using chemical management measures.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cranial depression	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Modified atmospheres	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterilisation	**P**

6.13. *Oxyura jamaicensis* (Gmelin, 1789)

Oxyura jamaicencis (Ruddy duck) © Ronald van der Graaf CC BY 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Американска тръноопашата потапница
Hrvatski	Croatian	grimizna patka
Čeština	Czech	kachnice kaštanová
Dansk	Danish	Amerikansk skarveand
Nederlands	Dutch	rosse stekelstaart
English	English	ruddy duck
Eesti	Estonian	valgepõsk händpart
Suomi	Finnish	kuparisorsa
Français	French	érismature rousse
Deutsch	German	Schwarzkopf-Ruderente
ελληνικά	Greek	Κεφαλούδι της Τζαμάικας
Magyar	Hungarian	halcsontfarkú réce
Gaeilge	Irish	Lacha rua
Italiano	Italian	gobbo della Giamaica
Latviskiski	Latvian	Jamaikas zilknābis
Lietuviškaiškai	Lithuanian	baltaskruostė stačiauodegė
Malti	Maltese	-
Polski	Polish	sterniczka jamajska
Português	Portuguese	pato-de-rabo-alçado-americano
Română	Romanian	rața roșcată
Slovenčina (Slovenský jazyk)	Slovak	potápnica bielolíca
Slovenščina (Slovenski jezik)	Slovenian	belolična trdorepka
Español	Spanish	malvasía canela
Svenska	Swedish	amerikansk kopparand

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting		A	A	A	A	Ruddy ducks spend the majority of their time on open water and are only rarely seen on land. This limits the attractiveness of traps for the population control of this species. Traps also require frequent checking to reduce the risks to the welfare of any captured animals, reducing the cost-effectiveness of this method if capture rates are low. Although they have been used in very limited cases for the capture of ruddy ducks, they are unlikely to provide a cost-effective method for the population control of this species and their usefulness is limited to very specific circumstances.
Shooting	Live trapping; Egg-oiling; Hand removal		A	A	A	A	Shooting birds has proven to be the most widely used and cost-effective method to manage this species. Ruddy duck shooting has primarily been through the use of firearms, principally .223 rifles and five-cartridge semi-automatic 12-guage shotguns. Shooting was conducted both from the shore and from boats, with small teams operating independently through most of the breeding season but with all of the control officers working together on the larger wintering sites. Similar methods are considered appropriate for population control or containment.
Egg oiling	Shooting			A	A	A	The effectiveness of the measure is highly dependent on the ease of locating and treating a very high proportion of nests in an area. For some species, such as the ruddy duck, this is unlikely to be achievable (only small numbers of animals have been managed in this way) and brings significant health and safety issues for operatives. Shooting is considered a more practical and cost-effective method for the management of this species, although egg oiling can provide a useful supplement in some circumstances. Egg oiling used in isolation is unlikely to achieve eradication or effective population control of this species.
Hand removal	Shooting; Egg oiling; Live trapping	P	P	A	A	P	Hand removal is only considered effective for eradication or population control when combined with other removal techniques. Nest destruction has been applied in some countries to support control and eradication programmes.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Cranial depression	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Modified atmospheres	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterilisation	**P**

6.14. *Perccottus glenii* Dybowski, 1877

Perccottus glenii (Amur sleeper) © Petrtyl CC BY-SA 3.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Китайски поспаланко
Hrvatski	Croatian	Rotan
Čeština	Czech	Hlavačkovec Glenův
Dansk	Danish	Kinesisk sovekutling
Nederlands	Dutch	Amoergrondel
English	English	Amur sleeper
Eesti	Estonian	Kaugida unimudil
Suomi	Finnish	Rohmutokko
Français	French	Goujon de l'amour
Deutsch	German	Amurgrundel
ελληνικά	Greek	-
Magyar	Hungarian	Amurgéb
Gaeilge	Irish	-
Italiano	Italian	-
Latviskiski	Latvian	Rotans
Lietuviškaiškai	Lithuanian	Nuodėgulinis grundalas
Malti	Maltese	-
Polski	Polish	Trawianka
Português	Portuguese	-
Română	Romanian	Somn chinezesc
Slovenčina (Slovenský jazyk)	Slovak	Býčkovec amurský
Slovenščina (Slovenski jezik)	Slovenian	Kitajska sladkovodna dremavka
Español	Spanish	Durmiente chinno
Svenska	Swedish	Amursömnfisk

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Aquatic habitat management - Pond drying/ draining	Chemical treatment of habitats; Electrofishing; Physical fishing methods; Hand removal	**P**	**A**		**A**	**P**	Drainage can be used to eradicate the species from isolated locations, and is often combined with other measures (e.g. fishing, electrofishing and hand removal) to remove individuals. However, as the species is able to survive in the mud of dried out water bodies, the measure needs to be combined with the application of chemicals (e.g. lime chloride) to the substrate to kill remaining individuals. Only feasible and cost-effective in small and isolated waterbodies.
Native predators					**A**	**A**	Suppression, and even eradication of isolated populations (but not eradication of widespread populations) is possible through the stocking of native predators (e.g. pike *Esox Lucius*, perch *Perca fluviatilis*). May only be effective in small shallow still waters.
Electrofishing	Hand removal; Aquatic habitat management - Pond drying/ draining	**A**	**A**		**A**	**P**	Effective as a sampling tool. The measure requires specialist equipment and training, and costs increase and effectiveness decreases as the size of the treated area gets larger. For management, although the method is known to be available for the target species, further details are needed on its effectiveness and costs. The measure requires specialist equipment and training, and costs increase and effectiveness decreases as the size of the treated area gets larger.
Aquatic barriers - physical & non-physical			**P**		**P**	**A & P**	Permeable barriers on the outflows of lentic habitats or fish farms could be used to prevent spread. Require ongoing maintenance costs. Non-physical in-stream barriers could potentially be used to prevent spread. However they are not yet 100% effective, and more suited to deterrent for entering hydroelectric plants etc. Require continuous costs for running and maintenance, and vulnerable to power outages.
Physical fishing methods	Native predators	**P**	**P**		**P**	**P**	Could potentially be effective (e.g. seine or fyke nets) when combined with use of native predators to reduce abundance. However, high effort would be needed after each breeding season to overcome compensatory response.
Chemical treatment of habitats			**P**	**P**	**P**		Although the measure is known to be available (e.g. chlorine) and potentially available (e.g. rotenone) for the target species, further details are needed on its effectiveness and costs. In general the measure is most effective in enclosed waterbodies. However, none of the chemical piscicides that are known to be effective (e.g. rotenone) or under development (e.g. CO2), are currently approved for use in the EU under the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012). Costs vary according piscicide used and will increase with size of the spatial area being treated.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Cranial depression	**P**
Decapitation	**P**
Electrocution	**P**
Keeping in captivity	**P**
Slaughter (knife)	**P**

6.15. *Plotosus lineatus (Thunberg, 1787)*

Plotosus lineatus (Striped eel catfish) © Prilfish CC BY 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Ивичесто змиорковидно сомче
Hrvatski	Croatian	Koralja som
Čeština	Czech	Plotos proužkatý
Dansk	Danish	Stribet koralmalle
Nederlands	Dutch	Gestreepte koraalmeerval
English	English	Striped eel catfish
Eesti	Estonian	Vöödiline angersabasäga
Suomi	Finnish	Juovakorallimonni
Français	French	Poisson-chat rayé
Deutsch	German	Gestreifter Korallenwels
ελληνικά	Greek	ριγωτό γατόψαρο
Magyar	Hungarian	Csíkos tengeriharcsa
Gaeilge	Irish	Cat mara coiréalach
Italiano	Italian	Pesce gatto dei coralli
Latviskiski	Latvian	Koraļļu sams
Lietuviškaiškai	Lithuanian	Dygusis unguruodegis šamas
Malti	Maltese	Il-gringu tal-mustaċċi
Polski	Polish	sumik węgorzowaty
Português	Portuguese	Peixe-gato-enguia-listado
Română	Romanian	Somn vărgat
Slovenčina (Slovenský jazyk)	Slovak	Plotos pruhovaný
Slovenščina (Slovenski jezik)	Slovenian	Progasti morski som
Español	Spanish	Patuna rayada
Svenska	Swedish	Korallmal

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Hand removal		**P**					Marine fish can be removed by hand removal, e.g. by spear fishing, although its effectiveness and costs for the target species are unknown. In general it is a time consuming measure.
Physical fishing methods					**P**		It is suggested that the intensive use of trawl nets in shallow waters during the summer months, especially during the spawning period could contribute the species population control or eradication. However, this is unlikely to be cost-effective, and also trawling at depths shallower than 50m is banned in the Mediterranean through Council Regulation (EC) No 1967/2006. Other methods could also be potentially applied, such as seine and gill nets, cages or angling, however more information is needed on their costs and effectiveness.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Decapitation	**P**
Electrocution	**P**
Slaughter (knife)	**P**

6.16. *Procyon lotor* (Linnaeus, 1758)

Procyon lotor (Raccoon) © Dennis Church CC BY-NC-ND 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Американски енот (миеща мечка)
Hrvatski	Croatian	rakun
Čeština	Czech	mýval severní
Dansk	Danish	vaskebjørn
Nederlands	Dutch	wasbeer
English	English	raccoon
Eesti	Estonian	pesukaru
Suomi	Finnish	pesukarhu
Français	French	raton laveur
Deutsch	German	Waschbär
ελληνικά	Greek	Ρακούν
Magyar	Hungarian	mosómedve
Gaeilge	Irish	-
Italiano	Italian	procione
Latviskiski	Latvian	jenots
Lietuviškaiškai	Lithuanian	paprastasis meškėnas
Malti	Maltese	-
Polski	Polish	szop pracz
Português	Portuguese	guaxinim
Română	Romanian	raton
Slovenčina (Slovenský jazyk)	Slovak	medvedík čistotný
Slovenščina (Slovenski jezik)	Slovenian	severnoameriški rakun
Español	Spanish	mapache
Svenska	Swedish	tvättbjörn

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting; Keeping in captivity; Sterilisation; Immuno-contra-ceptive vaccines by injection	A	A	A	A	A	Fully effective for rapid eradication measures – with evidence that individual animals have been quickly captured and removed from the wild (kept in captivity). Although the method is available for the target species for the other objectives, further details are needed on its effectiveness and costs for these projects. In general, where the objective is eradication, cage traps are best used in combination with another method to remove any trap shy members of the population, and to locate animals when capture rates are low. Where the objective is population control, care is needed to ensure that effort is sufficient to achieve the stated objectives. Cage trapping can be very labour-intensive and be difficult in some terrains.
Shooting	Live and kill traps; Judas animals; Hunting dogs		A	A	A	A	Although the method is available for the target species, further details are needed on its effectiveness and costs. Hunting is often integrated with other measures.
Hunting dogs (tracking/ baying)	Shooting; Judas animals; Live or killing traps	P	A	A	A	A	Although the method is available for the target species, further details are needed on its effectiveness and costs.
Neck-hold traps, and snares	Cage traps	P		A	A	A	Information on the effectiveness of these measures in managing IAS of Union concern is scanty. A study suggested that egg traps (a type of live restraint trap that encapsulates the foot) were more effective in trapping raccoons than cage traps.
Spring traps	Shooting; Habitat modifica-tion; Exclu-sion meas-ures such as fencing	A	P	P	P	P	Although the method is available or potential for the target species, further details are needed on its effectiveness and costs for eradication, population control and containment projects. In general, spring trapping is very labour-intensive and can be difficult in some terrains.
Judas animals	Hunting dogs; Sterilisation of the Judas animal	U					Although the method is potentially available for the target species, further details are needed on its effectiveness and costs.
Fertility Control - chemical (in bait) & injection	Live-capture measures (e.g. cage traps); Keeping in captivity				P	P	Although the method is potentially available for the target species, further details are needed on its effectiveness and costs. In captive males, progestin injections were used (Delvosteron). In females, progestin-implants (MGA and Implanon), GnRH agonist implants (Suprelorin), progestin-injections (Delvosteron, Depo-Provera) have been used successfully. In general, non-oral contraceptives are best utilised on isolated and small wild populations due to immigration and emigration that might affect the proportion of contracepted animals. The availability of chemical fertility control that could be delivered orally via species-specific baits would potentially greatly increase the scope for the application of these agents as an IAS management tool.

Measures to dispatch/remove once captured	
Measure	**Availability**
Keeping in captivity	**A**
Shooting - dispatch restrained animals	**A**
Surgical sterilisation	**A**
Cranial depression	**P**
Electrocution	**P**
Injection euthanasia	**P**
Modified atmospheres	**P**
Slaughter (knife)	**P**

6.17. *Pseudorasbora parva* (Temminck & Schlegel, 1846)

Pseudorasbora parva (Stone moroko)

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Псевдоразбора
Hrvatski	Croatian	Bezribica
Čeština	Czech	Střevlička východní
Dansk	Danish	Båndgrundling
Nederlands	Dutch	Blauwband
English	English	Stone moroko
Eesti	Estonian	Ebarasboora
Suomi	Finnish	Saharasbora
Français	French	Goujon asiatique
Deutsch	German	Blaubandbärbling
ελληνικά	Greek	Ψευτορασμπόρα
Magyar	Hungarian	Razbóra
Gaeilge	Irish	-
Italiano	Italian	Pseudorasbora
Latviskiski	Latvian	Amūras čebačeks
Lietuviškaiškai	Lithuanian	Rytinis gružlelis
Malti	Maltese	-
Polski	Polish	Czebaczek amurski
Português	Portuguese	Góbio-asiático
Română	Romanian	Murgoi bălțat
Slovenčina (Slovenský jazyk)	Slovak	Hrúzovec sieťovaný
Slovenščina (Slovenski jezik)	Slovenian	Psevdorazbora
Español	Spanish	Pseudorasbora
Svenska	Swedish	Bandslätting

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Aquatic habitat management - Pond drying/ draining	Hand removal; Physical fishing	**P**	**A**		**A**	**A**	Drainage combined with physical removal (see physical fishing below, also could be by hand nets) has been shown to be effective at eradicating *P. parva* populations. Only feasible and cost-effective in small and isolated waterbodies.
Physical fishing methods	Native predators	**A**	**A**		**A**	**A**	Repeated 'cropping' (using seine nets) potentially combined with stocking of native predators (e.g. *Perca fluviatilis*) has been shown to be effective at reducing *P. parva* populations. Only really cost effective in smaller (shallow) water bodies. Recreational fishing can also play a key role for early detection.
Electrofishing	Hand removal; Aquatic habitat management - Pond drying/ draining	**A**	**A**		**A**	**P**	Effective as a sampling tool. For eradication, most effective in shallow clear water bodies, and for larger fish. Because of the small size of *P. parva* (12-70 mm) electrofishing is not considered a feasible tool for eradication by itself. The measure requires specialist equipment and training, and costs increase and effectiveness decreases as the size of the treated area gets larger.
Chemical treatment of habitats			**A**	**A**	**P**		Most effective in enclosed waterbodies. However, none of the chemical piscicides that are known to be effective (e.g. rotenone) or under development (e.g. CO_2), are currently approved for use in the EU under the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012). Costs vary according to piscicide used and will increase with size of the spatial area being treated.
Native predators					**A**	**A**	A study has shown that adding pike (*Esox lucius*) to ponds in a trial found that they reduced substantially the biomass of *P. parva* compared to ponds where pike were not added.
Aquatic barriers - physical & non-physical			**P**		**P**	**A**	Physical permeable barriers on the outflows of lentic habitats (or fish farms) could be used to prevent spread, or support rapid eradication measures (e.g. pond drainage). Require ongoing maintenance costs. Non-physical in-stream barriers could potentially be used to prevent spread. However they are not yet 100% effective, and more suited to deterrent for entering hydroelectric plants etc. Require continuous costs for running and maintenance, and vulnerable to power outages.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Cranial depression	**P**
Decapitation	**P**
Electrocution	**P**
Freezing	**P**
Injection euthanasia [directly into water]	**P**
Keeping in captivity	**P**
Slaughter (knife)	**P**

6.18. *Sciurus carolinensis* Gmelin, 1788

Sciurus carolinensis (Grey squirrel) © Tomfriedel/BirdPhotos.com CC BY 3.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Източна сива катерица
Hrvatski	Croatian	siva vjeverica
Čeština	Czech	veverka popelavá
Dansk	Danish	gråt egern
Nederlands	Dutch	grijze eekhoorn
English	English	grey squirrel
Eesti	Estonian	hallorav
Suomi	Finnish	harmaaorava
Français	French	écureuil gris
Deutsch	German	Grauhörnchen
ελληνικά	Greek	Γκρίζος σκίουρος
Magyar	Hungarian	szürke mókus
Gaeilge	Irish	Iora glas
Italiano	Italian	scoiattolo grigio
Latviskiski	Latvian	pelēkā vāvere
Lietuviškaiškai	Lithuanian	pilkoji voverė
Malti	Maltese	-
Polski	Polish	wiewiórka szara
Português	Portuguese	esquilo-cinzento
Română	Romanian	veveriță cenușie
Slovenčina (Slovenský jazyk)	Slovak	veverica sivá
Slovenščina (Slovenski jezik)	Slovenian	siva veverica
Español	Spanish	ardilla de las Carolinas
Svenska	Swedish	gråekorre

Availability and effectiveness of measures

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting; Methods for treatment or humane dispatch	A	A	A	A	A	Cage traps are a widely used method for rapid eradication, eradication, population control and containment for many different species. However, cost-effectiveness can be compromised when capture rates are low, by trying to capture trap-shy individuals and where there are limits to the sites where they can be set. In such cases, cage-traps are often used in association with other methods, such as shooting. In the UK, *S. carolinensis* is often successfully cage trapped and then humanely dispatched, to avoid catching protected *S. vulgaris* or *Martes martes* in spring traps. Live-trapping successfully eradicated a population of *S. carolinensis* over a 12-year period on Anglesey.
Shooting	Trapping; Judas animals; Hunting dogs				A	A	Shooting can be highly cost-effective, reflecting its selective nature, its ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Shooting can provide the main population control method or be applied in combination with other methods, such as traps, given the restrictions on the use of shooting on some sites, and the changing cost-effectiveness of different methods as animal density changes. Shooting has been used to supplement the population control of smaller IAS such as squirrels.
Spring traps	Shooting	A	P	P	A	P	Spring-trapping which is very labour-intensive, was added to an existing shooting programme in an effort to eradicate *S. carolinensis* from Northumberland and parts of Durham in the UK. Ultimately the eradication effort was deemed a failure. Kill-trapping *S. carolinensis* is generally less efficient than live trapping, and can't be used where the native red squirrel is present. Some evidence from spring trapping suggests no reduction in the number of squirrels caught. Not only did the eradication mentioned above fail, but squirrel numbers also started to increase, indicating that spring trapping (with shooting) may not always be cost-effective at containing or controlling populations either.
Poisons and toxins in bait	Trapping; Shooting			A	A		There is no strong evidence that the poison bait approach has been cost-effective as a large-scale management tool for *S. carolinensis*. In one case, warfarin (no longer approved for *S. carolinensis*) was claimed to be more cost-effective than trapping or shooting, but this assumed that all warfarin bait taken led to squirrel death, rather than an empirical assessment.
Goodnature self-resetting traps	Spring traps	A	P	P	P	P	The measure has been used for this species and A18 Goodnature® traps are available for killing grey squirrels. No independent evidence is available on cost-effectiveness. The capital outlay of buying self-resetting traps is greater than for traditional traps, but since traps do not need to be reset regularly there should be a reduction in field effort and overall costs over time compared to more labour-intensive methods.
Hunting dogs (tracking/ baying)	Shooting	P	P	P	P	P	In general hunting dogs are considered very cost-effective. This method may be particularly effective for early detection and rapid eradication projects. The method can potentially be used for this target species, but further details are needed on its effectiveness and costs.
Fertility Control - chemical (in bait) & injection	Any type of live-capture measure; Culling; Keeping in captivity				A		Much work still needs to be done in this area before it can be widely used as a management tool. Studies with *S. carolinensis* indicate that an immune-contraceptive and an oral contraceptive can effectively cause infertility. However, one study indicated that 90% of a *S. carolinensis* population would need to have effective fertility control before the desired population control due to high birth rates. Methods involving live capture are labour-intensive.
Native predators	Trapping; Shooting					P	Reintroduction of top predators is rarely without complication, financial cost or social discord. These are unlikely to be off-set by the value predators may bring in helping to suppress populations of IAS. The cost/benefit equation is different if the predators arrive in their new landscapes through natural spread, though in this case the accrual of benefits is likely to take very many years. Evidence from predation of *S. carolinensis* by *Martes martes* suggests some level of population control.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical displocation	**A**
Cranial depression	**A**
Injection euthanasia	**A**
Modified atmospheres	**A**
Shooting - dispatch restrained animals	**A**
Surgical sterilisation	**A**
Decapitation	**P**
Electrocution	**P**
Keeping in captivity	**P**
Slaughter (knife)	**P**

6.19. *Sciurus niger* Linnaeus, 1758

Sciurus niger (Fox squirrel) © Ilona Loser CC BY-SA 3.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Лисича катерица
Hrvatski	Croatian	bryantova vjeverica
Čeština	Czech	veverka liščí
Dansk	Danish	ræveegern
Nederlands	Dutch	Amerikaanse voseekhoorn
English	English	fox squirrel
Eesti	Estonian	rebasorav
Suomi	Finnish	iso-orava
Français	French	l'écureuil-renard
Deutsch	German	Fuchshörnchen
ελληνικά	Greek	Αλεποσκίουρος
Magyar	Hungarian	amerikai rókamókus
Gaeilge	Irish	-
Italiano	Italian	scoiattolo volpe
Latviskiski	Latvian	melnā vāvere
Lietuviškaiškai	Lithuanian	juodoji voverė
Malti	Maltese	-
Polski	Polish	wiewiórka czarna
Português	Portuguese	esquilo-raposa
Română	Romanian	-
Slovenčina (Slovenský jazyk)	Slovak	veverica líščia
Slovenščina (Slovenski jezik)	Slovenian	lisičja veverica
Español	Spanish	ardilla zorro oriental
Svenska	Swedish	östlig rävekorre

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting; Chemical fertility control	A	A	A	A	A	The method is available for this target species, but further details are needed on its effectiveness and costs. In general, cage traps provide a cost-effective method to support large scale population control and eradication programmes of different species.
Hunting dogs (tracking/ baying)	Shooting; Judas animals	P	P	P	P	P	The method can potentially be used for this target species, as squirrels can potentially be hunted with dogs e.g. those traditionally used for squirrel hunting in Sweden and Finland. Further details are needed on the effectiveness and costs of the measure for this particular species.
Shooting			P	P	P	P	Shooting can be highly cost-effective, reflecting its selective nature, its ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Shooting can provide the main population control method or be applied in combination with other methods, such as traps, given the restrictions on the use of shooting on some sites, and the changing cost-effectiveness of different methods as animal density changes. Shooting has been used to supplement the population control of smaller IAS such as squirrels.
Goodnature self-resetting traps		P	P	P	P	P	The method can potentially be used for this target species, as A18 Goodnature® traps are available for killing grey squirrels and have been suggested to potentially be suitable for fox squirrels. Further details are needed on the effectiveness and costs of the measure for this particular species.
Spring traps		P	P	P	P	P	The method can potentially be used for this target species. A comparative study identified spring traps as best (over leghold and cage traps) to capture fox squirrels on the basis of moderate efficiency, low relative cost, high selectivity and moderate humaneness.
Fertility Control - chemical (in bait) & injection	Any type of live-capture measure				P		The method can potentially be used for this target species, as both immunocontraceptive injections and oral contraceptives are effective at inhibiting reproduction in grey squirrels. The costs of injections are much higher than those of oral contraceptives, but both methods are more expensive and less effective than lethal eradication measures for squirrels.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	A
Cranial depression	A
Injection euthanasia	A
Modified atmospheres	A
Shooting - dispatch restrained animals	A
Decapitation	P
Electrocution	P
Keeping in captivity	P
Slaughter (knife)	P
Surgical sterilisation	P

6.20. *Tamias sibiricus* (Laxmann, 1769)

Tamias sibiricus (Siberian chipmunk) © Alpsdake CC BY-SA 3.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Азиатски (сибирски) бурундук
Hrvatski	Croatian	Sibirski burunduk
Čeština	Czech	burunduk páskovaný
Dansk	Danish	Sibirisk jordegern
Nederlands	Dutch	Siberische grondeekhoorn
English	English	Siberian chipmunk
Eesti	Estonian	siberi vöötorav
Suomi	Finnish	siperianmaaorava
Français	French	tamia de Sibérie
Deutsch	German	Sibirisches Streifenhörnchen
ελληνικά	Greek	-
Magyar	Hungarian	Szibériai csíkosmókus (burunduk)
Gaeilge	Irish	Iora talún Sibéarach
Italiano	Italian	tamia siberiano
Latviskiski	Latvian	Sibīrijas burunduks
Lietuviškaiškai	Lithuanian	Sibirinis burundukas
Malti	Maltese	-
Polski	Polish	burunduk
Português	Portuguese	esquilo-da-Sibéria
Română	Romanian	veveriță siberiană
Slovenčina (Slovenský jazyk)	Slovak	burunduk pruhovaný
Slovenščina (Slovenski jezik)	Slovenian	Sibirski burunduk
Español	Spanish	ardilla de Siberia
Svenska	Swedish	Sibirisk jordekorre

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Often used as a method of restraint for other methods	A	A	A	A	A	Developing and investing in optimal trap designs and deployments (humane SOPs) can be expensive, as are the maintenance of trap lines across extensive areas. However, the method is proven, having been the primary tool in a number of successful IAS eradications for this and other species.
Hunting dogs (tracking/ baying)	Methods of restraint and removal	P	P	P	P	P	Used to locate and corral animals resistant to capture using other methods. Requires other methods to restrain and remove animals from the environment. Very useful for animals dispersed across extensive and difficult to work landscapes. The measure can potentially be used for this target species, but further details are needed on its effectiveness and costs.
Shooting			P	P	P	P	Shooting can be highly cost-effective, reflecting its selective nature, its ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Shooting can provide the main population control method or be applied in combination with other methods, such as traps, given the restrictions on the use of shooting on some sites, and the changing cost-effectiveness of different methods as animal density changes. Shooting has been used to supplement the population control of smaller IAS such as squirrels.
Spring traps		P	P	P	P	P	Assumed to be effective given the similarity of this species with other squirrels, for which the measure has been used.
Fertility Control - chemical (in bait) & injection					P		The method can potentially be used for this target species, as drug and vaccine contraceptives have been investigated for arboreal squirrel species. Further details are needed on the measure effectiveness and costs for this species.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Cranial depression	**P**
Decapitation	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Modified atmospheres	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterilisation	**P**

6.21. *Threskiornis aethiopicus* (Latham, 1790)

Threskiornis aethiopicus (Sacred ibis) © Helmy oved CC BY 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Свещен ибис
Hrvatski	Croatian	sveti ibis
Čeština	Czech	ibis posvátný
Dansk	Danish	hellig ibis
Nederlands	Dutch	heilige ibis
English	English	sacred ibis
Eesti	Estonian	pühaiibis
Suomi	Finnish	pyhäiibis
Français	French	ibis sacré
Deutsch	German	Heiliger Ibis
ελληνικά	Greek	ιερή ίβιδα
Magyar	Hungarian	szent íbisz
Gaeilge	Irish	-
Italiano	Italian	ibis sacro
Latviskiski	Latvian	svētais ibiss
Lietuviškaiškai	Lithuanian	šventasis ibis
Malti	Maltese	-
Polski	Polish	ibis czczony
Português	Portuguese	íbis-sagrado
Română	Romanian	-
Slovenčina (Slovenský jazyk)	Slovak	ibis posvätný
Slovenščina (Slovenski jezik)	Slovenian	sveti ibis
Español	Spanish	ibis sagrado
Svenska	Swedish	helig ibis

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Shooting	Hand removal (adult birds, chicks and eggs); Stupefying bait		A	A	A	A	Where it has been used, shooting has provided the main method for the management of sacred Ibis, with eradication appearing a feasible objective. Costs can vary widely, so further details are needed on the costs of the measure for this particular species.
Hand removal		P	P	A	A	P	Hand removal presents a method where animal is removed from its habitat using hands. It's the simplest method and can always be used along the other methods for wildlife control and management. Hand removal could potentially be used, through egg removal and destruction, to support other measures in the eradication of smaller populations. Cannon-nets could also be used to capture congregated birds. Its application is relatively low cost, but further research is needed to test its effectiveness.
Egg oiling	Shooting		P	P	A	P	The method is available for this target species, as for the related species *T. molucca* it has proven more cost-effective than nest and egg destruction measures due to its low labour requirements and costs.
Stupefying bait	Shooting; Hand removal (nest/egg destruction)			A			The method has been effectively used to manage the species as part of a wider programme to eradicate the species. The measure can be highly cost-effective, as it requires little or no equipment with comparatively low levels of effort. Together with this measure, bird eggs can be removed or destroyed to reduce productivity and, in some instances, removed eggs can be replaced by dummy eggs to prevent replacement with a new clutch.
Judas animals	Shooting; Sterilisation of the Judas animal	P					The method can potentially be used for this target species, as it has been used in other bird species. Further details are needed on the actual use, effectiveness and costs of the measure for this particular species.

Measures to dispatch/remove once captured	
Measure	**Availability**
Cervical dislocation	**P**
Cranial depression	**P**
Decapitation	**P**
Electrocution	**P**
Injection euthanasia	**P**
Keeping in captivity	**P**
Modified atmospheres	**P**
Shooting - dispatch restrained animals	**P**
Slaughter (knife)	**P**
Surgical sterilisation	**P**

6.22. *Trachemys scripta* Schoepff, 1792

Trachemys scripta (Red-eared, Yellow-bellied, and Cumberland sliders) © Shelia Sund CC BY 2.0

Common names in all EU languages

Language	(English name)	Common name
Български	Bulgarian	Червенобуза, жълтобуза и кембърлендова водни костенурки
Hrvatski	Croatian	crvenouha kornjača, žutouha kornjača
Čeština	Czech	želva nádherná
Dansk	Danish	rødøret terrapin, Cumberland terrapin, guløret terrapin
Nederlands	Dutch	lettersierschildpad, roodwangschildpad, geelbuikschildpad, geelwangschildpad
English	English	pond slider, red-eared slider, yellow-bellied slider, Cumberland slider
Eesti	Estonian	punakõrv-ilukilpkonn
Suomi	Finnish	punakorvakilpikonna
Français	French	tortue de Floride
Deutsch	German	Buchstaben-Schmuckschildkröte, Gelbwangenschmuckschildkröte, Rotwangenschmuckschildkröte, Cumberland-Schmuckschildkröte
ελληνικά	Greek	Ερυθροκρόταφη νεροχελώνα
Magyar	Hungarian	ékszerteknős
Gaeilge	Irish	-
Italiano	Italian	testuggine palustre americana, tartaruga dalle orecchie rosse, tartaruga dalle orecchie gialle, tartaruga dalle orecchie arancioni di cumberland
Latviskiski	Latvian	sarkanausu bruņurupucis
Lietuviškaiškai	Lithuanian	raštuotasis vėžlys
Malti	Maltese	il-fekruna tal-ilma ħelu, it-terapinn
Polski	Polish	żółw ozdobny, żółw czerwonolicy, żółw żółtobrzuchy, żółw żółtolicy

Language	(English name)	Common name
Português	Portuguese	tartaruga-da-Florida, tartaruga de orelha vermelha, tartaruga de orelha amarela, tartaruga de faces rosadas
Română	Romanian	Țestoasă de Florida cu tâmple galbene
Slovenčina (Slovenský jazyk)	Slovak	korytnačka písmenková
Slovenščina (Slovenski jezik)	Slovenian	popisana sklednica
Español	Spanish	tortuga pintada
Svenska	Swedish	gulbukig vattensköldpadda, rödörad, gulbukig, samt gulörad

Measures availability and effectiveness

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Cage traps	Shooting; Sterilisation; Immunocontraceptive vaccines by injection	A	P	A	A	A	Cage trapping provides a widely used, flexible and effective method to catch and restrain a wide variety of different species. It is a frequently used and successful method to support the management of IAS. The requirement for regular checking brings significant implications for cost and their cost-effectiveness can be low in situations where the rate of animal capture is poor. Although the method is known to be available for the target species, further details are needed on its effectiveness and costs.
Hand removal	Trapping; Passive netting; Electrofishing; Pond fencing	P	A	A	A	A	Hand removal is considered effective for eradication or population control only when combined with other removal techniques. The method includes also the destruction of eggs, nests, and hatchlings. *Trachemys scripta* can be captured by hand or through various trapping devices. Eradication could be obtained by draining a water body, removing sliders by hand, and finally filling again with water.
Physical fishing methods	Electrofishing; Hand removal; Shooting; Biocontrol; Pond draining	P	A	P	A	A	Seine nets, longline fishing, various traps, hook and line are all physical fishing methods used for *Trachemys*. For example, longline fishing can be used to help control populations of *T. scripta*. Fishing with a hook and line has been tested as a management technique for *T. scripta*. In Spain, France, Portugal and Italy, population control and eradication campaigns have successfully used various types of traps to capture specimens of *T. scripta*; fyke nets seemed to be particularly effective in canals and ditches. A particular type of trap that has also been effectively used in management campaigns of *T. scripta* are basking traps, which consist in floating enclosures with sloping sides and a basking surface, from which a mesh basket hangs suspended. In Corsica, France, the use of the trapping technique proved relatively effective in a confined and isolated area, but did not eradicate the species.

Measure	Commonly integrated with	Objective and availability					Effectiveness and costs
		Un	RE	Er	Cl	Ct	
Aquatic habitat management - Pond drying/ draining	Hand removal; Trapping; Netting; Spearing; Shooting; Electrofishing	P	P	A	P	P	Draining invaded waterbodies can be used for localised management of *T. scripta* populations. This has been successfully implemented in Australia, where a series of water bodies invaded with *T. scripta* were drained, de-silted using an excavator, filled and compacted; the muck was spread, turned and raked with a tractor, and all remaining animals were removed by hand. When a water body is drained rapidly, up to 75% of sliders will emigrate, therefore sites should be secured with fences and pitfall traps to prevent emigration.
Shooting	Traps; Judas animals; Pond draining		P	P	A	A	Shooting is widely used as a wildlife management tool. This reflects its selective nature, its ability to manage animals at a distance, and the flexibility offered by the range of weapons and applications available. Although the method is known to be available for the target species, further details are needed on its effectiveness and costs
Native predators	Many other non-lethal measures				P		The measure might include introducing predators where they have recently been absent, or enhancing the predatory activity of existing native predators. Although the method is known to be (potentially) available for the target species, further details are needed on its effectiveness and costs.
Hunting dogs (tracking/ baying)	Traps		P	P	A		Detection dogs which never hunt or come in direct contact with the IAS, are used to find egg laying places for *Trachemys* species, e.g. in Spain. In particular, the LIFE Trachemys project mentioned that the measure works for new laid nests or for hatchlings, but that older nests are missed by sniffer dogs, which reduces the effectiveness of the measure. The method seems particularly effective for early detection/rapid eradication projects. Care needs taken when undertaken in places where native turtles also nest.
Physical terrestrial barriers	Trapping; Pond drainage	P				P	In France, the measure was very effective in keeping the red-eared sliders in the studied ponds during the project duration (4 years). However, fences were temporary, therefore the long-term effectiveness (individuals can live for up to 40 years) is unknown and will depend upon regular upkeep and maintenance. The relatively high cost of fencing—both building and maintenance—means it is only appropriate for use in relatively small or specific areas.
Judas animals	Hunting dogs; Shooting; Sterilisation	U					The Judas animal technique, which is based on the use of tagged individuals to find conspecifics, in species that are known to aggregate, is considered as potentially applicable to pond sliders. The method is most cost-efficient at very low densities of the target population. When only few animals are left in a population up for eradication, Judas animals will often be the only way of finding them all. Although the method is known to be potentially available for the target species, further details are needed on its effectiveness and costs.

Measures to dispatch/remove once captured	
Measure	**Availability**
Freezing	**A**
Injection euthanasia	**A**
Shooting - dispatch restrained animals	**A**
Cervical dislocation	**P**
Cranial depression	**P**
Electrocution	**P**
Keeping in captivity	**A**
Surgical sterilisation	**A**
Modified atmospheres	**P**

7. Measure assessments

This section outlines the information presented for each of the measures that have been identified as available [incl. potentially] to eradicate, control, and contain populations of the 22 vertebrate IAS of Union concern. The measures are detailed in **Appendices 1-32** (see **Table 10**), starting with the measures used to *restrain, capture and/or kill in the field*, followed by measures used to *dispatch or remove an individual once captured*. It is important to note that the information collated for the assessments, especially in relation to the costs and effectiveness of case studies, is not based on a comprehensive literature search. **Appendix 33** provides the impact categories from Sharp and Saunders (2011), used to guide the humaneness assessments.

Table 10. List of Measure assessments with Appendix number

Category	Measure name	Appendix #
Biological control	Native predators	1
Habitat manipulation	Aquatic barriers - physical & non-physical	2
	Aquatic habitat management - Pond drying/draining	3
	Physical terrestrial barriers	4
Hand removal	Hand removal	5
	Physical fishing methods - including aquatic nets	6
Other	Egg oiling	7
	Electrofishing	8
	Chemical fertility control	9
	Hunting dogs (tracking/baying)	10
	Judas animals	11
Poisoning or toxicants	Stupefying bait	12
	Chemical treatment of habitats	13
	Poisons and toxins in bait	14
Shooting	Shooting	15
Trapping	Drowning traps	16
	Goodnature self-resetting traps	17
	Spring operated traps	18
	Cage traps	19
	Neck-hold traps, and snares	20
	Live decoy traps	21

Category	Measure name	Appendix #
Dispatch/removal once captured	Cervical dislocation	22
	Cranial depression	23
	Decapitation	24
	Electrocution	25
	Freezing	26
	Injection euthanasia	27
	Keeping in captivity	28
	Modified atmospheres	29
	Shooting - dispatch restrained animals	30
	Slaughter with a knife	31
	Surgical sterilisation	32
Humane impact categories, taken from Sharp and Saunders (2011)		33

7.1. Information presented in measure assessments

Each measure assessment is presented in a series of tables, **Table 11** provides a description of the information provided in each field (if available).

Note that the *Dispatch/removal once captured* measures use only a subset of the fields described below.

Table 11. A description of each field of information for the measure assessments

Field number	Field name	Description
1. Measure name		
1.1.	Measure name	The measure name in English.
1.2.	Intended lethality	Notes if the measure is intended to be lethal, non-lethal, or both (if there are different types of the measure that lead to different outcomes).
1.3.	Other languages	The measure name in English, and other EU languages if available.
2. Technical details of the measure		
2.1.a.	Measure description	Summarises methods of application, noting different types and changes in application in relation to different species.
2.1.b.	Integration with other measures	Outlines other measures that this measure is known to be combined with as part of an integrated strategy to meet a particular objective. For example, this measure may not be fully effective at eradication on its own, and so is often combined with another measure to remove all individuals. Note that these 'other measures' are assessed in a separate Appendix.

Field number	Field name	Description
2.2.a.	Availability of the measure for the different vertebrate IAS of Union concern	Details if a measure is available (either; available, under development, or potentially) for different management objectives (rapid eradication, eradication, population control, containment) for each of the species. Availability: • A = Available. Evidence shows the measure has been applied to the species with the aim of meeting a defined objective (see below). • U = Under development. Evidence (or expert opinion) shows that the measure is under development (e.g. field trials) for the species, but has not yet been applied to meet an objective. • P = Potential. Evidence (or expert opinion) shows that the measure has the potential to be applied to the species, but is not yet in development for the species (e.g. measure has been applied to a similar species). Objective: • Rapid eradication = Measures to achieve eradication (permanent removal) of the population of the IAS, at an early stage of invasion, after an early detection of a new occurrence (cf. Article 17). • Eradication = Measures to achieve eradication (permanent removal) of the species once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19). • Control = Measures to achieve population control of the species once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19). • Containment = Measures to achieve containment of a population of the species once it has become widely spread within a Member State, or part of a Member State's territory (cf. Article 19).
2.2.b.	Application of the measure in EU Member States	Details if evidence has been found that the measure has been applied in that Member State for a specific objective. Application: • X = Applied in country. Evidence shows that the measure has been applied for the objective within the country (note not to include if the measures has just been tested/in development/potential). Objectives: • See definitions provided above in 2.2.a.
3. Humaneness of the measure		
3.1.	Welfare for all measures	Measures are assessed in relation to being applied using any available best practices, but detail areas where common misapplication can lead to unnecessary pain. A rationale is provided for each of the 5 domains in the relevant impact category, indicating duration (minutes/hours/days) of the impact if known. For impact category definitions (used as a guide), see Appendix 33. The 5 domains are: • Water deprivation, food deprivation, malnutrition: Does the measure expose the animal to water or food restrictions [that are outside usual tolerance levels? • Environmental challenge: Does the measure expose the animal to environmental conditions which are outside the normal range encountered by the animal? • Injury, disease, functional impairment: Does the measure expose the animal to disease, injury or functional impairment? • Behavioural, interactive restriction: Does the measure interfere with the behavioural needs of an animal (being those activities which when thwarted produce untoward physiological or psychological effects)? • Anxiety, fear, pain, distress, thirst, hunger etc.: This impact is usually a cumulative effect of the other four domains and is generally, but not always, equivalent to the most extreme potential impact. If the measure has distinct 'types' with significantly different humaneness outcomes, a separate assessment table is provided. Note that a measure may lead to different welfare outcomes depending upon the species that it is applied to or other variables, such differences are discussed and their rationale may be placed in a separate impact category.

Field number	Field name	Description
3.2.	Mode of death	Where death is not immediate, the duration (e.g. seconds/minutes/hours) until insensibility or death is reported, if known. Note that suffering includes (not limited to) fear, anxiety, pain, distress, apprehension, sickness, fatigue, thirst, hunger. Also aversion refers to the avoidance or attempted avoidance of unpleasant, noxious stimuli and distressing stimuli. For impact category definitions (used as a guide), see Appendix 33. If the measure has distinct 'types' with significantly different humaneness outcomes, a separate assessment table is provided.
3.3.	Humaneness summary	Summarises the key findings of the humaneness assessment.
4. Costs and effectiveness of the measure		
4.1.	Case studies	A summary of the general effectiveness of the measure is provided. Case studies are then presented of the measures application for the 22 vertebrate IAS of Union concern. Each case study is presented in a different table, with the following information: • Species: The species the measure is being applied to • Objective: The management objective the measure is being applied for, Rapid eradication, Eradication, Population Control, or Containment • Use of measures: Description of measures use in this case study • Combined with other measures: Description of integration with another measure as part of an integrated strategy • Country(ies) of application: The country the measures was applied in for the case study • Geographic scale (km2) and/or population size measure applied to • Time period: The length of time the measure was applied over in the case study • Effort: A quantitative estimate of effort with units of effort and duration • Costs: A breakdown of the reported overall costs, if possible broken down to personnel, equipment and infrastructure, and other costs (incl. overheads). This can be financial or other • Effectiveness: Noting how effective the measure was at meeting its objective.
4.2.	Costs effectiveness summary	Summarises the cost-effectiveness findings from the case studies above.
5. Side effects		
	Side effects	Details any known or potential positive or negative side effects from the application of the measure. This does not include the intended outcome of the measure (e.g. native species recovery due to eradication/population control of the IAS). The side effects are discussed for: • Non-target native species, their habitats and the broader environment • Other invasive alien species: This can include direct impacts of the measure to non-target alien species (e.g. also caught in traps), but also indirect impacts to other alien species (e.g. mesopredator release) • Public health and well-being • Economic.
6. Conclusion		
	Overall assessment of the measure (qualitative)	A qualitative assessment of the measure based on all factors considered above, including the costs of its application, effectiveness, side effects, and humaneness. Differences in relation to its application for different objectives, geographic scales or population sizes are noted if known. Assessors and Reviewers of the measure assessment are listed.
7. References		
	References	Lists the references cited in the assessment

8. Regional conditions

This section outlines the Appendices that contain information collated through the workshops on the regional conditions relevant to the application of the measures. These are presented in eight 'Regional conditions' Appendices (**Appendices 34-41** listed in **Table 12**), each corresponding to a different workshop region. Each of these appendices contains information on the presence of the 22 vertebrate IAS of Union concern in Member States from the region; the restrictions and/or bans of the measures (and corresponding legislation) in Member States from the region; an overview of the legislation, standards and guidance regarding management of IAS of Union concern within Member States from the region.

It is important to note that national (and sub-national) legislation are constantly being updated, and therefore information presented within each Regional conditions Appendix could soon become outdated. The information in these appendices **should not be taken as legal guidance** to identify if a measure can or cannot be used, or what restrictions are placed on their use, but rather as a general overview to inform the user. **It is therefore essential that anyone planning on undertaking any of the measures set out in this manual should first contact their relevant national authorities to understand the current legal frameworks that they need to operate within**.

Table 12. Region with Appendix number

Workshop Region	Member States included	Appendix number
Alpine	Austria, Slovakia, Slovenia (and Liechtenstein)	34
Atlantic	Belgium, France, Ireland, Netherlands (and UK)	35
Black Sea, Steppic & Continental (EAST)	Bulgaria, Romania	36
Boreal	Estonia, Finland, Latvia, Lithuania, Sweden	37
Continental (CENTRAL) & Pannonian	Croatia, Czechia, Hungary, Poland	38
Continental (WEST)	Denmark, Germany, Luxembourg	39
Mediterranean (EAST)	Cyprus, Greece	40
Mediterranean (WEST)	Italy, Malta, Portugal, Spain	41

Non-EU countries in brackets

8.1. Information presented in the Appendices for Regional conditions

Each Regional conditions Appendix includes a series of tables and text. **Table 13** provides a detailed description of the sections present and the information provided therein.

Table 13. Description of the information presented in each section of the Regional Appendices.

Section number/name	Description
1. Species presence in Member States from the region	Presents Table 1, which describes the presence, status and impact of the 22 vertebrate IAS of Union concern for each Member State in the region, as well as respective references.
2. Toolbox of measures - restrictions/bans in Member States from the region	Presents Table 2, which shows the legal restrictions and/or bans for measures that are (potentially) available to eradicate, control and contain populations of the vertebrate IAS of Union concern present in the region.
3. Details of restrictions/bans of Toolbox measures in Member States from the region	Presents Table 3, with details of measures presented in Table 2 that are restricted or banned due to welfare or other legislation (Measure name; Details on restrictions/ban; Member State where applied; Name of legislation).
4. Overview of legislation, standards and guidance within Member States from the region	Overview of each legislation/standard/guidance directly or indirectly related to the management of vertebrate IAS of Union concern in each Member State in the region.
5. Overview of management measures that are restricted or banned from use due to the different legislation, standards and guidance)	Some Regional appendices also contain a section providing further details on how the different legislation, standards and guidance affect the specific management measures mentioned in the Toolbox in the region.
6. References	List of the full References mentioned throughout the Regional Appendix.

9. References

This section provides the references cited in this manual. However, note that the humaneness summaries (**Section 5**) and species accounts (**Section 6**) are taken from the individual measure assessments, the references for which are not presented here but in the relevant measure assessment (**Appendices 1-32**).

Baker, S.E., M. Ayers, N.J. Beausoleil, S.R. Belmain, M. Berdoy, A.P. Buckle, C. Cagienard, D. Cowan, J. Fearn-Daglish, P. Goddard, H.D.R. Golledge, E. Mullineaux, T. Sharp, A. Simmons, and E. Schmolz. 2022. 'An assessment of animal welfare impacts in wild Norway rat (*Rattus norvegicus*) management', Animal Welfare, 31: 51-68.

Baker, S.E., Sharp, T.M., & Macdonald, D.W. 2016. Assessing animal welfare impacts in the management of European rabbits (*Oryctolagus cuniculus*), European moles (*Talpa europaea*) and Carrion Crows (*Corvus corone*). *PLoS ONE*, 11(1): e0146298. https://doi.org/10.1371/journal.pone.0146298.

Barun, A., Hanson, C.C., Campbell, K.J., & Simberloff, D. 2011. A review of small Indian mongoose management and eradications on islands. *Island invasives: eradication and management*. IUCN, Gland, Switzerland, 17-25.

Baylis, S.M., Cassey, P., & Hauber, M.E. 2012. Capsaicin as a Deterrent Against Introduced Mammalian Nest Predators. *The Wilson Journal of Ornithology*, 124: 518–524.

Boakes, E.H, McGowan, P.J.K., Fuller, R.A., Chang-qing, D., Clark, N.E., et al. 2010. Distorted Views of Biodiversity: Spatial and Temporal Bias in Species Occurrence Data. *PLOS Biology,* 8(6): e1000385. https://doi.org/10.1371/journal.pbio.1000385

Broom, D. 1999. The welfare of vertebrate pests in relation to their management. *Advances in Vertebrate Pest Management*, 1: 309-329.

Crowley, S.L., Hinchcliffe, S.T., & McDonald, R.A. 2017. Conflict in invasive species management. *Frontiers Ecology and Environment*, https://doi.org/10.1002/fee.1471

Dansk Ornitologisk Forening. 2020. Elhegn redder koloni af kystfugle fra sultne ræve https://www.dof.dk/om-dof/nyheder?nyhed_id=1843.

Dubois, S., Fenwick, N., Ryan, E.A., Baker, L., Baker, S.E., Beausoleil, N.J., Carter, S., Cartwright, B., Costa, F., Draper, C., Griffin, J., Grogan, A., Howald, G., Jones, B., Littin, K.E., Lombard, A.T., Mellor, D. J., Ramp, D., Schuppli, C.A., & Fraser, D. 2017. International consensus principles for ethical wildlife control. *Conservation Biology*, 31: 753-760.

EC. 2015. EU Zoos Directive good practices document. https://ec.europa.eu/environment/nature/pdf/EU_Zoos_Directive_Good_Practices.pdf

ECHA. 2018. Guidance on the Biocidal Products Regulation Volume II Efficacy - Assessment and Evaluation (Parts B+C) Version 3.0 April 2018. https://echa.europa.eu/documents/10162/23036412/bpr_guidance_assessment_evaluation_part_vol_ii_part_bc_en.pdf/950efefa-f2bf-0b4a-a3fd-41c86daae468

EU. 2020. 2019 report on the statistics on the use of animals for scientific purposes in the Member States of the European Union in 2015-2017. https://ec.europa.eu/info/sites/info/files/com-2020-16-f1-en-main-part-1.pdf

EuroGroup for Animals. 2020. Analysis of national legislation related to the keeping and sale of exotic pets in Europe https://www.eurogroupforanimals.org/sites/eurogroup/files/2020-07/Eurogroup%20for%20Animals_Exotic%20pets%20reoprt_v5%20%281%29.pdf

Fisher, P., Beausoleil, N.J., Warburton, B., Mellor, D.J., Campion, M., & Booth, L. 2010. How humane are our pest control tools? MAF Biosecurity New Zealand, Wellington.

Goverse, E., Creemers, R., & Spitzen–van der Sluijs, A., 2010. Case study on the removal of the American bullfrog in Baarlo, the Netherlands. RAVON, Report. https://www.ravon.nl/Portals/2/Bestanden/Publicaties/Rapporten/2010.139%20Bullfrog%20Baarlo.pdf

Gregory, S.D., Henderson, W., Smee, E., & Cassey, P. 2014. Eradications of Vertebrate Pests in Australia: a Review and Guidelines for Future Best Practice, PestSmart Toolkit publication, Invasive Animals Cooperative Research Centre. Canberra, Australia. https://pestsmart.org.au/wp-content/uploads/sites/3/2020/06/AusEradications_2014.pdf

Groom, Q., Strubbe, D., Adriens, T., Davis, A.J.S., Desmet, P., Oldoni, D., Reyserhove, L., Roy, H.E., & Vanderhoeven, S. 2019. Empowering Citizens to Inform Decision-Making as a Way Forward to Support Invasive Alien Species Policy. *Citizen Science: Theory and Practice*, 4(1):33. https://doi.org/10.5334/cstp.238

Hampton, J. O., Fisher, P. M. & Warburton, B. 2020. Reconsidering humaneness. *Conservation Biology*, 34: 1107-1113.

Hampton, J.O., Arnemoc, J.M., Barnsley, R., Cattet, M., Daoust, P-Y, DeNicola, A.J., Eccles, G., Fletcher, D., Hinds, L.A., Hunt, R., Portas, T., Stokke, S., Warburton, B. & Wimpenny, C. 2021. Animal welfare testing for shooting and darting free-ranging wildlife: a review and recommendations. *Wildlife Research*, https://doi.org/10.1071/WR20107

Harris, S., Soulsbury, C. & Iossa, G. 2005. Trapped by bad science: The Myths behind the International Humane Trapping Standards: A Scientific Review. International Fund for Animal Welfare (IFAW) and Eurogroup for Animals.

Iossa, G., Soulsbury, C. & Harris, S. 2007. Mammal trapping: a review of animal welfare standards of killing and restraining traps. Animal Welfare - UFAW, 16, 335.

Kaczensky, P., Knauer, F., Jonozovic, M., Walzer, C., & Huber, T. 2002. Experiences with Trapping, Chemical Immobilization, and Radiotagging of Brown Bears in Slovenia. *Ursus*, 13: 347-356.

King, K., Wallis, R., Wallis, A., Peucker, A., & Williams, D. 2015. Successful Protection Against Canid Predation on Little Penguins (*Eudyptula minor*) in Australia using Maremma Guardian Dogs: "the Warrambool method". *International Journal of Arts & Sciences*, 8: 139–150.

Larkin, R.P., Vandeelen, T.R., Sabick, R.M., Gosselink, T.E., & Warner, R.E. 2003. Electronic Signaling for Prompt Removal of an Animal from a Trap. *Wildlife Society Bulletin* (1973-2006), 31: 392-398.

League Against Cruel Sports. 2017. The Problems of Snaring in the UK, and its alternatives.

Marks, C. A. 2010. Haematological and biochemical responses of red foxes (*Vulpes vulpes*) to different capture methods and shooting. *Animal Welfare*, 19: 223-234.

Littin, K.E., Mellor, D.J., Warburton, B., & Eason, C.T. 2004. Animal welfare and ethical issues relevant to the humane control of vertebrate pests. *New Zealand Veterinary Journal,* 52(1):1–10. PMID: 15768076

Marks, C.A., Allen, L., Gigliotti, F., Busana, F., Gonzalez, T., Lindeman, M., & Fisher, P.M. 2004. Evaluation of the tranquilliser trap device (TTD) for improving the humaneness of dingo trapping. *Animal Welfare*, 13: 393-399.

Mellor, D.J. & Reid, C.S.W. 1994. Concepts of animal well-being and predicting the impact of procedures on experimental animals. In: Baker, R.M., Jenkin, G. & Mellor, D.J., (eds.). *Improving the Well-Being of Animals in the Research Environment*. 1994 Glen Osmond, South Australia. Australian and New Zealand Council for the Care of Animals in Research and Teaching (ANZCCART), 3-18.

Mellor, D.J. & Littin, K.E. 2004. Using science to support ethical decisions promoting humane livestock slaughter and vertebrate pest control. *Animal Welfare* 13, 127-132

Moberg, G.P. 2000. Biological response to stress: implications for animal welfare. In: Moberg, G.P. & Mench, J.A. (eds.). *The biology of animal stress: basic principles and implications for animal welfare*. Cabi Publishing.

National Research Council (US) Committee on Pain and Distress in Laboratory Animals 1992. Chapter 7, Euthanasia. Recognition and Alleviation of Pain and Distress in Laboratory Animals. Washington (DC): National Academies Press (US).

Orueta, J.F., & Ramos, Y.A., 2001. Methods to Control and Eradicate Non-Native Terrestrial Vertebrate Species. Council of Europe.

Pescott, O.L., Walker, K.J., Pocock, M.J., Jitlal, M., Outhwaite, C.L., Cheffings, C.M., Harris, F., & Roy, D.B. 2015. Ecological monitoring with citizen science: the design and implementation of schemes for recording plants in Britain and Ireland. *Biological Journal of the Linnean Society*, 115: 505–521. https://doi.org/10.1111/bij.12581

Potoçnik, H., Kljun, F., Raçnik, J., Skrbin ek, T., Adamiç, M., & Kos, I. 2002. Experience obtained from box trapping and handling wildcats in Slovenia. *Acta theriologica*, 47: 211-219.

Powell, R.A., & Proulx, G. 2003. Trapping and Marking Terrestrial Mammals for Research: Integrating Ethics, Performance Criteria, Techniques, and Common Sense. *ILAR Journal*, 44: 259-276.

Proulx, G., Cattet, M., Serfass, T.L., and Bakwer, S.E. Updating the AIHTS Trapping Standards to Improve Animal Welfare and Capture Efficiency and Selectivity. *Animals* 2020, *10*, 1262. https://doi.org/10.3390/ani10081262

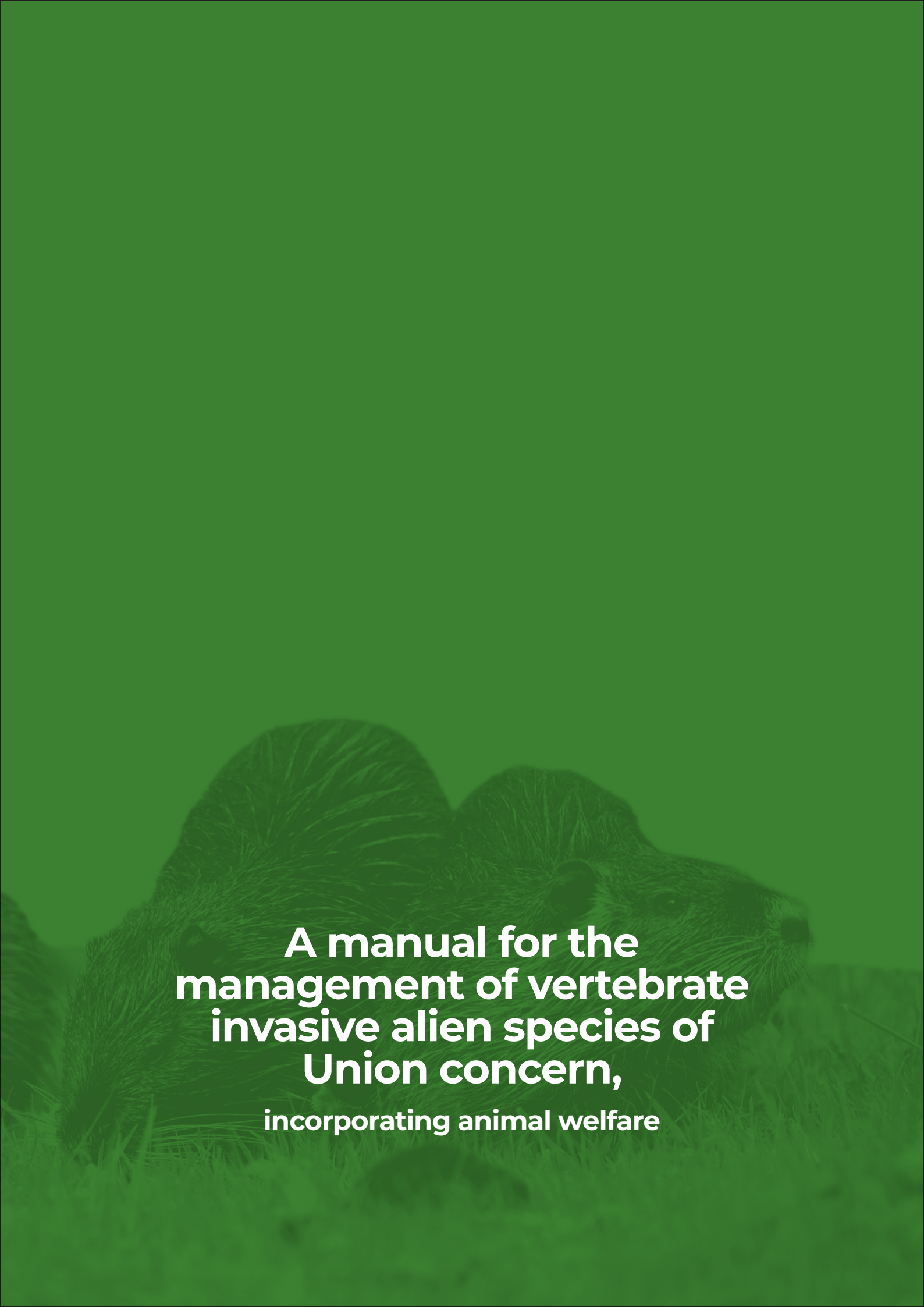
Robertson, P.A., Adriens, T., Lambin, X., Mill, A., Roy, S., Shuttleworth, C.M., & Sutton-Croft, M. 2017. The large-scale removal of mammalian invasive alien species in Northern Europe. *Pest Management Science*, 73(2):273-279. https://doi.org/10.1002/ps.4224

Sharp, R.L., Larson, L.R., & Green, G.T. 2011. Factors influencing public preferences for invasive alien species management. *Biological Conservation*, 144(8):2097-2104 https://doi.org/10.1016/j.biocon.2011.04.032

Sharp, T., & Saunders, G. 2011. A model for assessing the relative humaneness of pest animal control methods, Department of Agriculture, Fisheries and Forestry Canberra, Australia.

Underwood, W., & Anthony, R. 2020. AVMA Guidelines for the Euthanasia of Animals: 2020 Edition.

Talling, J.C., & Inglis, I.R. 2009. Improvements to trapping standards. DG ENV, 361 p. Available: http://ec.europa.eu/environment/biodiversity/animal_welfare/hts/pdf/final_report.pdf.



A manual for the management of vertebrate invasive alien species of Union concern,

incorporating animal welfare