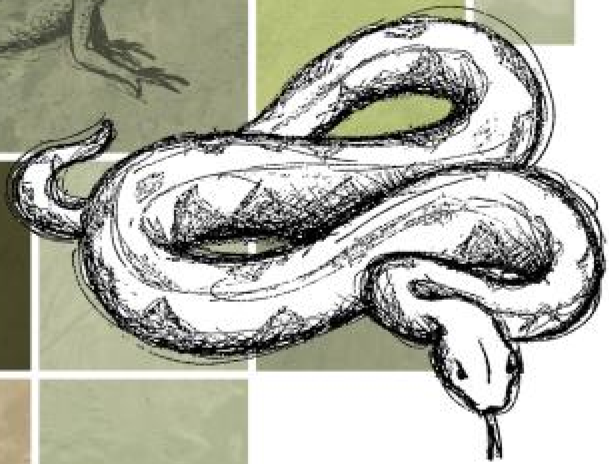

PESTSMART

National Incursion Response Plan

Terrestrial Snakes

Endorsed by the Invasive Animals and Plant Committee (IPAC) – August 2016

M.T. Christy (compiler)

Department of Agriculture and Food, Government of Western Australia
Invasive Animals Cooperative Research Centre
Australian Government, Department of Industry and Science
Business Cooperative Research Centres Programme

National Incursion Response Plan

Terrestrial Snakes

Endorsed by the Invasive Animals and Plant Committee (IPAC) – August 2016

M.T. Christy (compiler)

Department of Agriculture and Food, WA

3 Baron-Hay Court
South Perth, W.A. 6151

2016

An Invasive Animals CRC Project

NOTE: This Plan should be used by Incursion Response Specialists and professional snake handlers only.

Published by: Invasive Animals Cooperative Research Centre.

Telephone: (02) 6201 2887

Facsimile: (02) 6201 2532

Email: contact@invasiveanimals.com

Internet: http://www.invasiveanimals.com | http://www.pestsmart.org.au/

ISBN: 978-0-6480088-6-6

Web ISBN: 978-0-6480088-7-3

The IA CRC gratefully acknowledges funding support from the Australian Government through its Cooperative Research Centres Programme.

This document should be cited as: Christy, M.T. (2016). *National Incursion Response Plan for Terrestrial Snakes.* PestSmart Toolkit publication, Invasive Animals Cooperative Research Centre, Canberra, Australia.

Name of Document:		National Incursion Response Plan for Terrestrial Snakes	
Prepared by:		Michelle Christy	
Description of Content:		This plan provides nationally consistent guidance aimed at incursion prevention and response activities of non-indigenous terrestrial snakes (Order Squamata) in the wild.	
Approved by:		Invasive Plant and Animal Committee (IPAC)	
Date of Approval:		1 August 2016	
Version Number	**Version Date**	**Authorised Officer**	**Amendment Details**
1	January 2016	Michelle Christy	Preparation of draft plan
2	February - August 2016	Michelle Christy	Comments incorporated into draft from DAFWA, PIRSA, DEDJTR, DAF QLD, DPIPWE, DPI NSW, Department of Agriculture and Water Resources, Department of Environment and Energy, Univeristy of Adelaide, University of Canberra, and Interdepartmental Committee for the Introduction and Keeping of Animals Western Australia (CIKA)

NOTE: This Plan should be used by Incursion Response Specialists and professional snake handlers only.

Contents

Figures

Tables

1. Introduction

This plan provides basic information and procedures that can be used to respond to terrestrial snake incursions in Australia. It is designed to be used as a reference resource for the preparation of species, and region/area specific emergency response plans should a terrestrial snake incursion occur. Information and techniques in this plan cannot cover all species; as a result, the plan focuses on five of the 17 Families (Boidae, Pythonidae, Colubridae, Elapidae, and Viperidae). The selection of Families and genera included in this plan is representative of species that have, or may enter Australia and is based on their impact, risk of incursion and establishment, and prevalence in the international and Australian wildlife trade. Species held in zoos or wildlife parks under permit are also included.

This plan was initially modelled on Department of Economic Development, Jobs, Transport and Resources (DEDJTR) Pre-Incursion Plans for boas and pythons, and vipers (Wisniewski 2012a; b).

"This Plan is an important tool to enable governments to be prepared to respond to an incursion from new invasive snake species"

Bruce M Christie, Chair of the Invasive Plants and Animals Committee

1.1 Incursion Reporting

Incursion response protocols for animals are governed by national and state/territory procedures, systems, plans and frameworks. Responsibilities, notifications and response procedures are detailed elsewhere and summarised in Table 1. Note that the level of expertise, capacity, training, capability and infrastructure varies between states/territory.

Table 1 Incursion response agreements, protocols procedures, systems, plans and frameworks

Name	Purpose
National Environmental Biosecurity Response Agreement (NEBRA)	Establishes emergency response arrangements for nationally significant biosecurity incidents, including marine related incidents **http://www.coag.gov.au/node/74**
Biosecurity Incident Management System	• Provides guidance in practices for the management of biosecurity incident response and initial recovery operations in Australia. Can be used for: • planning for response to biosecurity incidents • conducting staff training and development activities • designing and conducting exercises that focus on elements of a biosecurity response • responding to biosecurity incidents • planning and conducting evaluation of any of the above activities

	http://www.agriculture.gov.au/SiteCollectionDocuments/animal-plant/pihc/bepwg/biosecurity-emergency-management-biosecurity-incident-management-system.doc
National Surveillance and Diagnostics Framework	• Provides an integrated approach to the funding and management surveillance and diagnostic activities to: • ensure they are supported by risk based decision making • help prioritise the allocation of government resources and investment to areas of greatest return • maximise the use of existing capability and infrastructure **http://www.agriculture.gov.au/SiteCollectionDocuments/animal-plant/pihc/bepwg/national-surveillance-diagnostic-framework.pdf**
State/Territory Response Plans	State/Territory specific plans to guide responses to high risk invasive animal incursions

1.2 Nebra Reporting Requirements

In addition to state/territory-specific reporting requirements, reporting under National Environmental Biosecurity Response Agreement (NEBRA) may be necessary. Under the NEBRA, once a potentially nationally significant pest or disease outbreak is detected in a jurisdiction, that party must undertake the following:

- Determine whether the outbreak can be managed through pre-existing cost-sharing arrangements and notify a NEBRA reporting point of the outbreak.
    - Reporting must occur within 24 hours of the jurisdiction becoming aware of the outbreak.
    - The state or territory chief biosecurity officer, chief veterinary officer, chief plant health manager or equivalent is responsible for notifying a NEBRA reporting point.
    - The primary reporting point is the Australian Chief Veterinary Officer (ACVO). Although snake incursions are animal incursions, the notification can still go to the Commonwealth's Chief Veterinary Officer, Chief Plant Protection Officer or an equivalent environmental officer.
    - Current ACVO contact details are:

      Australian Chief Veterinary Officer
      Phone: (02) 6272 5512 or (02) 6272 4644
      Email: http://www.agriculture.gov.au/general-inquiries?query=ocvo
    - Carbon Copy the IPAC Secretariat (ipac@agriculture.gov.au) and the NEBRA Custodian (nebra@agriculture.gov.au) when notifying the contact of a detection.

- Once the reporting point is notified, an appropriate National Biosecurity Management Consultative Committee (NBMCC) will be established for the particular animal pest outbreak. If appropriate, this will be one of the existing consultative committees, such as the Consultative Committee for Emergency Animal Diseases (CCEAD). Otherwise, the parties must create an ad hoc NBMCC.
    - The NBMCC is a technical committee, chaired by a representative of the Commonwealth that provides advice to the National Biosecurity Management Group (NBMG). This includes an assessment of the national significance of the outbreak, the technical feasibility and cost-benefit of eradication, and the proposed response plan.
- The NBMG, which is comprised of the heads of all state and territory agencies responsible for biosecurity, decides if a national response is required and, before a response can commence, must agree to the response plan and indicative budget for cost-sharing purposes. The NBMCC monitors progress against the response plan and provides advice to the NBMG as required.
- If the NBMG decides that a national response is not required, any ongoing action will fall back to the affected jurisdiction and/or affected stakeholders.
- The NBMG also makes decisions on changes to the response plan (recognising that it is a living document that may have incremental versions), expenditure limits, financial and efficiency audits of the response and cessation of the response.

2. General Biology

A table listing specific species for each of the five Families (see below) and their general description, diet, habitat, behaviour, reproduction, IPAC classification and incursion history in Australia is included in (Appendix A).

2.1 Boidae and Pythonidae

Boidae and Pythonidae are most commonly found in south and south-east Asia, Africa, central to South America and outlying islands in a variety of habitats (Groombridge and Luxmoore 1991; Reed and Rodda 2009). Many are primarily terrestrial and often found in arboreal environments, while others such as the anaconda are found predominately in aquatic environments (Reed and Rodda 2009).

Boids and pythons are generally highly fecund, meaning they are capable of producing many offspring (McDiarmid et al. 1999). Some, like the boa constrictor, are ovoviviparous, giving birth to live young. They generally grow rapidly and reach reproductive age within 2 years. Both Families are long lived (20 to 30 years in the wild) and can move large distances (around 200 m per movement) over short time periods (Fearn et al. 2005; Mehrtens 1987; Reed and Rodda 2009).
In areas of abundant prey, the snakes can reach very high densities (Madsen and Shine 1996).

Pythons and boas use their sharp, backward-curving teeth to grasp prey and their bodies to kill by coiling and constricting, cutting off the blood supply to vital organs (Bartlett and Wagner 2009; Reed and Rodda 2009). Most species are non-venomous generalist predators, taking a variety of terrestrial vertebrates (Bartlett and Wagner 2009). All prey is swallowed whole, and may take several days or even weeks to fully digest. Prey size varies from small rodents to adult deer.

Unprovoked attacks on humans are principally limited to reticulated pythons, and only the larger Burmese/Indian and Northern/Southern African pythons have killed adult humans (Bartlett and Wagner 2009; Reed and Rodda 2009).

2.2 Colubridae

Colubridae is the largest snake Family, comprising of almost two-thirds of all known living snake species (Pough et al. 1998). They are found on every continent except Antarctica and occupy almost every habitat type (McDiarmid et al. 1999). This Family has classically been a "dumping ground" for snakes that don't taxonomically fit elsewhere. They are not a natural group; in fact many are more closely related to other groups, such as elapids, than each other.

Most colubrids are non-venomous, however some groups such as the genus *Rhabdophis* have caused human fatalities through envenomation (Cogger et al. 1998). Members of this Family vary in reproductive mode, having both oviparous and viviparous species, and they occupy a wide variety of habitats.

Because of the considerable number of species within this Family, and the propensity of individuals to be trafficked in the illegal pet trade, there is a risk of incursions into Australia. For example, the corn snake (*Pantherophis guttatus* formally *Elaphe guttata*) is particularly common in the international pet trade (Page et al. 2008b), and many have been found at large in Australia (P. Garcia Pers. Comm.).

2.3 Elapidae

Elapids are a diverse group, comprising more than 300 species in about 60 genera (Grzimek et al. 2004). Well-known examples of elapids include cobras, mambas, coral snakes, death adders, and sea snakes. They are found primarily in tropical and subtropical regions around the world, although most Australian elapids are found in arid, semi-arid and temperate areas (Keogh 2004). Terrestrial elapids range from Asia, Australia, and Africa, to north and South America, while their aquatic counterparts can be found in the Pacific and Indian oceans (McDiarmid et al. 1999). This plan considers only terrestrial elapids whose native range does not include Australia.

The main prey of elapids are small vertebrates such as mice, rats, frogs, lizards, birds, occasionally other snakes, and eggs (Cogger et al. 1998). While some species have very generalized diets, many have narrow prey preferences. Most are active foragers, but some lay in wait, such as the green mamba (*Dendroaspis angusticeps*), which remains poised in an ambush position for extended periods of time (Angilletta 1994).

All elapids are front-fanged (proteroglyphous) and inject venom from glands located in the upper rear oral cavity (Shea et al. 1993). These fangs are hollow and fit into grooved slots in the jaw when the mouth is closed. Elapids use their venom both to immobilize their prey and in self-defence. Because of the fang structure, most elapids bite rather than stab to envenomate (Keogh 2004). This action is therefore not as quick as with the viperids that can envenomate with only a quick, stabbing motion. Some species of elapids are capable of spraying their venom from forward-facing holes at the tips of their fangs using pressure; this is thought to be a means of defence (Shea et al. 1993).

Most terrestrial elapids (including mambas, kraits, and almost all cobras) are oviparous (lay eggs) (Grzimek et al. 2004). Viviparity (live-bearing) is common in some groups, although they do not take care of their young or eggs (McDiarmid et al. 1999).

2.4 Viperidae

The Family Viperidae contains over 200 species spread across the globe except Australia, New Zealand, Ireland and Madagascar (McDiarmid et al. 1999). Vipers are predominantly found in north and South America, Africa and Eurasia.

All species of Viperidae are venomous and dangerous to humans (Schuett et al. 2002). They have relatively long, hinged, front fangs that are used to inject large quantities of venom into their prey. Due to the nature of the venom, a viper bite is often very painful, even though it may not necessarily prove fatal. Vipers generally have haemotoxic /cytotoxic venom causing destruction of red blood cells and damage to the tissues.

Experiments have shown that strikes are not only guided by visual and chemical cues, but also by heat; warm targets are struck more frequently (Mallow et al. 2003). They often strike suddenly before returning quickly to the defensive position, ready to strike again, sometimes striking up to three times in a matter of seconds. During a strike, the force of impact is so strong the long fangs penetrate deeply and prey is often killed by the physical trauma alone. Vipers can strike to a distance one third of their body length, and juveniles will launch their entire body forwards in the process of a strike (Schuett et al. 2002). Vipers are known to strike humans even if unprovoked.

Most vipers are ovoviviparous, although a few, such as *Pseudocerastes*, *Cerastes* and some *Echis* species are oviparous (Mallow et al. 2003). Typically species are nocturnal and ambush their prey, which predominantly consists of small rodents and reptiles, birds and amphibians (Page et al. 2008c). Vipers are primarily terrestrial, some arboreal. Notably they are also good swimmers.

The term Viper is used in this document to cover all species with the Family Viperidae and covers old world vipers, pit vipers and new world vipers.

3. Incursion and Establishment Risk

To date, no introduced populations of reptiles have been intentionally eradicated (Reed and Rodda 2009), even though significant control efforts continue (e.g., introduced giant constrictors in Florida, brown tree snake in Guam, habu in Japan, Californian kingsnake in Gran Canaria etc). This is due in part to the factors that positively influence establishment success for snakes:

- Greater number of incursion incidents (via the pet trade);
- Longer time-lag between initial incursion and detection (secretive and cryptic);
- Similarity in climate and habitat conditions between native range and introduced location (ideal conditions);
- Absence of competitors or predators (apex predator); and
- Favourable breeding biology (e.g., high fecundity, parthenogenesis, sperm storage etc.).

Recent analyses for the establishment risk of reptiles in Australia suggest that it is the propagule number, small body size, and fecundity that are the characteristics that most influence establishment success (Garcia-Diaz 2015). Recent research indicates that low genetic diversity is not a limiting factor to establishment and long term population growth in some snakes; as a consequence the incursion of less than 10 individuals can produce catastrophic results (Richmond et al. 2015)

The risk of incursion of terrestrial snakes is enhanced by a number of factors. In terms of animal care, snakes are considered easy to keep in captivity. As a consequence, easy care or high value species such as constrictors and colubrids are prized in the pet trade, even though most trading and keeping of these animals is illegal in Australia. Further, snakes can survive for long periods without food and water (e.g., Henderson and Bomford 2011; Keogh 2004; Reed and Rodda 2009; Rodda et al. 1999a) and can thermoregulate successfully in relatively extreme temperatures (e.g., Christy et al. 2007). Consequently many species can survive for long periods as stowaways in cargo containers and transportation vessels (USGS 2005).

Traits that increase the impacts, should they establish, include being a potential host for diseases of economic, human and wildlife health significance, a tolerance of urbanisation that will increase human/snake interactions, and the ability to occur in high densities.

3.1 Boidae and Pythonidae

At present, the only probable pathway by which non-Australian boids and pythons would become established in Australia is via the illegal pet trade. However, once in Australia, they are known to be accidentally translocated to other states (Kirkpatrick 2015), and as a result, this risk cannot be ignored. Traits of some boid and pythons that categorise them as a high risk of incursion include body size, generalised habitat use, good swimmers and climbers, sedentary generalist predators, low detectability and the capability of long distance dispersal (Page et al. 2008a; Reed and Rodda 2009; Wisniewski 2012a). The inclusion of giant constrictor species in this incursion plan was based on concern over the risk to humans and native fauna combined with their prevalence in the international pet trade (NISC 2003; Reed and Rodda 2009). Most species are well adapted to tropical, subtropical, arid and semi-arid climates and therefore would thrive throughout most of Australia.

Establishment risk is increased by the relative difficulty of detecting boids and pythons in the wild. If average per-day-detectability is low ($\hat{p}$ = ~ 0.001) with no discernible heterogeneity among individuals (Reed and Rodda 2009), very few individuals would be detected for removal even with a substantial search effort. Based on the fecundity of most species, natural recruitment would far exceed the capture rate. Kraus and Cravalho (2001) suggest the likelihood of establishment may be increased by the ability of female boas to facultatively reproduce parthenogenically in the prolonged absence of males. Hence incursion prevention for these species is paramount.

Beyond presenting a pest risk to Australia, non-native boids and pythons present a significant disease risk to native snakes because they are known to carry infectious diseases such as Inclusion Body Disease (IBD; Chang and Jacobson 2010), and Snake Fungal Disease (SFD; Allender et al. 2015). The distribution of IBD in captive constrictors is world-wide with several cases reported in pythons in Australia (Carlisle-Nowak et al. 1998). However, the length of time this disease has been present in Australia and the method/s of introduction are impossible to define until the agent is characterised and molecular or serological tools are available for evaluation of archival samples (Carlisle-Nowak et al. 1998). The transport of captive snakes may contribute to the apparent spread of IBD around the world (Chang and Jacobson 2010), although there is no evidence of this in Australia. There is strong circumstantial evidence that IBD is caused by an arenavirus, but this has not yet been unequivocally demonstrated. This viral disease, which can be diagnosed in sick snakes (reliability of antemortem diagnosis is still in question) and most often confirmed at autopsy, has no cure and is always fatal. Snakes can be asymptomatic while still carrying and transmitting the disease (Schumacher et al. 1994). The causative agent of SFD (*Ophidiomyces ophiodiicola*) was first observed in 2006 (Clark et al. 2011) and has caused wide-spread morbidity and mortality across the eastern United States (Allender et al. 2015).

3.2 Colubridae

Colubrids have several attributes (e.g., habitat and diet generalist, moderate fecundity) that suggest some species, such as the corn snake (*P. guttata*), beauty snake (*Orthriophis taeniurus*), wolf snake (*Lycodon aulicus*), and California kingsnake (*Lampropeltis californiae*) have the potential to become widespread and abundant if introduced into Australia (Bomford et al. 2005; Cabrera-Pérez et al. 2012; Massam et al. 2010). Species held in captivity, primarily for the illegal pet trade increase the risk of Colubridae establishing in Australia, either by accidental or intentional release (Bomford et al. 2005).

Since many species are generalist predators, their diet is not likely to impede establishment when incursion has occurred (Pough et al. 1998). Once in Australia, their pre-adaption to much of the country's climate, diversity of suitable habitats, and prolific reproductive cycles would facilitate the risk of establishment and population growth. Furthermore, detection and eradication would be unlikely since most species are highly cryptic and secretive (Csurhes and Fisher 2010).

There have been numerous reports of an *Chrysosporium* anamorph of *Nannizziopsis vriessii* (CANV) and SFD in non-venomous colubrid snakes such as garter snakes (*Thamnophis radix*), ribbon snakes (*T. sauritus*), and rat snakes (e.g., Allender et al. 2015; Dolinski et al. 2014; Rajeev et al. 2009). Such diseases can be transferred to Australia's native snake populations, in which those diseases are rare.

3.3 Elapidae

Elapids are generalist predators that persist in a diverse range of habitats, some highly commensal and inhabiting urban and peri-urban areas (Csurhes and Fisher 2010). Most species are also well adapted to the tropical, subtropical, temperate as well as arid/semi-arid climates and would likely thrive if they established in Australia.

Currently there are no wild populations of non-native elapids in Australia, although there are many native species. Cobras are kept under permit in high-security premises such as zoos, reptile parks or facilities involved in the production of antivenin or research. Individuals in these facilities are unlikely to escape and therefore pose a negligible risk.

While the import of elapids (and other Squamata) is restricted by law, species have been illegally smuggled into the country. These snakes are believed to be kept in private collections by snake enthusiasts. The majority of detections have been through the postal system (Csurhes and Fisher 2010) and highlight a significant incursion risk.

Impacts of incursion include the venomous and aggressive nature of most elapids that increase their danger to people. As with the other snake Families, pathogens and diseases such as SFD present significant disease risk to Australian native snakes (Allender et al. 2015), and require consideration when assessing incursion risk and response. Note that the likelihood of infected snakes establishing populations is unknown.

3.4 Viperidae

Vipers possess many traits that increase their potential for incursion and subsequent establishment (Bomford et al. 2005). Climate and habitat in Australia are well suited for many species within this Family (Page et al. 2008c). They are food generalists, arboreally adept, competent swimmers, tolerate urbanisation, have low detectability due to their cryptic nature, and are considered harmful to humans and other animals, particularly mammals (McDiarmid et al. 1999; Schuett et al. 2002; Wasko and Sasa 2012; Wisniewski 2012b). Illegal or privately held captive vipers increase the risk of incursion in Australia (Bomford et al. 2005).

Predation by some introduced vipers is believed to be a major cause of the decline of native wildlife, particularly amphibians in areas where they have been introduced (Moore et al. 2004a; Moore et al. 2004b; Tonge 1986).

The risk of non-native vipers bringing diseases and pathogens to Australia is considerable. For example, SFD has been observed in a variety of Viperidae such as pitvipers, eastern massasaugas (*Sistrurus catenatus*) and rattlesnakes (Allender et al. 2015; Cheatwood et al. 2003; Clark et al. 2011). As with other snake families, the likelihood of infected snakes establishing populations is unknown.

4. Tools and Techniques

Follow relevant state-territory response planning documents and augment with the information provided here.

4.1 Design and Data Recording

Prior to the deployment of field teams a surveillance plan must be designed and implemented. This includes:

- *Preparation*: Establish the plan of action, coordinate relevant networks, acquire/repair/develop required tools and techniques, undertake essential training, and assess and assemble necessary resources for detection and delineation actions.
- *Detection Surveillance and Delimitation*: Undertake surveys and monitoring activities to provide initial evidence on the occurrence of a potentially invasive snake. A delimiting survey needs to be undertaken and then any immediate low-cost steps which have a good prospect of eliminating the incursion or controlling the organisms spread are implemented. Also provide mechanisms for reporting and verifying species identification.
- *Rapid Assessment*: Determine the distribution and abundance of the snake occurrence, and evaluate its potential risks with regard to environmental, health, and economic impacts. Identify options for rapid response based on the particular circumstances associated with the occurrence of the species. These include species type, specific location, extent of spread, and relevant authorities.
- *Rapid Response*: Establish a set of coordinated actions to eradicate the founding snake population before it establishes and/or spreads to the extent that eradication is no longer feasible.

At a minimum, the following logs, plans and reports must be completed.

Response Activity Log - Data recording starts with a Response Activity Log (Appendix B). This log details all the activities of the response including correct identification of the organism and notification of appropriate persons/stakeholders.

Situation Report - Following the activity log, determination of the nature and scope of the incursion and any interim action to be taken is assessed and described. This starts with the completion of a situation report (Appendix C). This situation report will assist in deciding on management options, and guides the development of the Emergency Response Plan.

Emergency Response Plan - The purpose of an Emergency Response Plan (Appendix D) is to establish an organisational structure and procedures for response to major incursion events. It assigns the roles and responsibilities for the implementation of the plan during an emergency, and outlines procedures to be undertaken. Liaising with local and national experts will be required to get the best and most up to date information on the organism, habitat and control options. Contact details for experts and scientists are included in the Emergency Response Plan along with details of each partners' resources

Incursion After Action Review – This review finalises data recording and indicates future actions, if any are required (Appendix E).

4.2 Detection and Delineation

Tools for detection and delineation of new incursions are the foundation of incursion response. Below are brief reviews of each available or potential tool that could be used for terrestrial snake response. The list is a guide only and each state/territory is responsible for choosing tool/s that work within their capacity and capability. A summary of these tools and their possible application for selected snake species can be found in Table 2.

Table 2 Detection and delineation tools and how they can be used in the event of a snake incursion for a number of species. * = equipment-assisted visual searches. ✓ = the tool is known to work with the species. Blank = there is not enough evidence to determine whether or not the tool is effective. Refer to Appendix A for a summary of each species. Descriptions of tools listed here follow Table 2.

	Visual Searches	Barriers	Trapping	Refugia	Other Animals	eDNA	Passive Surveillance
BOAS AND PYTHONS							
Dumeril's boa *Acrantophis dumerili*	✓	✓	✓	✓			✓
Boa constrictor *Boa constrictor*	✓*	✓	✓	✓	✓	✓	✓
Reticulated python *Broghammerus reticulatus*	✓*	✓	✓	✓			✓
New Guinea Tree Boa *Candoia carinata*	✓						✓
Emerald tree boa *Corallus caninus*	✓						✓
Rainbow boa *Epicrates cenchria*	✓	✓	✓	✓			✓
Yellow anaconda *Eunectes notaeus*	✓						✓
Sand boas *Eryx* and *Gongylophis* sp	✓						✓
Rosy boa *Lichanura trivirgata*	✓	✓	✓				✓
Burmese python *Python bivattatus*	✓*	✓	✓	✓	✓	✓	✓
Blood python *Python curtus*	✓	✓	✓	✓			✓
Indian python *Python molurus*	✓*	✓	✓	✓			✓
Ball python *Python regius*	✓	✓	✓	✓			✓
African rock python *Python sebae*	✓*	✓	✓	✓			✓
COLUBRIDAE							
Corn snake *Pantherophis guttatus*	✓	✓	✓	✓	✓		✓
Southern hog-nosed snake *Heterodon simus*	✓	✓	✓	✓	✓		✓

California kingsnake *Lampropeltis getula californiae*	✓	✓		✓			✓
ELAPIDAE							
King Cobra *Ophiophagus Hannah*	✓	✓					✓
VIPERS							
Puff Adder *Bitis arietans*	✓*	✓	✓	✓			✓
Gaboon Viper *Bitis gabonica*	✓*	✓	✓	✓			✓
Uracoan Rattlesnake *Crotalus vegrandis*	✓	✓		✓	✓		✓
Russel's Viper *Daboia russelii*	✓*	✓	✓	✓			✓
Nose-horned Viper *Vipera ammodytes*	✓	✓	✓	✓			✓
Horned vipers *Cerastes* sp	✓	✓		✓			✓

4.2.1 Active Searches

Active searches (also known as visual or spotlight searches) remain the primary detection method used for many snake species. This method is particularly useful at habitat interfaces such as roads, fences, along the base of buildings and other barriers (Vice and Pitzler 2002). It is also useful where other methods, such as trapping and toxicants, have not been developed or are ineffective (Gragg et al. 2007; Rodda et al. 2007). With enough effort, it is possible to eradicate at least some snake species using visual searches. Visual searches can occur either at night, during the day or in combination.

Daytime Visual Searches

Description – Can be used to delineate or control a new incursion. Visual surveillance involves trained personnel conducting directed searches for individual animals, tracks, scats, or other indirect signs. Can be achieved unaided (naked eye) or using binoculars or spotting scopes to locate snakes. Searches are often conducted from a vehicle to maximise the size of the searchable area; however, unless species are traversing a road, or is at least partially arboreal, this technique may not be effective. Pythons, for example, rarely visit roads, trails or areas of high human traffic (Reed and Rodda 2009). Although more resource-intensive, searching on foot yields the best results (Christy et al. 2010; Rodda et al. 2007).

The optimum times to search for most snakes is mid-morning or afternoon on sunny days as individuals basking tend to be on the surface. Searching at the warmest time of the day (usually just after midday) may be optimal in winter in southern Australia. Windy days should be avoided (Christy et al. 2010).

After a cool night, search open areas (including roads) for basking snakes early morning or late afternoon.

Unless the snake is in a heavily vegetated area, searching nearby man-made structures such as buildings, sheds and rooves is necessary. Focus where possible on fences, sides of buildings, burrows, holes, under vegetation, base of trees or root balls of toppled trees for ground dwelling snakes.

Timing –Daily searches for several weeks at a time is preferable, although the exact number of searches will depend on the species, abundance, terrain and habitat. For rapid response incursion control, search intensity and duration is also dependent weather/climate, the ability for snakes to relocate to other areas, and the use of other techniques such as traps and barriers (Christy et al. 2010; Tyrrell et al. 2009).

Resources Required – Visual searching is the most widely used tool for locating many reptiles, however it is labour intensive and therefore costly. Regardless, it is effective at capturing all size classes and both sexes of snakes if the right search intensity and duration is used (Christy et al. 2010). Training in techniques, identification and detectability of both native and non-native species are a critical component of search success (Henke 1998).

Risks – Weather, obstructing vegetation and access are three primary challenges of visual surveys for terrestrial snakes (Reed and Rodda 2009). Other risks include misidentification, disturbance, searcher fatigue, and health and safety of the searcher. The cryptic nature of these species, remaining hidden and immobile for long periods, makes them very difficult to detect with active searches. Be prepared to search over extended periods of time.

Current Feasibility of Use – High

Nocturnal Visual Searches

Description - Can be used to delineate or control a new incursion.

Nocturnal visual searches are similar to daytime visual searches (see above), and are aided by spotlights or headlamps. Because of Australia's hot, dry climate, nocturnal searches are likely to give the best chance of success, except in southern Australia's winter months. Spotlighting involves shining a flashlight at an animal so the light reflects off the animal's retina, creating a noticeable eyeshine (Corben and Fellers 2001). The method works well for herpetofauna with larger eyes such as crocodiles, geckos and frogs, but is fairly ineffective for detecting most medium- and small-sized snakes because their eye shine doesn't stand out sufficiently from the background (Lardner et al. 2007). This is particularly true for most snakes whose eyes normally do not reflect much light (Ribi 1981). Therefore, detecting a snake in the dark typically relies on spotting the characteristic shape or the somewhat different sheen of the animal compared to the surrounding habitat (Lardner et al. 2007).

- For night-time surveillance, the best time to search is the first 3-4 hours after sunset.
- Optimum searches should occur in temperatures over 22°C and humidity greater than 75 percent.
- At night, focus on paths, edges, roads and paved areas if there is still heat on those hard surfaces.
- Even ground dwelling snakes spend some time arboreally. Searching between ground level and 1m to 3m is optimal.

Timing - See Daytime Visual Searches above. Temperature dependent, particularly in non-tropical areas where yearly temperature and humidity varies greatly.

Resources Required – See **Daytime Visual Searches** above.

Risks – See **Daytime Visual Searches** above.

Current Feasibility of Use – High

Equipment-Assisted Visual Searches

Description – Equipment-assisted visual search methods are similar to those described in **daytime visual searches** (see above), with the aid of devices that increase the probability of detection. There are a couple of different devices that could be usefully applied to snake visual searches in addition to spotlights, binoculars and scopes[1]:

Infrared (heat) detection technology - Although infrared works well on endotherms, it is less effective for detecting ectotherms because of the propensity for thermal equilibrium with the surrounding area to be more easily reached (Christy et al. 2007; Welbourne 2013). Use of Forward Looking InfraRed (FLIR) technology has potential to aid in incursion searches once the incursion area has been delineated.

Night-vision binoculars – Night vision has facilitated detection of wildlife at night (Boonstra et al. 1994, Garner et al. 1995, Focardi et al. 2001) and may be used for some species. Note the method was not useful for detecting brown treesnakes in forest habitat because their image does not adequately stand out from their surroundings and their eyeshine is weak to non-existent (M. Christy, pers. obs.).

Burrow cameras – Cameras mounted on flexible PVC tubing or endoscopes can be used to view the inside of tree hollows, root calls and burrows (Smith et al. 2005). A typical burrow camera system comprises of three main parts: 1) a camera head within a PVC body; 2) a flexible PVC tube (2 cm diameter conduit) that houses the power and video cables connecting the camera head to the display unit; and 3) a small video monitor. High intensity infrared LEDs mounted on the front of the camera head allow camera use in complete darkness without disturbing snakes or non-target species.

Timing – Immediate

Resources Required – Appropriate equipment and trained personnel required. Good quality infrared and FLIR equipment is expensive. Burrow cameras are relatively inexpensive to assemble from readily available materials.

Risks – Snakes are ectothermic so these methods have limited practicality. Further, techniques that rely on a different temperature profile between the target species and the background will not provide consistent results. Therefore, snakes will only be discernible from the background if they have recently moved to a different temperature, or have absorbed solar radiation at a rate greater than background. For example, a basking snake may be at a similar temperature to its substrate, but if that snake were to move into cool water, the thermal contrast may be evident (Rovero et al. 2013). If snakes are within line of sight but are routinely overlooked (e.g., cryptic species), the use of technology to aid visual detection (such as FLIR) would be valuable. However if snakes are undetected because vegetation, underground crevasses or water facilitate concealment, these aids would be of no use.

Current Feasibility of Use – Low, except burrow cameras which are moderately feasible

[1] Note that the use of remote cameras is discussed in **Passive Surveillance** section

4.2.2 Barriers

Temporary Barriers

Description – Temporary barriers such as drift fences can be used to intercept moving snakes. Snakes can be captured along the fence or directed into traps (see **Trapping section** below). As fences can be made very long, they can be highly effective, even for sit and wait predatory snakes (Hayashi et al. 1999). Whether this concept will work for giant constrictors is unknown.

Temporary barriers can be used when permanent fencing is not feasible or necessary. Temporary barriers work well during delineation phases of incursion response, or to protect a short-term event such as turtle or bird nesting, military and other government training exercises, and storm/fire recovery phases.

A temporary barrier can be constructed from shade cloth, netting, or wire mesh supported by wooden sticks, posts, rebar and/or PVC pipe (Figure 1). The bottom is either buried in the ground (Figure 1a and b) or weighted with rocks, metal or sandbags (Figure 1c). Rebar can be angled or straight depending on the use of the barrier and how arboreal the snake. Height will depend on barrier use and type of snake.

Timing – Depends on application. Set up may take an hour to several days. Recommend checking at least once per day or as necessary. Frequent checking decreases adverse risk to non-targets.

Resources Required – Such structures are built for short periods of time and may need considerable maintenance while deployed. They must also be stored in suitable storage facilities when not in use. Construction materials are relatively inexpensive and barriers can be repositioned easily.

Risks – Temporary barriers may be easily breached if not set up correctly or adequately maintained. Larger snakes may be able to breach the barrier and they may impact non-targets. Should be used in conjunction with other control methods.

Current Feasibility of Use – Medium to High

Figure 1. Temporary barrier constructed of A) wire mesh, B) plastic and C) rebar and shade cloth. Photos: USGS.

Permanent/Semi Permanent Barriers

Description – Although permanent/semi-permanent barriers are often used as asset protection against already established invasive species, they can be equally useful to prevent or contain a new incursion (e.g., at points of entry such as sea- and air-ports. Physical barriers can be effective over a limited area. They can also block incursion and dispersal of snakes into or away from specific areas (e.g., endangered species breeding sites, cargo containment). The degree of arboreality of each snake species (including juveniles) is a good predictor of the challenges associated with snake barrier construction.

- Barriers can be used to direct snakes to traps, or to exclude or contain a snake in an area. An exclusionary barrier (i.e., prevents snake entrance), is used around high value habitat or infrastructure, such as a cargo holding facility or a native animal reintroduction area (Colvin et al. 2005). A containment barrier (i.e., prevents snakes from exiting an area), is used to prevent snakes escaping into the surrounding area, such as a zoo enclosure.
- Types of semi-permanent and permanent barriers include bulge, pre-cast concrete, bio-security, and electric (e.g., Figure 2). Each type of barrier varies in its building cost, however all barriers require regular maintenance for repairs and removal of vegetation to prevent snake incursion (Colvin et al. 2005). Permanent barriers are capable of reaching up to 100 percent efficacy (Perry et al. 1998).

Figure 2. Examples of permanent barriers A) hardware cloth bulge barrier, B) hybrid concrete barrier with security fence above.

- Electric fences powered by solar panels or cells have proven successful. One designed for the habu (*Trimeresurus flavoviridishas*) had electric pulses timed at 0.75 second intervals with 480 mA, 0.13 m coulombs at a load of 500 ohms and estimated peak of 8 to 10 kV (Hayashi et al. 1999). The anode from a pulse maker is connected to a stainless steel plate or metal string, with a grounded cathode.
  - The necessary height of an electric fence is usually shorter than that of a standard fence. This is an advantage in windy areas or areas prone to cyclonic weather where taller fences are more vulnerable. In the case of habu, the fence height was about 0.6 m (Hayashi et al. 1983).
  - A wiring configuration design capable of prohibiting the passage of all snake sizes may be problematic, and larger snakes may not be deterred (Campbell 1999).

- Net barriers could be constructed at any topographical conditions with less expense than a rigid fence (Hayashi et al. 1983).
- Existing walls, building perimeters and fences may be utilised as snake barriers where possible.

Timing – Design and build time dependant on snake species, barrier use and topography. Inspections of barrier at least once per week. Frequent checking also decreases adverse risk to non-targets. Perimeter searches for snakes several days to a week apart.

Resources Required – Such structures need to be built to withstand random events such as bushfires or extreme storms which can make them costly.

Risks – If a barrier is not properly maintained, its efficacy will be compromised. Larger snakes may be able to breach the barrier. A barrier is not species specific and therefore non-target egress and ingress may be compromised. Snakes or susceptible non-targets may be killed while attempting to pass through an electric fence could result in a short circuit, rendering the barrier useless. Electrified barriers may create some community resistance. Barriers should be used in conjunction with other control methods that can remove snakes.

Current Feasibility of Use – Low

4.2.3 Trapping

Pitfall and Funnel Traps

Description – Pitfall traps are open containers buried in the ground such that the tops of the containers are level with the ground. They can be set out in a linear, grid, or multiple armed arrays (Figure 3a). They are most effective when used in conjunction with drift fencing (see section 4 - Barriers above). The technique has been shown to be effective when compared to other capture techniques (Case and Fisher 2001; Fisher et al. 2008). Various containers have been used as pitfall traps such as plastic buckets, coffee cans, metal buckets, and drums. Larger containers more effectively capture snakes (e.g., Friend 1984; Friend et al. 1989; Ribeiro-Júnior et al. 2011).

- Twenty-litre white buckets are recommended, although these should be larger (around 25 litres) in desert sites to provide increased insulation from heat (Fisher et al. 2008). Black pitfalls may create high internal temperatures when exposed to intense sunlight for long periods.
- Additionally, fitting a plastic collar to the top of pitfall traps reduces escapes (Vogt and Hine 1982). Alternatively, a funnel can be fitted to the top (Figure 3b). The funnel can reduce snake escape and provide shade.
- The containers should have small drain holes in the bottom to minimize flooding during rain events when traps are open. This assumes pitfalls are set up in well trained areas.
- Containers are then buried such that the rim is flush with the ground.
- Consider the use of slanting boards or other means of shading if trap checks are infrequent or traps are exposed to extreme heat. Fisher et al. (2008) used an inverted lid set on top of the trap with wooden spacers. This design prevents most litter, sunlight, and precipitation from entering the open bucket while allowing sufficient space for small animals to enter.

- Shelter should be provided within the pitfall traps for captured animals. Use differently sized PVC pipes (approximately 150 - 200 mm long, with a 25 – 40 mm diameter). Some form of insulation should be provided in the PVC pipes if small mammals are likely to be captured.
- Placing a wet sponge in the pitfall trap is recommended to help keep amphibians (potential non-targets) hydrated. The sponges should be moistened on a daily basis when traps are opened. However, the use of sponges may attract ants which can kill or seriously injure small vertebrates in the traps.

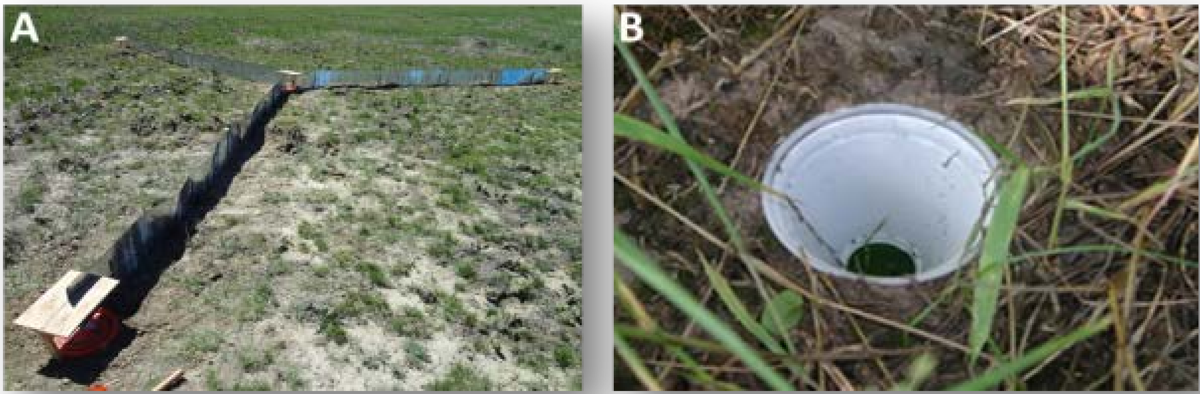

Figure 3. A) Example of a three-armed pitfall trap array using shadecloth and star picket drift fences, 20-litre lidded buckets, and plywood shade covers. Photo: Wyoming Cooperative Fish and Wildlife Research Unit. B) An inverted funnel fitted to the top of the bucket can reduce snake escape and provide shade. Photo: chamownersweb.net.

Timing – Dependant on area to be trapped and snake density. Frequent checks decrease the risk of adverse risk to target and non-target species. Recommend checking daily at a minimum.

Resources Required - Fabrication and materials will require modest outlay ($10-$20 per pitfall trap). Trap arrays require 1-2 personnel to setup and monitor.

Risks - Pitfall traps may not be large enough to contain a captured snake. Since traps are not species specific, there is a high risk of non-target captures. Trapping will need to be deployed along with other detection and capture techniques.

Current Feasibility of Use – High

Unbaited Traps

Description - Funnel traps are elongated traps that have funnels at one or both ends that allow animals to pass easily into them through the large end of the funnels. The animals, once inside the traps, have difficulty finding their way out through the small end of the funnels and are trapped. Traps equipped with funnel style entrances have been used for over half a century to capture a variety of snakes (Dargan and Stickel 1949; Fitch 1951). Enge (2001) found that funnel traps with drift fences were more efficient at catching snakes in Florida than pitfall traps with drift fences.

A key consideration for traps is that some snakes are sit-and-wait or ambush foragers. Therefore control tools that rely on the snakes' movements may be limited in application. Above all, the practical size of an area that could be trapped is small, and thus it would be necessary for a new incursion to be discovered and treated before the population spread very far. Although a variety of traps that capture snakes are available, few have been rigorous tested for efficacy (Maritz et al. 2007; Reed et al. 2011; Rodda et al. 1999b) so care should be taken when choosing trap design.

- Constrictor snake traps are roughly 0.6 x 0.6 x 1.8 m, although smaller traps (0.4 x 0.4 x 1 m) will work well and are easier to construct and transport. The traps are fitted with a series of rectangular or round entrance flaps. The trap can be sheathed partially or completely in plywood or wire mesh depending on whether it is to be used in shaded areas (Figure 4).

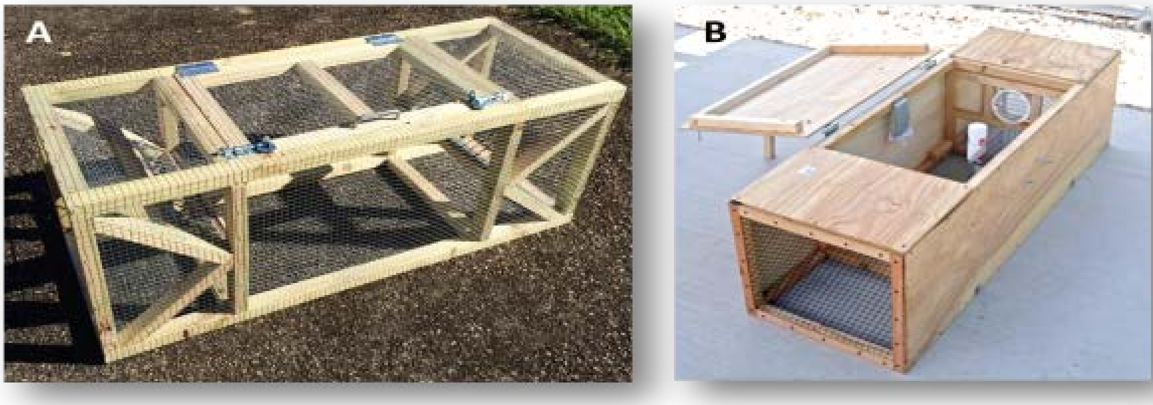

Figure 4. Constrictor trap with A) rectangular entrance and metal mesh sides. Photo A: D. Swan; B) plywood trap with circular entrance. Photo B: R. Rozar

- Some colubrids and vipers can be trapped using the funnel traps, which have been in use since the 1940s (Imler 1945). The trap design is dependent on the one-way door flap installed at each of the two funnel entrances (Linnell et al. 1998). The door flaps have specially designed hinge pins so they swing shut even when the trap is rotated 75-80° along its horizontal axis, preventing escape (Figure 5).
- Modified minnow traps have been successfully used for a number of species (Figure 5). However, some studies have not had success using modified minnow traps (e.g., Cabrera-Pérez et al. 2012; Garcia-Diaz 2015).
- Commercial snake traps are also available (Figure 6) but their efficacy on a variety of species has not been tested.

Figure 5. Modified minnow trap with circular entrance flap. Photo: USGS

Figure 6. Commercially available snake traps may be used but their efficacy is unknown. A) Snake Safe Snake Trap, B) Humane Snake Trap.

- Trap density or spacing will depend on habitat and snake species. For example, optimal trap spacing along perimeter fences using modified minnow traps for brown treesnakes is 40-50m (Engeman and Linnell 2004), or about 16 per hectare (16/ha) in forest. Habu traps set at a density of 100/ha were successful in eradicating Habu from an island in Japan (Shiroma and Akamine 1999). Spacing for sit and wait predatory snakes requires much smaller intertrap spacing, around 10 m, or 100-200/ha (Katsuren et al. 1999; Shiroma and Akamine 1999). Thus 1,000 traps would service about 10 ha (Reed and Rodda 2009).

Sit and wait predatory snakes, may be ill-suited to control with stationary traps. However, some traps are designed to force the occasional movements of a target into the vicinity of a trap, through the combined use of traps and drift fencing. This combination is effective for snakes because they tend to follow the line of the fence rather than change trajectory. Traps are placed alongside long stretches of barrier fencing and when a snake encounters the barrier, it moves along the fence until it encounters a trap (Figure 7).

Figure 7. Drift fence and trap configuration. Photo R. Rozar

Timing – Dependant on area to be trapped, snake species and density. Frequent checks decrease the adverse risk to target and non-target species.

Resources Required – Fabrication and materials will require modest outlay ($50-$100 per trap depending on volume). Commercially available traps can be purchased for $25 to $400 each. Trap arrays require 1-2 personnel to setup and monitor.

Risks – The primary drawback for trap control is there are not yet any designs that have demonstrated effectiveness across all sizes, even within a single species (Reed et al. 2011; Rodda et al. 2007; Tyrrell et al. 2009). Modification of existing, or development of new, traps will likely be necessary in the event of an new snake incursion into Australia. Trapping will need to be deployed along with other detection and capture techniques.

Current Feasibility of Use – Medium to High

Attractant Traps

Description – The traps described above can be baited with live or dead animals, eggs, scent or meat, although live baiting is not considered acceptable in Australia. Attractant traps have been used successfully to trap Habu (Shiroma and Akamine 1999) and brown treesnakes (Rodda et al. 1999b; Vice et al. 2005). These traps can be relatively easily constructed. Large box traps equipped with bamboo and rattan funnel entrances and baited with live chickens have also been used successfully in Borneo to trap large constrictors (Reed and Rodda 2009). Prey-scented spray or impregnated materials can also be used to attract snakes, although efficacy of most commercial products is untested.

Timing – Traps using attractants are labour intensive as attractants need to maintained/reapplied, or replaced as well as additional approvals sought. Frequent checks decrease adverse risk to target and non-target species.

Resources Required – See Unbaited Traps above. There are additional costs with laying, maintaining, checking and removing traps with attractants. Resources are required to develop and test additional attractants.

Risks – There is the possibility that live bait could escape or the snake may predate the bait. The infrequent feeding nature of snakes impacts their trapability using food-based attractants. There are also animal welfare considerations when using live bait and this type of baiting is considered highly unlikely to garner public or animal welfare acceptance.

Current Feasibility of Use – Low to Medium

4.2.4 Refugia

Artificial Refugia and Burrows

Description - Can be used to delineate or control a new snake incursion. Pipes may act as artificial burrows for snakes, and improve surveillance efforts (Figure 8). Boa constrictors, for example, are known to favour burrows in which they can hide during the day. Artificial refugia (also known as cover objects) have been successful in capturing snakes (e.g., Cabrera-Pérez et al. 2012).

- Pipes of various sizes are placed in the ground with approximately 60% of its length covered. Pipe length should be at least 1 m.
- Alternatively, cover boards made of wood or other light material can be used as surface refugia. Size depends on species; however, 600 × 1200 × 140 mm or larger is recommended.
- Both may be useful in conjunction with other survey methods.

Timing – Preferably daily inspection. Early morning inspections are desirable, before basking temperatures have been reached. Late afternoon prior to dusk will also be effective.

Resources Required – Fabrication and materials will require Small outlay ($5-$10 per trap depending on pipe diameter and material). Modest labour costs depending on ground hardness and number of refugia/burrows.

Risks – Micro-climate needs to be considered when deploying artificial refugia/burrows. Surface refugia may overheat in summer depending on the material used. Burrow entrances may also collapse, trapping the species inside. Occupancy may take time and the probability of occupancy is low. This may necessitate the deployment of many refugia/burrows for an extended period of time. Therefore, artificial refugia/burrows will need to be deployed along with other detection and capture techniques.

Current Feasibility of Use – High

Figure 8. Artificial burrows are dug into the ground. Photo: Queensland Department of Agriculture, Fisheries and Forestry

4.2.5 Use of Other Animals

Detector Dogs

Description - Domestic dogs have been successfully used to locate a range of items such as contraband, humans, cancer, plants and animals because of their superior olfactory acuity (Browne et al. 2006). Their effectiveness is dependent on the scent they are searching. For example, detector dogs on Guam successfully detected known radio-telemetered brown tree snakes in a defined forest search plot in about 35% of trials (Savidge et al. 2011), and an average location rate of 62% in outward-bound cargo (Engeman et al. 2002). Stevenson et al. (2010) reported an 81% success rate for live eastern indigo snakes (*Drymarchon couperi*) and 100% for shed skins. Dogs have also been used to detect Habu (Shiroma and Ukuta 1999), and Burmese pythons (Reed and Rodda 2009). Although detector dogs are not able to detect all snakes, particularly in complex environments, dog teams are far more effective than human searchers and should be considered.

- Where they might be indispensable is in the detection of the last few snakes in a population.
- The dog would have to be able to distinguish introduced from native snakes.
- Training of detector dogs may not be justifiable for incursions unless they can be trained on multiple species/genus/Families, and can be shared with other programs or states/territories (i.e., shared resource)
- If training was delayed until an incipient population was unequivocally established, the requisite training and testing period might be too great for the dog team to be deployed and able to successfully eradicate the species.

Timing – Ongoing. Training a new dog and handler can take between six weeks to over a year.

Resources Required – Experience with detector dogs indicates that this capability is well within a well-trained dog's abilities, but requires lengthy training. The training phase can be expensive, and maintenance costs are moderate.

Risks – The risk of injury, particularly from snake bites should be considered when determining training and deployment techniques. Even a survivable snake bite may still shorten the working life of a dog if the dog becomes reluctant to hunt snakes. Since the training period can be quite lengthy, the lead time required may not warrant resource allocation unless the dog team could become a nationally shared resource. Use of detector dogs for first response may be limited if the dogs require extensive training.

Current Feasibility of Use – Medium

Judas Animals

Description – Judas animals are used primarily for highly social animals such as ungulates and some birds (e.g., starlings). The Judas has a transmitter attached or surgically implanted so the animal can be reliably tracked. In theory, the released animal would seek out and join a group of its own kind, allowing trackers to efficiently locate the group (Taylor and Katahira 1988). From a demographic perspective the most valuable targets are adult females; thus adult males would be targeted as the Judas.

Timing – Medium to long term.

Resources Required – Transmitters need to be surgically implanted under anaesthetic. Depending on the time of year, it could take weeks for the Judas snakes to find a mate so transmitter battery life would need to be reasonable. Snakes would need to be tracked and located daily.

Risks – Since a Judas snake would likely work only for mating snakes, sterilization of the Judas prior to release would not be feasible. Coupled with the risk of the transmitter failing, the possibility of a new reproductive snake being introduced using this technique is high. The window of opportunity may be limited for some species who have a short breeding season. As snakes seek out their own kind primarily or exclusively for mating, juvenile snakes are not likely to be vulnerable to exposure by the Judas. A constraint on this approach is that the Judas snake would generally lead to only a single female at a time. The cost of the requisite radio-tracking is also substantial. Further, this method is not readily accepted by many in the community.

Current Feasibility of Use – Low

4.2.6 Forensics

Where possible, molecular tools should include voucher specimens and population genetics that can estimate effective population size and source.

Environmental DNA

Description –The use of environmental DNA (eDNA) in detection of rare and non-native species to inform management actions is increasing being used for detection (Noble et al. 2015). eDNA is nuclear or mitochondrial DNA that originates from cellular material shed by organisms (usually via shed skin, excrement, and gametes) into aquatic or terrestrial environments (Mahon et al. 2013) and frequently provides increased detection sensitivity compared to traditional detection methods (Jerde et al. 2011). An environmental sample is collected and the often quite small amount of DNA is then amplified by a polymerase chain reaction (PCR). By using species-specific primers that only bind to the DNA of the target species, the presence of the species can be inferred if a bar that appears on the gel on which the results are viewed. Gels are one of several methods used to detect species from eDNA; real-time PCR, or quantitative PCR (qPCR), is becoming more popular (Ginzinger 2002).

Monitoring of invasive snake species using eDNA could provide a decision support tool for long-term management strategies through the estimation of occurrence and detectability using occupancy models (Hunter et al. 2015). This approach can provide evidence for identifying newly colonized areas, movement corridors, and potential pathways of dispersal. Environmental DNA tools may also assist with short- or long-term surveillance to assess the success of control or eradication efforts.

Collection of data will depend on whether water, soil or other samples (such as snakes passing by a nexus point with adhesive tape) are taken. A field test kit is used to collect eDNA samples The test kit will contain:

- Methodology document and datasheet to record information. This will detail exactly how samples should be collected, stored and shipped.
- Sterile sampling bag (e.g., Whirl Pak™ or non-greased paper, or sealable plastic bags) for collecting samples
- Sterile collection tubes partially filled with ethanol in which to store samples
- Sterile ladle and clear pipette for water samples,
- Two pairs of sterile disposable rubber gloves - one to wear collecting samples, one to wear when filling collection tubes.

- Field kits may be stored in the refrigerator before use. The testing laboratory will provide specific information on transporting the samples to the lab.

For further information on the use and deployment of eDNA in the field, please contact:

Dianne.Gleeson
University of Canberra
Faculty of Education, Science, Technology, and Maths
Dianne.Gleeson@canberra.edu.au

Timing – Medium to long term.

Resources Required – Moderate funding needed. Species specific genetic markers (primers) are required at an estimated cost of $500 per primer. Test kits are necessary to take field samples to send to a lab for testing (current cost unknown). The cost of analysis is also required.

Risks - Imperfect detection can result in an under- or over-estimation of the distribution of the species. False positive results can also occur due to contamination. Thus sterile field data collection and lab conditions are vital. Not all negative results mean the species is absent from the area. Low eDNA concentrations or a lack of positive detections in locations suspected of containing snakes may be due to environmental conditions (e.g., temperature, rainfall, wind, seasonality, water flow, terrain, soil etc.). Variations in sampling location, species abundance, environmental heterogeneity, assay sensitivity and detection threshold could affect the probability of detection, as will variation among samples within the same location and/or region (Furlan et al. 2015).

Since marker development (to design species-specific primers) is required for eDNA detection, this technique may have limited application in the short term. For example, early detection of an unknown species or a species without marker development will not be feasible.

eDNA is relatively volatile and may not persist in the environment for more than 21 days (Noble et al. 2015). This may present a problem for new incursions because populations would be small and snakes may be either hypermobile or so sedentary that their DNA is too scarce to detect. Infrequent shedding and defecation may also impact detectability of snakes in the wild (Hunter et al. 2015). (Hunter et al. 2015). Water sampling can be successfully used to detect the eDNA of aquatic of semi-aquatic snakes (Hunter et al. 2015), while soil sampling may provide an opportunity to detect terrestrial snakes. Tree-dwelling and subterranean species are likely to be more difficult to detect using the eDNA method.

Tree-dwelling and subterranean species may be particularly difficult to sample.

Current Feasibility of Use – Medium

4.2.7 Passive Surveillance

Opportunistic Encounters

Description – Individual snakes are located incidentally, often on roads on warm days or nights usually by members of the public. While dedicated (active) searches are usually more effective per person-hour than opportunistic (passive) detections, the general public populous is much higher and better dispersed, which increases the probability of detection through opportunistic encounters (Stanford and Rodda 2007). Therefore, passive detections are an important tool for incursion control.

- Professional snake catchers and herpetological groups are a great resource for passive surveillance. Many recent incursions of non-native snakes in Australia have been detected and handled by professional snake catchers. Engaging these groups has many advantages including expertise, enthusiasm to collaborate, networking, and their ability to interact and educate the public.

- Consideration must be given to the number of available volunteers. The pool of volunteers is limited in number and the length and intensity of their participation is partially dependent on the longevity of project.
- The key is to ensure that public reporting is used where it is most effective. Maximal efficacy is likely to occur in areas where sightings are so rare that early detection is at a premium, and too few professional searchers are available to address the need. Thus opportunistic call-ins and volunteer searches will be most productive if steered towards areas at the periphery of the known occupied range of an incursion.
- The focus on peripheral areas may conflict with volunteer desires; that is a preference to participate in searches that result in many captures. Low reward rate is well known to diminish the efficacy of searchers, even trained searchers (Henke 1998).
- Most ground dwelling snakes are encountered by chance (Shine et al. 1998), and the expertise necessary to refine visual search techniques is scarce.

Timing – Dependent on project duration and timing of media/educational material. Timing can also be impacted by the propensity of false positive detections.

Resources Required – Low cost as snakes are reported as they are incidentally located. Local pest lines or biosecurity government agencies handle such calls.

Risks – Numbers of snakes detected using this method will likely be inadequate to reduce a population if one is established. However, individual snake incursions may be detected by opportunistic encounters. Although it is the most common tool currently in use in Australia, the method will not detect every snake. However, it can be a good indicator of a breach in a controlled area. This method could only be used in conjunction with other methods.

Current Feasibility of Use – High

Community Involvement

Description – Can be used to detect, delineate or control a new incursion. If the community is well informed of the significance of sighting non-native snakes, most people will be willingly to submit such information to responsible authorities. Professional snake catchers and herpetological groups should also be involved.

- Opportunistic encounters are presently being reported to state/territory or national hotlines. Hotlines of this sort have proven to be of enormous value in locating snakes (Gibble et al. 2014; Hawley 2007). In addition, volunteers can be encouraged to provide systematic searches in areas of special interest. Both approaches (opportunistic encounters and volunteer searches) are powerful tools that not only address a crucial information need, but also generate interest and support among the public.
- Doorknocking areas, letterbox drops, media articles and campaigns, networking with local reptile groups are other avenues to garner community involvement.

Timing – As required and as funding allows.

Resources Required – Depends on the application but costs are usually minimal. Current platforms could be used or expanded, further cutting or sharing costs. Requires good extension material.

Risks – The use of community volunteers can potentially lead to misidentification (Somaweera et al. 2010) if interview methods are not well thought out and executed (use of systems such as ADVOKATE (Bromby and Hall 2002) may mitigate risk). Irresponsible or poor handling techniques can cause injury or death to community members. Furthermore, reptile enthusiasts may take advantage of specimens they find and bring them into captivity. Legal liabilities need to be addressed if the community is to be actively involved.

Current Feasibility of Use – High

Remote Cameras

Description – The use of automatically triggered cameras has advanced and expanded over the years with most now utilizing digital technology triggered by active-infrared (AIR) or passive-infrared (PIR) sensors (Rovero et al. 2013; Swann et al. 2004). Under some circumstances where incursions may arise but adequate surveillance cannot be delivered, cameras may provide proof of species presence.

The design of camera trapping is important. Understanding what the intention of camera-use and how to set up are critical factors. Recommended use may involve integrating with other tools such as trapping or barrier grids.

Timing – Can be used year-round, diurnally and nocturnally.

Resources Required – Cameras can be expensive ($250-$1000 per camera). The number required is dependent on the habitat and what the camera information will be used for. Resources will also be needed to deploy camera, change batteries, and download and sort images.

Risks – Due to trigger limitations, the use of cameras for snake detections has been restricted (Welbourne 2013). New methods using PIR-triggered cameras to detect multiple species of diurnal terrestrial reptile including snakes may overcome that issue (Rovero et al. 2013; Swann et al. 2004).

Current Feasibility of Use – Moderate

Bounties and Sanctioned Hunts

Description – A bounty is a payment offered for the capture of a person, object or animal (e.g., fugatives, drugs or invasive species such as Australian fox bounty). A sanctioned hunt is a legal hunting season targeting specific species, usually with prizes offered (e.g., Florida Python Hunt). Some believe if eliminating an invasive species is a social good, an economic incentive for its persistence should not be created (Reed and Rodda 2009). Bounties and hunts have not had lasting or significant impacts on target invasive species populations or establishment, and should only be considered for their education and publicity value.

Timing – Bounties are often run for a period of weeks to a few months.

Resources Required – Bounties can be reasonably expensive to run as there are administrative costs as well as payouts or prizes.

Risks – Bounties and hunts do not have a favourable reputation for invasive species management, in that they pay people for activities they would do anyway, give incentives to captive breed for bounty payment or selectively capture the most desirable individuals (e.g., slowest, easiest to capture). Moreover, bounties rarely result in eradication and misidentification of key species is a big risk (Somaweera et al. 2010). They also decrease in effectiveness as the target species becomes rarer or hard to find.

Current Feasibility of Use – Low

4.3 Containment and Eradication

4.3.1 Capture

Description – Detecting snakes is a key step to containment and eradication. In doing so, personnel must consider the challenges of capturing a snake. Methods differ depending on the species. For example, larger snakes such as boas and pythons will require several handlers. Giant constrictors up to about 3–4 m total length can be handled safely by two trained people (Reed and Rodda 2009). Venomous snakes will require equipment that negates the need for the handler to touch the snake (e.g., snake tongs, hoop bags etc).

Timing – Ongoing, although frequency can change due to seasonality and weather.

Resources Required – Resources are dependent on type of snake, size, habitat type and area to be covered. Solitary searchers should attempt handling non-venomous snakes less than 1.5 m in length; an additional person needs to be present for each additional metre in total length (De Vosjoli and Klingenberg 2012; Reed and Rodda 2009). Elapids and vipers should never be approached unless there are a minimum of two individuals present.

Risks – If not handled correctly, a detected snake can avoid capture. Rapid escape is rarely a problem with boas and pythons on land, but can be an issue if the animal is close to, or in water. Vipers, elapids, and colubrids can be quite fast moving and can easily avoid capture. However, the greatest risk during capture is harm to humans from bites and constriction. Envenomation is the greatest concern, particularly from vipers and elapids. Although non-venomous, bites from giant constrictors can do considerable tissue damage, so care is needed to avoid their many sharply recurved teeth.

Current Feasibility of Use – High

4.3.2 Shooting

Description – Shooting has often been suggested for safety in capturing snakes, although its use in Australia is not common. The method is a quick and effective means of humanely destroying animals, and in some situations is the only practical method available for use in the field. It is most effective when the snake is large enough and readily detectable but will not easily allow a searcher to get close enough to hand capture or noose. Mortally wounded snakes are notorious for crawling some distance before dying. It is recommended only to be used on large snakes over 1.5 m in length, such as boas and pythons.

Note that this section is not designed to provide specific guidance on the use of firearms as part of control programs. These are general principles only and should not be used without first consulting a firearms expert.

- Shooting should only be performed by skilled operators who have the necessary experience with firearms and who hold the appropriate licences and accreditation.
- Shooting is often restricted to certain locations such as national parks, rural areas and private property for reasons of safety or visitor equanimity. There may be legal restrictions on discharging a firearm in certain areas. Police permission may be necessary.
- The accuracy and precision of firearms should be tested against inanimate targets prior to the commencement of any shooting operation.

- Head shots are preferred - correctly placed head shots cause brain function to cease and results in an instantaneous loss of consciousness. Shots must be aimed so that the projectile enters the brain, causing instant loss of consciousness.
- To maximise the impact of the shot and to minimise the risk of misdirection the range should be as short as possible (e.g. 50 -200 mm from the head if using a rifle, 1 -2 m if using a shotgun). The barrel should never be touching the snake's head.
- Ensure an effective calibre is used. Smaller calibre rifles (0.22 or 0.410 magnum) are adequate for euthanasia of most species of animals at short range (< 5 metres), as long as the shot is correctly positioned (Leary et al. 2013). Rifles are preferred to handguns because the longer barrel length ensures better control by the shooter and places the shooter further away from the snake.

Firearms are potentially hazardous and safety must be considered.

- Firearm users must strictly observe all relevant safety guidelines relating to firearm ownership, possession and use. They must only be used by fully qualified and proficient users with experience shooting snakes.
- No-one should stand in front of the shooter, and the line of fire must prevent accidents or injury from stray bullets or ricochets.
- The line of fire must be chosen to prevent accidents or injury from stray bullets or ricochets. Most ricochets are caused by accident and while the force of the deflection decelerates the projectile it can still be energetic and almost as dangerous as before the deflection. The possibility of ricochet is one of the reasons for the common firearms rule - never shoot at a flat, hard surface.
- When not in use, firearms must be securely stored in a compartment that meets state legal requirements. Ammunition must be stored in a locked container separate from firearms.
- Adequate hearing protection should be worn by the shooter and others in the immediate vicinity of the shooter. Safety glasses are recommended to protect the eyes from gases, metal fragments and other particles

Timing – As required and as funding allows.

Resources Required – Minimal; cost of at least 2 personnel and equipment.

Risks – An appreciable drawback of reliance on firearms is the restriction to ricochet-safe areas and the required use of trained shooters. Snakes are notoriously difficult to kill via shooting as their heads are small and offer a relatively small target.

Current Feasibility of Use – Low

4.3.3 Toxicants

Description – Toxicants have not been used widely for snakes, although a number of substances highly toxic to snakes are known. Toxic baits of dead neonatal mice implanted with 80-mg acetaminophen have been tested and used for brown treesnakes. They were found to be twice as effective at reducing brown treesnake populations as trapping, and could target all size classes (Clark et al. 2012). Note that there is currently no registered toxicant for use on snakes. If toxicants are to be used, an emergency use permit from Australian Pesticides and Veterinary Medicines Authority (APVMA) would be required.

Timing – Long term research is necessary. Dependant on size of area to be baited.

Resources Required – Unknown at this stage as few reliable toxins have been tested. A toxin delivery system would also require development, as would determination of non-target risk of poisoning.

Risks – Snakes may go without eating for months at a time and therefore may not be motivated enough to take baits during the baiting period. The main obstacle is finding a method of delivery exclusively to target snakes. If a targeted delivery system could be found, toxicants could be highly valuable, but at present none are in use. Another key challenge is finding a way to prevent harm to non-target species.

Current Feasibility of Use – Low

4.3.4 Biocontrol Agents

Description – Biocontol agents can include predators, pathogens and parasites. Predator-based biocontrol involves the introduction of a higher order predator that will reduce the population of the target species. Vertebrate predator-based biocontrol has periodically been attempted. An advantage of this system is once released, the control agent is self-sustaining. By introducing a disease, parasite, or fungus there is the possibility they will be highly contagious and fatal, and thereby depress the population (Reed and Rodda 2009). Note that pathogenic biocontrol has not been used for the eradication of invasive vertebrates, and none are currently known for potentially invasive snakes.

Timing – Long term. Slow acting and should be considered as containment/control if the snake establishes rather than incursion eradication.

Resources Required – Extensive; research on a biocontrol agent typically takes many years.

Risks – The record of success is low, and the number of catastrophic failures is high. There are questions regarding which higher order biocontrol predator would prey on larger snakes such as the giant constrictors. If the biocontrol agent is unsuccessful, it is unlikely it could be successfully eliminated from the environment in which it was introduced. In terms of pathogens and parasites, one impediment is the current knowledge of snake epidemiology. Little is known about the virulence, spread, or pathways of diseases of most snakes in the wild. Pathogen based biocontrol has limitations. Vertebrate immune systems tend to interact with pathogens to produce progressively lower virulence in the biocontrol agent over generations. Viruses are also notoriously unstable and prone to jump to non-target hosts.

Current Feasibility of Use – Low

4.3.5 Reproductive Inhibitors

Description – There is some support for non-lethal reproductive inhibitor control tools for the humane treatment of target animals and avoidance of non-target deaths. Very little is known of the reproductive physiology of most snakes that pinpoints a uniqueness that could be exploited for the purpose of contraception.

Timing – Long term and slow acting.

Resources Required – Basic research for this approach runs a high risk of being time consuming, expensive, and fruitless.

Risks – Difficulty finding an inhibitor to impair the reproduction of invasive but not native snakes.

Current Feasibility of Use – Low

4.3.6 Transportation of Live Specimens

Although transportation of a live venomous snake incursion is not recommended, there may be instances where this is necessary (e.g., it is considered unsafe to euthanize in the field, species cannot be positively identified as a non-native). This section outlines the general considerations and practices required to transport live snakes within Australia (also see Table 3). Information has been gathered from Commonwealth of Australia (2011) and NHMRC (2013). Note that most states have their own animal welfare legislation which should be consulted before transporting snakes.
See **Appendix F** for list of links to state/territory animal welfare codes of practice.

- Transportation can cause distress due to confinement, movement, noise (vibration), temperature and changes in the environment and personnel. Further, the extent of any distress will depend on the snake's;
    - Condition/health
    - Species and temperament
    - Age and sex
    - Duration and type of travel
    - Number and type of animals travelling together
    - Length of time without food and/or water
    - Environmental conditions, particularly extremes of temperature
    - Ability to give care during the journey
- Snakes should be transported in a strong, dry, durable, porous linen bag. This bag should be double bagged, and enclosed by a sufficiently ventilated, escape-proof, rigid container.
- Any empty space should be padded with shredded paper to prevent excessive movement within the container.
- A cardboard box is <u>not</u> a suitable container.
- Transport in the shade or an air-conditioned vehicle cab.
- Maintenance of biosecurity standards requires that there is only one snake kept per container.

Table 3. General considerations for the transportation of snakes (either dead or alive). Specific protocols for transportation of snakes are the responsibility of each state/territory.

Specimen type	Size	Comments
Boas, Pythons and Colubrids		
Hatchlings and small snakes	<1.0m	Snakes transported in double bagged linen/calico snake bags in an escape-proof, ventilated, rigid container. Care taken to ensure bagged hatchlings are securely enclosed as they are able to escape through even small gaps. Transport according to the Code of Practice.
Medium snakes	<2.5m	Snakes transported in double bagged linen/calico snake bags in an escape-proof, ventilated, rigid container. Transport according to the Code of Practice.
Large snakes	>2.5m	As above for medium snakes that can fit into snake bag. If appropriately large linen bags are not available, securely lidded rubbish bins should be used with appropriate signage if the snakes are aggressive. Transport according to the Code of Practice.
Vipers and Elapidae		
All sizes	All sizes	Extreme caution exercised around any viper or elapid. Avoid handling by persons not experienced in the capture of venomous snakes and left to experienced personnel. Snake tongs and other equipment used. Snakes transported in double bagged linen/calico snake bags in an escape-proof, ventilated, rigid container. Transport according to the Code of Practice.
Hatchlings and small snakes	<1.0m	As above. Snakes transported in double bagged linen/calico snake bags in an escape-proof, ventilated, rigid container. Care taken to ensure bagged hatchlings are securely enclosed in rigid containers as they are able to escape through even small gaps.
Large snakes	>1.5m	As above. If appropriately large linen bags are not available, securely lidded rubbish bins should be used with appropriate signage indicating the contained snake is venomous and deadly. Placing snakes directly in the bin may cause unnecessary risk when lid is opened.

4.4 Euthanasia

This section outlines the general considerations and practices required to humanely euthanize terrestrial snakes. Information has been gathered from (Leary et al. 2013; NHMRC 2008; 2013). It follows requirements detailed in the Australian code of practice for the care and use of animals for scientific purposes (NHMRC 2004).

The euthanasia of any animal must be achieved in the shortest time possible, with minimum distress. Intravenous (into a vein), intracardiac (into the heart – only suitable in a previously sedated animal) or intrahepatic (into the liver) injection of specially formulated euthanasia solutions offers almost instantaneous death. Where these routes are not available, suitable alternatives may be considered. These include intraperitoneal (into the abdominal cavity) injection if a non-irritant solution.

The information here is intended for remote or field situations. Where full veterinary facilities are available, there may be more appropriate alternatives (such as inhalant anaesthetics), which should be used in preference to the methods outlined here.

4.4.1 Chemical

Barbiturates

- Usually in the form of sodium pentobarbital.
- Sodium pentobarbital (60-100 mg/kg) can be administered by intracardiac, intravenous or intraperitoneal injection. Cardiac and venous injection in snakes should only be undertaken by experienced personnel.
- Depresses the central nervous system, which at high doses causes the cessation of respiration followed by cardiac arrest.
- Barbiturates are a registered schedule 4 drug and can only be administered by, or under supervision of, a veterinarian (Sharp and Saunders 2004), and with an appropriate state/territory licence.

Inhalant Anaesthetics

- Commonly Halothane or Isoflurane.
- An anaesthetic induction chamber or face mask attached to a gas anaesthetic machine are used to induce anaesthesia in the snake.
- Inhalant anaesthetics may take a protracted time period to kill the snake, and a physical or chemical method of euthanasia must be used after anaesthetic induction.
- Occupational exposure to inhalant anaesthetics constitutes a human health hazard.
- This method is useful for small snakes in which venipuncture may be difficult.

Toxicants

- Toxicants are more suited to field control than laboratory euthanasia applications.
- An 80-mg dose of acetaminophen orally delivered via a bait to colubrids up to about 300g has been shown to be lethal (Savarie et al. 2001).

Carbon Dioxide

- Snakes may breathe too slowly for the use of CO_2. Therefore this method is **not** a recommended form of euthanasia.

4.4.2 Physical

Decapitation

- Complete removal of the head, usually with a guillotine.Decapitation alone is not considered an acceptable means of euthanasia in snakes because of the high tolerance of nervous tissue to hypoxia and hypotensive conditions. Decapitation followed by double pithing, is required to ensure brain death. Ideally these methods should follow anaesthesia.

Pithing

- Used to immobilize or kill an animal by inserting a needle or metal rod into its brain.
- Performed by inserting a pithing tool through the skull and manipulating it to substantially destroy both brainstem and spinal cord tissue.
- Highly recommend that snake is anesthetized prior to pithing.

Shooting

- Shooting with firearms is covered previously (see **Containment and Eradication**).
- Shooting with an electroshock device has been used in Australia to incapacitate large crocodilians and potentially could be used on giant constrictors.
- Mortally wounded snakes (even those shot through the head) are notorious for crawling some distance before dying.

4.4.3 Sampling/Autopsy Requirements

Under some circumstances, ante-mortem and post-mortem examination, necropsy procedure, gross examination of tissues, collection and storage of samples will be required.

Cost - The cost of these procedures varies between states/territories and providers, estimated at around $130 for specimens up to 5 kg, and $200 for specimens between 5 – 60 kg (Wisniewski 2012a; b).

Considerations - Cost includes euthanasia via lethal injection. Cost for analysis of necropsy samples is additional and dependant on the number of samples.

4.4.4 Voucher Specimens

Voucher specimens provide verifiable and permanent records of wildlife and environmental (Clemann et al. 2014). Where possible and practical, voucher specimens should be collected and lodged at one of Australia’s state/territory museums. A voucher specimen is usually (but not always) a whole animal that is killed humanely, preserved and retained in an accessible collection museum. It serves as a basis of study and is retained as a reference.

- The museum should be contacted as soon as possible to determine if a voucher specimen is necessary. The museum contact may guide the process.
- It is the responsibility of the senior investigator/incursion manager to ensure that the specimen becomes part of a publicly accessible scientific reference collection.
- To be optimally useful, voucher specimens should be lodged with a museum that can properly house and curate them, and make them available for further study.
- This is dependent upon specimens being properly stored or prepared after collecting, or maintained in live condition, before delivery to such institutions.
- Proper documentation of the specimens is essential. Data should be maintained with the specimen.
- Consultation with the institution before collecting will ensure that there is an understanding of the proper preservation and holding techniques, necessary equipment and essential data required.
- Arrangements should also be made to ensure voucher specimens can be accepted by the institution.
- The senior investigator/incursion manager is responsible for ensuring competency regarding the collection of voucher specimens.
- Animal Ethics Committee approval may be required for the taking of some voucher specimens under certain circumstances.

4.4.5 Disposal Methods

The primary objective of disposal of carcasses, animal products, materials and wastes is to prevent the spread of infection. This process is therefore an essential part of an animal disease eradication program. Disposal should be completed as soon as possible after destruction to minimise opportunities for infectious material to disperse. As part of preparedness planning, potential stakeholders should be identified and engaged in the process of identifying appropriate disposal methods. Please refer to AHA (2015) for specific methods and techniques.

If voucher specimens are not required, snake carcasses can be disposed of by either incineration or deep burial. Carcasses should be disposed of properly and in accordance with acceptable practices as required by local councils and applicable state/territory or Commonwealth regulations at a Federal quarantine or suitably accredited facility.

Incineration - Snake remains are destroyed in a high temperature incinerator at a cost of around $3.00/kg.

Deep Burial - Snake remains are buried to reduce transmission and spread of disease at a minor cost. This option can only apply for burial in a Council approved animal pit.

5. Disease, Parasite, Infection Risks

Below is a summary table (Table 4) describing some of the common disease risks, parasites and fungal infections that could be transmitted through terrestrial snakes (Allender et al. 2015; Wisniewski 2012a; b). This summary is not comprehensive and is designed to highlight potential wildlife health issues that may result from a terrestrial snake incursion. Each of Australia's states and territories has a Wildlife Health Australia (WHA) Coordinator appointed by the corresponding Chief Veterinary Officers. If there has been an incursion and there is concern regarding disease risks, it is recommended that the relevant State/Territory WHA Coordinator be contacted (**https://www.wildlifehealthaustralia.com.au/AboutUs/ContactDetails.aspx)**

Fact sheets on various snake diseases can be found at **https://wildlifehealthaustralia.com.au/FactSheets.aspx**.

When handling snakes, gloves should be worn to prevent envenomation or bite injury. However, the type of glove to be worn is not specified under Work Health and Safety (WHS) considerations. All venomous snakes should be handled with leather or Kevlar gloves to avoid envenomation with a latex glove underneath to avoid transmission of disease. If the snake is non-venomous and secured in such a way that a snake bite injury is improbable, tight weave cotton gloves with latex gloves underneath or double latex gloves may be worn. Appropriate hand hygiene techniques may negate to use of latex gloves. Primary considerations to prevent the spread of disease include:

1. Hands cleaned or disinfected between handling individuals.
2. Cover cuts and other open wounds before handling snakes.
3. If a non-venomous bite or scratch breaks the skin, wash the area thoroughly with warm water and an anti-bacterial soap, dry well and apply an antibacterial skin treatment.
4. Do not put your hands near or in your mouth, eat or drink while handling a snake.
5. Do not allow reptile to reptile contact. Always apply the rule 'one bag, one reptile'.

Additional information on hygiene protocols for the control of disease in snakes can be found at **http://www.environment.nsw.gov.au/resources/nature/hygieneProtocolSnakes.pdf**

Table 4. Common disease risks, parasites and fungal infections potentially effecting terrestrial snakes. WHS = work health and safety. WHS considerations listed here are in addition to those discussed in the text above.

Disease	Disease Agent	Impact and Transmission Route	Additional WHS Considerations
Salmonella	Bacterial agent	Faecal-oral transmission through direct or indirect ingestion.	Captivity appears to predispose snakes to excrete Salmonella which could then be ingested
Campylobacter	Bacterial agent	Direct contact is required for transmission of this bacteria	

Disease	Disease Agent	Impact and Transmission Route	Additional WHS Considerations
Aeromonas	Bacterial agent	Common bacteria found in healthy snakes. Transmitted directly from bites and scratches or infected water.	
Enterobacter/ Klebsiella	Bacterial agents (collectively called the coliform bacilli)	Common bacteria found in healthy snakes. Transmitted via direct contact.	
Proteus	Bacterial agent	Faecal-oral transmission through direct or indirect ingestion.	
Pseudomonas	Bacterial agent	This organism is fairly common in the oral cavities of snakes and can be transmitted through contamination of wounds.	
Mycobacterium	Bacterial agent	Ubiquitous in the environment and can be transmitted through water or air via direct contact, ingestion or inhalation.	
Leptospirosis	Bacterial agent (Spirochaete bacterium called *Leptospira* spp.)	Transmitted via contact (through skin or ingestion) with water, soil or food contaminated with body fluids from infected animals.	
Q fever (*Coxiella burnetti*)	Bacterial agent	Transmission is thought to occur by direct contact, tick bite or inhalation.	Face masks should be worn
Yersiniosis (eg. *Plesimonas*)	Bacterial agent	Ingestion of bacterium through consumption of undercooked meat, unpasteurized milk or contaminated water.	Snakes should not be consumed
Rocky Mountain Spotted fever	*Rickettsia honei*	Transmitted by the snake tick, *Aponomma hydrosauri*	Use insect repellent, wear long sleeved tops and pants and thick gloves when handling
Snake Fungal Disease	*Ophidiomyces ophiodiicola*	Persists as an environmental saprobe in soil, as well as colonizing living hosts	Face masks should be worn
Fungal infections	Fungal organisms (including Mucor, Rhizopus, Candida, Trichosporon, Trichophyton, Aspergillus, Basidioholus and Geotrichum)	Inhalation or ingestion of spores, or through inoculation of wounds. Fungal disease caused by organisms transmitted via inhalation (eg Mucor) is generally only seen in non-immunocompetent people, thus, face masks are not warranted	

Disease	Disease Agent	Impact and Transmission Route	Additional WHS Considerations
Pentastomiasis (*Linguatula seratta)*	Internal parasite	Ingestion of the organism's eggs or larvae in faeces, saliva or body secretions	
Cryptosporidia	Internal parasite (coccidian parasite)	Organism is shed in faeces	
External parasites	Mites and ticks	Direct contact with animals or infested enclosures	Disposable gloves and insect repellent should be worn when cleaning/ maintaining enclosures and equipment

6. Workplace Health and Safety

Below is a summary table (Table 5) describing some treatment specific workplace health and safety considerations associated with handling terrestrial snakes. Note, this section and the previous section may be used to develop a Job/Activity Hazard Analysis (JHA) that includes terrestrial snake detection and capture.

Table 5. Work Health and Safety (WHS) concerns and recommended treatment in addition to those listed in **Disease, Parasite and Infection Risk** section above.

Hazard		Control
All snakes	Accidental contact with terrestrial snakes	Be alert at all times for the snake or multiple snakes, some of which may be dangerous. Do not reach into dark cracks, crevices, or holes. Do not place hands or feet in places out of view. Use caution when moving, sitting on, or stepping over rocks or logs. Use leather gloves or tools when turning or moving potential snake refugia. Use caution when walking through tall grass or heavy brush, particularly off-trail. Carefully move and shake out boots and equipment before putting them on or away in the morning. Learn to identify and avoid venomous snakes where possible.
Boas and Pythons	Spread of viral, bacteria and other disease	Ensure proper cleaning, disinfecting and /or sterilising of equipment and footwear when moving between sites. Wear single-use gloves (latex or nitrile) under leather or cotton gloves when handling any snake. Appropriate hand hygiene techniques may negate to use of latex gloves. Animals obtained at different sites are kept isolated from each other.
	Injury caused by constriction	Constrictor snakes will coil and constrict, particularly under stress. Avoid working alone when capturing a constrictor. Never loop a snake around your neck, or any part of your body. If the snake begins to coil around any part of your body, uncoil immediately.
Vipers and Elapids	Spread of viral, bacteria and other disease	Ensure proper cleaning, disinfecting and /or sterilising of equipment and footwear when moving between sites. Wear single-use gloves (latex or nitrile) under leather or Kevlar gloves when handling any snake. Appropriate hand hygiene techniques may negate to use of latex gloves. Animals obtained at different sites are kept isolated from each other.
	Potential envenomation if snake strikes	Venomous snakes should be euthanized immediately in the field wherever possible to decrease the risk of envenomation. Live holding and transportation of vipers and elapids may only be considered where absolutely necessary.

Hazard		Control
		If handling of the snake is necessary, this must only be undertaken by those trained in capture of venomous snakes. Note that handling vipers is different from elapids, and these differenced must be understood by the handler. Use proper equipment for capture: Snake tongs (at least 1.2 m long), tightly woven snake bags, venomous reptile box (e.g., Pullman) or 22 L bucket with fitted lid and snake bag (1.5 m long and able to fit around bucket). The use of clear plastic tubing to restrain venomous snakes may be used. Place the polymer tube over the snake's head and allow the snake to enter the tubing (Walczak 1991). Thick leather or kevlar gloves must be worn when handling elapids or vipers. Secure the head and the neck properly. Vipers' fangs are mobile and thus you can still be bitten if you do not. When removing a snake from a container, select an open space where there is ample room to manoeuvre in case the snake strikes or moves away quickly. Proceed only if environmental conditions (i.e., no extreme temperatures, rain, or wind) are suitable for the snake and do not interfere with safe handling. Ensure you have all necessary equipment and arrange it so it is readily accessible. If bitten, seek medical attention immediately. Keep the wound lower than the heart and keep the victim as calm and immobile as possible until help arrives.

7. Regulatory Requirements

Consideration to national and state/territory regulatory requirements is necessary. Table 6 lists some legislation, regulation and permits that will been to be considered when responding to an incursion. Please note that the list does not contain all regulatory requirements as these can differ between states and territories.

Table 6. List of legislation and permits that may be required when responding to an incursion. Table also includes the rationale behind the need and what legislation the requirement is based.

Permits and Training	Why Required	Legislation
Animal Ethics Approval	To trap, sample and euthanize potentially invasive terrestrial snakes. AEC approval is only required for research and teaching purposes under the NHMRC Code	Varies by State/Territory
Health Licence	To possess and use controlled substances such as barbiturates for euthanasia	Varies by State/Territory
Local Land Manager (e.g. Council, Parks or Water authority	Seek appropriate approvals to access land or facilities	Varies by region/municipality
Private property owners	Seek appropriate approvals to access land or facilities	Varies by owner
Pest Animal – Approved Collections Permit	Permits are required for any captured or seized animals. They allow pest animals to be kept in captivity for longer than 12 hours. Animals retained for communications and engagement activities must be kept under permit	Varies by State/Territory
Scientific Permit	To carry out collection (including inadvertent), live capture and release of wildlife. This permit is necessary for potential non-targets	Varies by State/Territory
Firearm Permit	Required if firearms are used for snake control. Also includes special circumstances such as use in a populous (urban) environment, or use of a silencer	National Firearms Agreement (1996) Varies by state/territory

Appendix A: Species Specific Table

The species listed here are representative of the five Families considered at most risk of incursion, establishment or that are likely to have considerable negative impact if they establish in Australia (Bartlett and Wagner 2009; Cabrera-Pérez et al. 2012; Groombridge and Luxmoore 1991; Henderson and Bomford 2011; Human Ageing Genomic Resources 2016; IPAC 2015; Mallow et al. 2003; McDiarmid et al. 1999; Page et al. 2008a; Reed and Rodda 2009; Schuett et al. 2002; Wasko and Sasa 2009; 2012; Wilson et al. 2006; Wisniewski 2012a; b). Seized implies at the border. In terms of IPAC threat category, if a species has not been assessed or if there is too little information to be able to properly adopt a risk analysis approach, the precautionary approach has been adopted. In these cases, snakes are assigned Extreme (P) [Where 'P' = Precautionary]. Extreme = a formal risk assessment has been completed and the species categorised Extreme based on the outcome of the assessment. Not listed = the snake does not appear in IPAC (2015).

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
BOIDAE AND PYTHONIDAE						
Acrantophis dumerili **Dumeril's boa**	Up to 2 m in length Colour pattern grey-brown with darker patches Maximum captive longevity is 26 years	Wide variety of animals including other snakes	Found on Madagascar and Reunion Island Lives in semiarid habitats with low rainfall In captivity they typically have docile natures	Sexual maturity reached within 3-5 years Mating season March – May, young born 6-8 months later Ovoviviparous, litters of between 6-28 neonates Fairly prolifically in captivity	Not Listed	Wild – 0 Seized >11

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
Boa constrictor **Boa constrictor**	Up to 2.5 m in length Variable colour pattern with distinctive brown, grey or cream base and red/brown saddles more pronounced towards the tail Large and heavy-bodied snake with no labial pits Maximum captive longevity is 40 years	Wide variety of mammals and birds	Found in Mexico, Central and South America Utilises wide variety of habitats, prefers rainforests Capable swimmer, will occupy burrows Predominantly nocturnal and will bask during the day Extremely common in the international pet trade	Sexual maturity reached within 4-5 years Their natural range mating season is between April and August, during the dry season. They are ovoviviparous and females can produce over 30 live young per litter	Extreme	Wild – 3 Seized >180
Broghammerus reticulatus **Reticulated python**	Up to 8.7 m in length (world's longest snake) Name refers to the complex colour pattern Maximum captive longevity is 29 years	Mammals and occasionally birds	Found in south-east Asia Excellent swimmer, allowing for colonisation of offshore islands Inhabits rainforest, woodlands and grasslands	They are oviparous and females can lay up to 80 eggs per clutch which take 88 days to hatch.	Extreme (P)	Wild – none Seized >2
Candoia carinata **New Guinea Tree Boa**	Up to 1 m in length Colour pattern highly variable varying from dark brown to orange-brown Maximum captive longevity is 16 years	Primarily Frogs and lizards	Found in Indonesia, New Guinea and the Bismarck Archipelago Nervous disposition but will tolerate human habitation	Breeding typically occurs early in the years after rains in their native range. Gives birth to an average if 10 young.	Extreme (P)	Wild – none Seized >5

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
Corallus caninus **Emerald tree boa**	Up to 1.8 m in length Colour pattern emerald green with white, irregular zigzags on back with a yellow belly Maximum captive longevity is 19 years	Primarily mammals, also birds, lizards and frogs	Found in the rainforests of South America Strictly nocturnal and arboreal	Ovoviviparous with the female producing average litters of 6-14 young	Extreme	Wild – none Seized >2
Epicrates cenchria **Rainbow boa**	Up to 1.5 m in length Attractive iridescent sheen with red and black markings Maximum captive longevity is 31 years	Rodents, birds and lizards	Found in Central and South America. terrestrial species popular as a pet	Viviparous. Gestation lasts about five months. Average litter size is 25, but can be as large as 35 young	Extreme (P)	Wild – none Seized >28
Eunectes notaeus **Yellow anaconda**	Up to 3.7 m in length Color pattern yellow, golden-tan or greenish-yellow base with black or dark brown saddles, blotches, spots and streaks Maximum captive longevity is 23 years	Primarily wading birds, also fish, turtles, lizards and small mammals	Found in South America. Prefers aquatic habitats Has a reputation for being unpredictable	Viviparous. They breed between April and May in their native range. Gestation is 6 months after which the female gives birth to 4 to 82 young	Extreme (P)	Wild – none Seized >1
Eryx and *Gongylophis* species **Sand boas**	Up to 1 m in length Some species have been bred into various colour varieties Stout-bodied snakes with small eyes and small scales Maximum captive longevity 20-28 years	Primarily rodents, also lizards and birds	Found in Europe, northern Africa, Middle East and south-west Asia. Competent burrowers. Usually occurs in semi-desert and scrub savannah. Prefers sandy, friable soil	Ovoviviparous, although some lay eggs. Generally small clutches laid in spring	Extreme (P)	Wild – 3 Seized >13

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
Lichanura trivirgata **Rosy boa**	Up to 1 m in length Colour pattern highly variable with some trace of three longitudinal stripes Maximum captive longevity is 31 years	Primarily small mammals, also lizards and birds	Found in the American south west and Mexico Prefers dry habitats, spends time beneath rocks and in crevices Wild snakes are extremely docile	Rosy boas are viviparous and bear live young, about 6 per litter	Not listed	Wild – none Seized >11
Python bivittatus **Burmese python**	Up to 4.5 m in length Colour pattern dark with many dorsal brown blotches bordered in black Maximum captive longevity is 27 years	Mammals and birds	Native range of southern and south-eastern Asia. Mainly nocturnal rainforest dwellers that are often found near water Excellent swimmers Invasive/ established in Florida Primarily diurnal in winter, nocturnal in summer Popular in pet industry	Females usually lay 12-36 eggs, but are capable of laying as many as 100 eggs after a 60-90 day gestation period. The mother incubates and protects the eggs by coiling on top of them. Incubation lasts about 2 months after which the hatchlings emerge	Not Listed	Wild – none Seized >29
Python curtus **Blood python**	Up to 2.5 m in length with extremely short tail Colour pattern beige, tan, or grayish-brown with red blotches Maximum captive longevity is 27 years	Mammals and birds	Found in south-east Asia Prefer rainforest, marshes and swamp Docile, can be unpredictable	Oviparous with females seldom laying more than 12 eggs. The female protects the clutch during incubation which usually lasts 2.5-3 months	Extreme (P)	Wild – none Seized >1

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
Python molurus **Indian python**	Up to 6 m in length Colour pattern white/yellow with tan to dark brown blotches Maximum captive longevity is 34 years	Mammals and birds	Found in India and bordering countries Occurs in a wide range of habitats, dependent on permanent water Generally lethargic and timid	Oviparous with up to 100 eggs laid	Extreme (P)	Wild – none Seized > 0
Python regius **Ball python**	Up to 1.2 m in length Colour pattern black/ dark brown with light brown/gold sides and dorsal blotches Stocky build with relatively small head Smooth scales, both sexes have anal spurs on either side of the vent Maximum captive longevity is 47 years	Small mammals and occasionally birds	Found throughout central Africa Prefer grasslands, savannah and sparsely wooded areas	Females are oviparous and lay between 3-11 large eggs. The female incubates the eggs which hatch after 55-60 days	Extreme (P)	Wild – none Seized >7
Python sebae **African rock python**	Up to 4.8 m in length Colour pattern brown to yellow with light, irregular blotches. The head marked with a dark brown spear head outlined in yellow Maximum captive longevity is 27 years	Mammals, reptiles, and birds	Found in sub-Saharan Africa and south Africa From forest to near desert, usually near water Known to have an unpredictable temperament	Reproduction occurs in the spring in their native range. Female lay between 20-100 eggs and will guard eggs and hatchlings	Not Listed	Wild – none Seized >7

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
COLUBRIDAE						
Pantherophis guttatus **Corn snake**	Up to 1.8 m in length Colour pattern varied, usually copper with contrasting bands Maximum captive longevity is 32 years	Small rodents, reptiles, amphibians, and bird eggs	Found in southeast USA Fields, open forest, rural and peri-urban environs Calm temperament	Reproduction occurs in the spring in their native range. Female lay between 12-24 eggs	Serious	Wild – >14 Seized >160
Heterodon simus **Southern hog-nosed snake**	Up to 0.6 m in length Colour pattern light brown to red with rows of dark blotches Distinctive upturned snout Maximum captive longevity is 9 years	Frogs, toads, and lizards	Found in southeast USA Dry, open areas like floodplains and fields	Oviparous. Reproduction occurs in the autumn in their native range. Female lay between 6-14 eggs	Extreme (P)	Wild – 0 Seized >3
Lampropeltis getula californiae **California kingsnake**	Up to 2 m in length Numerous colour morphs, usually dark and light stripes Non-venomous, constricts Maximum captive longevity is 33 years	Mammals, reptiles, amphibians, and birds	Found on west coast of USA Fields and open forest Diurnal but nocturnal in hot weather Can mimic rattlesnakes Popular in the pet trade	Oviparous. Reproduction occurs in the autumn in their native range. Female lay between 3-24 eggs	Extreme (P)	Wild – 0 Seized > 0

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
ELAPIDAE						
Ophiophagus hannah **King Cobra**	Up to 4 m in length Colour pattern olive to black with faint yellow bands Highly venomous Maximum captive longevity is 22 years	snakes, lizards, birds, and rodents	Found in east and southeast Asia, and Indian subcontinent Dense highland forests, close to water Can be highly aggressive	Females lay between 20-40 eggs and will remain with eggs until they hatch	Extreme (P)	Wild – none Seized >
VIPERIDAE						
Bitis arietans **Puff Adder**	Up to 1.5 m in length Colour pattern varies geographically, usually yellow to brown with dark bands Maximum captive longevity is 15 years	Mammals, birds, amphibians, and lizards	Found Morocco through Africa Primarily savannah and grasslands Nocturnal, sluggish, but bad-tempered if threatened Ambush predator and aggressive	Females lay up to 80 young per litter	Serious	Wild – none Seized >11
Bitis gabonica **Gaboon Viper**	Up to 2 m in length Colour pattern pale, rectangular blotches interspaced with dark, yellow-edged hourglass markings World's heaviest vipe Maximum captive longevity is 18 years	Unusually will hang on to prey rather than bite and release	Found in sub-Saharan Africa Prefers rainforests and woodlands Unaggressive nature	Clutch rarely exceeds more than 24 live young but can produce as many as 60. Gestation is a year with births occurring in late summer in their natural habitat	Extreme (P)	Wild – none Seized >115

Species	General description	Diet	Habitat / Behaviour	Breeding	IPAC Threat Category	Incursions since 1999
Crotalus vegrandis **Uracoan Rattlesnake**	Up to 0.65 m in length Brown base colour with pale speckling, resembling a zig zag pattern from head to tail. Large head and short broad body. Maximum captive longevity is 19 years	Small mammals	Found in Uracoa, Venezuela Prefers savannah	5-20 young are born after a gestation of 150 to 180 days	Extreme (P)	Wild – none Seized > 2
Daboia russelii **Russel's Viper**	Up to 1.6 m in length Colour pattern yellow to brown base with dark brown spots ringed with white/yellow Maximum captive longevity is 15 years	Wide variety of animals mainly rodents, also crabs and scorpions	Widespread throughout Asia Not restricted, including urbanised areas Terrestrial and nocturnal forager	Ovoviviparous. Young produced mostly in June and July in native range. Prolific breeder, up to 40 in an average clutch	Not Listed	Wild – none Seized > 5
Vipera ammodytes **Nose-horned Viper**	Up to 0.95 m in length Colour pattern sexual dimorphism. Light brown with dark zig-zag pattern Single "horn" on the snout Maximum captive longevity is 22 years	Primarily small mammals and birds. Juveniles prefer lizards	Found in southern Europe Prefers rocky habitats, but also urban areas Hibernates and generally lethargic	Mating takes place in spring in their native habitat and up to 20 live young born (ovoviviparous) in late summer	Not Listed	Wild – none Seized > 8
Cerastes species **Horned vipers**	Up to 0.5 m in length Colour pattern varies Not all species have horns Maximum longevity is between 18 and 27 years in captivity	Rodents, birds and lizard	Found northern North Africa Prefers desert to semi-desert Nocturnal and terrestrial will bury themselves in sand Will strike with provocation Ambush predators	All species lay eggs, although eggs can hatch within hours of laying	Not Listed	Wild – none Seized > 28

Appendix B: Incursion Response – Activity Log Template

Incursion Event Name		**Incursion/Detection Event No**	
Project Sponsor/Agency		**Sheet Number**	

Activity Number	Date	Time	Action (e.g., phone call, conversation, email, activity)	Follow up action required	Name/signature

Appendix C: Incursion Response - Situation Report Template

Note: Report structure based on Animal Health Australia (AHA) Australian Veterinary Emergency Plan (AUSVETPLAN)

To:

From:

Date:

Subject: Biosecurity Incursion (Species name)

WHAT WE KNOW AND DON'T KNOW

Information available at present

What has happened?

- A short factual summary about the current status of the incursion.
- What is the organism?
  - Description, distribution, habitat, basic biology and tolerances, known impacts.
  - Name and contact details of identification expert
- Is it a suspected incursion or has it been confirmed?
- When was it discovered? How? By whom?
- Where is the incident? How wide spread? Area of incursion and delineation
- Clinical symptoms, diagnosis, how it has spread, human health implications.

How did it happen?

- Relevant history in Australia (new to Australia or record of previous incursion/s) and overseas
- Pathway, activity and/or vectors of incursion (suspected or known)

Risk of establishment

- Species risk assessment
- Likelihood of spread

Implications

- Environmental and/or agricultural repercussions
- Environmental/Human health and/or food safety implications
- Trade implications/restrictions

- How long will it take to resolve the incursion (either complete or hand over to ongoing control operations)?

WHAT WE ARE DOING

What actions are currently underway to manage and resolve the incursion?

- Containment, tracing and eradication activities (activated incursion plans and procedures)
- Delineate incursion, quarantine areas and movement restrictions
- Trace forwards/trace backs (determine pathways and point/s of incursion/s)
- Surveillance and monitoring
- Testing/diagnostics
- Border security measures
- Product recalls, bans, food/product safety info (if relevant)
- Market access protocols/negotiations
- Meetings/taskforces
- Cost-sharing arrangements and/or financial assistance
- Current public information
- Ongoing management issues

WHAT WE WANT TO/NEED TO DO

- Additional options for immediate response
- Options for medium and long term response
- Movement restrictions (e.g., transportation modes, livestock, vegetation etc.)
- Implement and maintain good biosecurity practices
- Immediately report any signs of incursion species
- Follow instructions given by biosecurity authorities

INFORMATION SOURCES

List sources:

- For further information visit website, social media sites, phone hotline number.

Suspected Pathways and Vector

Life Cycle Implications

- Time of Year, Weather Implications

Habitat in the Area

Hydrography in the Area

RISK

Likelihood of Spread

Pest Status in Australia and Overseas

MANAGEMENT

Options for Immediate Treatment

Options for Medium to Long Term Treatment

RECOMMENDATIONS

Appendix D: Incursion Response - Emergency Response Plan Template

The Emergency Response Plan summaries what the problem or issue is and what information is currently available. In addition it considers what needs to be done.

It describes response goals, operational objectives and support activities. Essentially it is a proposed plan of action and strategy for the biosecurity response. The plan may be written once or routinely updated as more information is made available.

Name of Document:	
Prepared by:	
Description of Content:	
Approved by:	
Date of Approval:	

Version Number	Version Date	Authorised Officer	Amendment Details
1			
2			

Distribution List

Name	Agency	Involvement in Incursion

CITATION

This report should be cited as:

(Author/s). (Year). (Species Name) Incursion Response - Emergency Response Plan. (Lead Agency). State/Territory).

Introduction and Nature of Incursion

- Species, biology and distribution (as it impact potential management techniques, establishment and spread)

Situation Summary

Biosecurity Response Objective

- What is the planned outcome?

Biosecurity Response Organisation Chart

- Responsibilities of key personnel

Plan of Action/Incursion Management

- Develop a plan of action that includes the following critical elements:
    - What must happen
    - When it is required
    - Who is responsible
- Plan must include:
    - Scope (must be specific, measurable, achievable, timely and realistic)
    - Schedule (work breakdown structure, gantt chart etc)
    - Contingency planning

Resource and Budget Needs

- Who will provide what and by when
- Were and how response will be funded

Information Flow

- Who needs to be informed
    - Provide advice to property owners, managers and government stakeholders
- Who has information that will benefit the response?

Communications Plan

- What will be communicated and to whom?
- Form of communication used, to whom, its contents, and how often you will communicate
- Technical aspects included, such as frequencies, cell phone numbers and media contacts and releases

Appendix E: Post Incursion Response - Review and After-Action Review

The Post-Incursion After Action Review document is the final document produced for a particular incursion. It should be used to assess the success of the response, inform future incursion events, 'tidy up' any loose ends and formally close the response. Specifically it should seek to accomplish three things:

- Confirm all work has been performed and documented in line with requirements;
- Provides a summary of what happened and where to find relevant information; and
- Ensures that any lessons learnt are passed on.

Report Name			
Report Date		**Detection Event No**	
Author/s			
Project Sponsor/Agency			

Revision History

Version Number	Date	Reason/Comments	Reviewed by

Distribution List

Name	Agency	Involvement in Incursion

Citation

This report should be cited as:

(Author/s). (Year). (Species Name) Incursion Response - Review and Closeout Report. (Lead Agency). State/Territory).

SUMMARY INCURSION INFORMATION

To reduce repetitive work, this information may be derived from the Annual Vertebrate Detection xls database, or vice versa.

Organism	common and scientific name
New or persisting Incursion	Is this the first record of the organism in the area or is it a persisting incursion?
Initial Detection Date/Time	
Number and type of Individuals Detected	Please specify whether numbers are actual or estimated Include sex, age (if possible), size, and any other traits if known or can be estimated
Initial Detection Location	Towns and postcode, GPS latitude and longitude, and/or hyperlink/reference to a map
Brief Description of What Happened and Area	e.g., Member of public phoned to report a boa constrictor in a suburban bushland near the Spit, Gold Coast. Bushland approx. 10 ha and surrounded by mowed grass, shrubs and trees in residential area
Suspected Source Location	e.g., Central America, Brazil, illegal pet trade, unknown
Suspected Vector	e.g., aircraft, shipping container, luggage, illegal pet trade, unknown
Pest Status	Summary of national and international status if known. For international status, check http://www.issg.org/database/welcome/
Outcome	e.g., individual found/not found, captured, euthanized, unknown What is the fate of the organism/s?
Incident Documentation	Please include hyperlinks or citations all documents associated with this incursion

INCURSION RESPONSE – AFTER ACTION SUMMARY

Planned Activity	Supporting Documents	Did Activity go to plan?	Deviation from Activity Plan
Describe the primary tasks within each Activity	e.g., Communication Plan, Incursion Plan, methodology paper etc Please include citation or hyperlink	Yes/No	If activity deviated from what was planned, please record the difference/s here
Management and Incursion Team			
Detection			
Tracking or Tracing (monitoring of location and status of species)			
Surveillance			
Control			
Communication (including media)			
Reporting			
Resourcing			

SUCCESSES

From the table above, please list all aspects of the incursion response that you deem successful.

1.1

1.2

1.3

CHALLENGES

From the table above, please list all aspects of the incursion response that you consider were a challenge and could be improved.

2.1

2.2

2.3

HANDOVER TO OPERATIONS

If eradication is not feasible, describe how the incursion response will be handed over to operations or activities terminated.

RECOMMENDATIONS

Based on the incursion response experience, we recommend the following:

- [refer to number above (1.1) etc]
- [refer to number above (2.1) etc]
- [refer to number above (2.3) etc]

Appendix F: Animal Welfare Codes of Practice

Below are current (as of January 2016) links to national, State and Territory animal welfare codes of practice. Codes of practice set out recommended minimum standards and practices for the keeping and use of a wide range of species and animal related activities, including terrestrial snakes. Websites last accessed 8 August 2016.

Location	Current Link
Australian Government	**http://www.agriculture.gov.au/animal/welfare/standards-guidelines** **http://www.australiananimalwelfare.com.au/** **http://www.nhmrc.gov.au/guidelines-publications/ea28** **https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/ea18.pdf**
Australian Capital Territory	**http://www.legislation.act.gov.au/a/1992-45/li.asp**
New South Wales	**http://www.dpi.nsw.gov.au/agriculture/livestock/animal-welfare/codes** **http://fennerschool-associated.anu.edu.au/myna/humane_files/gen-001.pdf**
Northern Territory	**http://www.animalwelfare.nt.gov.au/national_standards_and_guidelines** **http://www.nt.gov.au/d/Primary_Industry/animalwelfare/animalact/?pg=definition**
Queensland	**https://www.business.qld.gov.au/industry/agriculture/animal-management/land-management-for-livestock-farms/welfare-movement-livestock/animal-welfare/overview-codes-practice/animal-welfare-codes-list**
South Australia	**http://www.environment.sa.gov.au/managing-natural-resources/plants-and-animals/Animal_welfare/Codes_of_practice/Animal_welfare_codes_of_practice** **https://www.legislation.sa.gov.au/lz/c/r/animal%20welfare%20regulations%202012/current/2012.187.un.pdf**
Tasmania	**http://dpipwe.tas.gov.au/biosecurity/animal-biosecurity/animal-welfare/legislation-standards-guidelines/animal-welfare-standards-guidelines/animal-welfare-guidelines** **http://dpipwe.tas.gov.au/Documents/Keeping-Tasmanian-Reptiles-Brochure.pdf**
Victoria	**http://agriculture.vic.gov.au/agriculture/animal-health-and-welfare/animal-welfare/animal-welfare-legislation/victorian-codes-of-practice-for-animal-welfare** **http://agriculture.vic.gov.au/agriculture/animal-health-and-welfare/animal-welfare/animal-welfare-legislation**
Western Australia	**https://www.agric.wa.gov.au/animalwelfare/animal-welfare-codes-practice** **https://www.dpaw.wa.gov.au/images/documents/get-involved/wildlife-courses/20140408_standardsforwildliferehab_final.pdf**

Appendix G: Definitions and Acronyms

DEFINITIONS

Arboreal	A terrestrial animal that lives in trees, as opposed to living in water or on the ground
Asymptomatic	Without obvious signs or symptoms of disease
Brumation	Dormancy in reptiles that is similar to hibernation, but differs from hibernation in the metabolic processes involved
Constrictor	Snakes that use constriction to subdue and kill their prey
Cytotoxic	Venom that is directly toxic to cells, preventing their reproduction and growth
Ectothermic	An animal whose body temperature varies with the temperature of its surroundings. A “cold blooded” animal that cannot regulate their body temperature
Fecund	Able to produce lots of young
Haemotoxic	A toxin that destroys red blood cells, disrupts blood clotting and/or causes organ degeneration and generalized tissue damage
Invasive	A species that does not naturally occur in a specific area and whose introduction does or is likely to cause economic or environmental harm or harm to human health
Labial pit	Facial pits that allow some snakes the ability to sense infrared thermal radiation, essentially allowing these snakes to “see” radiant heat. Boas and pythons have three or more comparatively small pits lining the upper and sometimes lower lip, in or between the scales
Loreal pit	Facial pits that allow some snakes the ability to sense infrared thermal radiation, essentially allowing snakes to “see” radiant heat.
Neurotoxic	Poisonous or destructive to nerve tissue
Non-indigenous	Arriving from another place rather than naturally existing in a place
Non-target	Species not being the subject or goal of a particular action, program, technique, method, manoeuvre, or the like
Oviparous	Animals that lay eggs, with little or no other embryonic development within the mother
Ovoviviparous	Animals in which the embryos develop inside eggs that are retained within the mother’s body until they are ready to hatch
Proteolytic compounds	Compounds within venom that have anti-coagulant properties
Proteroglyphous	Snakes that have fangs at the front of the maxilla (upper jaw), often with small solid teeth behind. The fangs are hollow and short, as in cobras, mambas, and coral snakes (Elapidae).
Terrestrial	An animal that lives on ground, as opposed to living in water. Terrestrial animals may also be arboreal.

Target Species that are the subject or goal of a particular action, program, technique, method, manoeuvre, or the like

Viviparous Animals in which development of the embryo is inside the body of the mother, eventually leading to live birth

ACRONYMS

ACT	Australian Capital Territory
Animal Welfare Act	*Animal Welfare Act 1992* (ACT)
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQIS	Australian Quarantine and Inspection Service
AusBIOSEC	Australian Biosecurity System for Primary Production and the Environment
AusVETPLAN	Australian Veterinary Emergency Plan
CCEAD	Consultative Committee for Emergency Animal Diseases.
CIKA	Interdepartmental Committee for the Introduction and Keeping of Animals (Western Australia)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COAG	Council of Australian Governments
COP	Code of Practice
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DAFWA	Department of Agriculture and Food, Western Australia
DEC	NSW Department of Environment and Conservation (now Office of Environment and Heritage)
DECC	NSW Department of Environment and Climate Change (now Office of Environment and Heritage)
DPI	Department of Primary Industries
DPIPWE	Department of Primary Industries, Parks, Water and Environment, Tasmania
DSE	Victorian Department of Sustainability and Environment
DSEWPac	Department of Sustainability, Environment, Water, Populations and Communities
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IA CRC	Invasive Animals Cooperative Research Centre
IBD	Inclusion Body Disease
IGAB	Intergovernmental Agreement on Biosecurity

IPAC	Invasive Plants and Animals Committee (merger of Australian Weeds Committee and Vertebrate Pest Committee)
IS	Invasive Species
NBC	National Biosecurity Committee
NC Act	*Nature Conservation Act 1980* (ACT)
NEBRA	National Environmental Biosecurity Response Agreement
POCTA	Prevention of Cruelty to Animals Act (1986)
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SOP	Standard Operating Procedure
VPC	Vertebrate Pest Committee (now merged with Australian Weeds Committee to become Invasive Plants and Animals Committee (merger of and Vertebrate Pest Committee)
WHS	Work Health and Safety

Acknowledgements

This plan is a component of the Invasive Animals Cooperative Research Centre (IA CRC) project, ‘National Incursion Response Facilitator’ (Project No. 1.L.1), funded by the IA CRC and hosted by Department of Agriculture and Food, WA (DAFWA).

We are grateful to Biosecurity Victoria (DEDJTR) for their generous permission to use their Pre-incursion Plans (PIP005 Pythons and Boas and PIP010 Vipers) written by Susan Wisniewski (Biosecurity Victoria). These documents were used as a template and information source for the development of this plan.

The project’s steering committee — Andrew Woolnough (DEDJTR), John Virtue (PIRSA), Malcolm Kennedy (DAFWA), Phill Cassey (U Adelaide), and Andrea Byrom (Landcare NZ)— are thanked for their input, guidance and valuable comments on early versions. P. Garcia Diaz (U Adelaide), P. Bird (PIRSA), B. Page (PIRSA), S. Csurhes (DAF QLD), Q. Hart (DPI NSW), Interdepartmental Committee for the Introduction and Keeping of Animals Western Australia (CIKA), M. Pauza (DPIPWE), C. Elliott (DPIPWE), J. Quinn (DoA), J.Hutchinson (DAWR), C. McDonald (DAWR), R. Iglesias (DAWR), and D. Gleeson (UoC) are also thanked for reviewing drafts.

We are extremely grateful to everybody for their assistance and willingness to provide information and reviews.

References

AHA, (Animal Health Australia). 2015. Operational manual: Disposal (Version 3.1). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3. National Biosecurity Committee. Canberra, ACT.

Allender MC, Raudabaugh DB, Gleason FH, Miller AN. 2015. The natural history, ecology, and epidemiology of Ophidiomyces ophiodiicola and its potential impact on free-ranging snake populations. Fungal Ecology 17:187-196.

Angilletta M. 1994. Sedentary behavior by green mambas *Dendroaspis angusticeps*. Herpetological Natural History 2:105-111.

Bartlett P, Wagner E. 2009. Pythons: Complete Pet Owner's Manual: Barron's Educational Series. 96 pp.

Bomford M, Kraus F, Braysher M, Walter L, Brown L. 2005. Risk assessment model for the import and keeping of exotic reptiles and amphibians. Bureau of Rural Sciences. Canberra, ACT. 110 pp.

Bromby MC, Hall MJJ. 2002. The Development and Rapid Evolution of the Knowledge Model of ADVOKATE: An Advisory System to Assess the Credibility of Eyewitness Testimony. In: Bench-Capon T, Daskalopulu A, Winkels R, editors. Legal Knowledge and Information Systems The Fifteenth Annual Conference, Amsterdam.IOS Press Jurix, Amsterdam. pp 143-152.

Browne C, Stafford K, Fordham R. 2006. The use of scent-detection dogs. Irish Veterinary Journal 59:97-104.

Cabrera-Pérez MÁ, Gallo-Barneto R, Esteve I, Patiño-Martínez C, López-Jurado LF. 2012. The management and control of the California kingsnake in Gran Canaria (Canary Islands): Project LIFE+ Lampropeltis. Aliens: The Invasive Species Bulletin Newsletter of the IUCN/SSC Invasive Species Specialist Group 32:20-28.

Carlisle-Nowak M, Sullivan N, Carrigan M, Knight C, Ryan C, Jacobson E. 1998. Inclusion body disease in two captive Australian pythons (*Morelia spilota variegata* and *Morelia spilota spilota*). Australian veterinary journal 76:98-100.

Case TJ, Fisher RN. 2001. Measuring and predicting species presence: coastal sage scrub case study. Spatial Uncertainty in Ecology.Springer. pp 47-71.

Chang L-W, Jacobson ER. 2010. Inclusion body disease, a worldwide infectious disease of boid snakes: a review. Journal of Exotic Pet Medicine 19:216-225.

Cheatwood JL, Jacobson ER, May PG, Farrell TM, Homer BL, Samuelson DA, Kimbrough JW. 2003. An outbreak of fungal dermatitis and stomatitis in a free-ranging population of pigmy rattlesnakes (*Sistrurus miliarius barbouri*) in Florida. Journal of wildlife diseases 39:329-337.

Christy MT, Savidge JA, Bischof R, Rodda GH. 2007. Can temperature be used as a tool for limiting brown treesnake invasion via transportation pathways? In: Witmer G, Pitt W, Fagerstone K, editors. Managing vertebrate invasive species: Proceedings of an international symposium.APHIS Wildlife Services, National Wildlife Research Center. Fort Collins, CO. pp 246-256.

Christy MT, Yackel Adams AA, Rodda GH, Savidge JA, Tyrrell CL. 2010. Modelling detection probabilities to evaluate management and control tools for an invasive species. Journal of Applied Ecology 47:106-113.

Clark L, Savarie P, Shivik JA, Breck SW, Dorr BS. 2012. Efficacy, effort, and cost comparisons of trapping and acetaminophen-baiting for control of brown treesnakes on Guam. Human–Wildlife Interactions 6:222-236.

Clark RW, Marchand MN, Clifford BJ, Stechert R, Stephens S. 2011. Decline of an isolated timber rattlesnake (*Crotalus horridus*) population: Interactions between climate change, disease, and loss of genetic diversity. Biological Conservation 144:886-891.

Clemann N, Rowe KM, Rowe KC, Raadik T, Gomon M, Menkhorst P, Sumner J, Bray D, Norman M, Melville J. 2014. Value and impacts of collecting vertebrate voucher specimens, with guidelines for ethical collection. Memoirs of Museum Victoria 72:141-151.

Cogger HG, Zweifel RG, Kirshner D. 1998. Encyclopedia of reptiles and amphibians: Academic Press. San Diego. 240 pp.

Colvin B, Fall M, Fitzgerald L, Loope L. 2005. Review of brown treesnake problems and control programs: report of observations and recommendations. Office of Insular Affairs. Honolulu, HI. 27 pp.

Commonwealth of Australia. 2011. Australian Animal Welfare Strategy and National Implementation Plan 2010–14. Australian Government Department of Agriculture, Fisheries and Forestry Canberra, ACT. 64 pp.

Corben C, Fellers GM. 2001. A technique for detecting eyeshine of amphibians and reptiles. Herpetological Review 32:89-91.

Csurhes S, Fisher P. 2010. Pest animal risk assessment; Cobra (all species). Biosecurity Queensland, Department of Employment, Economic Development and Innovation. Brisbane, QLD. 17 pp.

Dargan LM, Stickel WH. 1949. An experiment with snake trapping. Copeia:264-268.

De Vosjoli P, Klingenberg R. 2012. Burmese pythons: plus reticulated pythons and related species: Advanced Vivarium Systems. Irvine, CA.

Dolinski AC, Allender MC, Hsiao V, Maddox CW. 2014. Systemic Ophidiomyces ophiodiicola Infection in a Free-Ranging Plains Garter Snake (*Thamnophis radix*). Journal of Herpetological Medicine and Surgery 24:7-10.

Enge KM. 2001. The Pitfalls of Pitfall Traps. Journal of Herpetology 35:467-478.

Engeman RM, Linnell MA. 2004. The effect of trap spacing on the capture of brown tree snakes on Guam. International biodeterioration & biodegradation 54:265-267.

Engeman RM, Vice DS, York D, Gruver KS. 2002. Sustained evaluation of the effectiveness of detector dogs for locating brown tree snakes in cargo outbound from Guam. International biodeterioration & biodegradation 49:101-106.

Fearn S, Schwarzkopf L, Shine R. 2005. Giant snakes in tropical forests: a field study of the Australian scrub python, *Morelia kinghorni*. Wildlife Research 32:193-201.

Fisher RN, Stokes D, Rochester C, Brehme C, Hathaway S, Case T. 2008. Herpetological monitoring using a pitfall trapping design in southern California: US Department of the Interior, US Geological Survey Techniques and Methods 2-A5. Reston, VA. 44 pp.

Fitch HS. 1951. A simplified type of funnel trap for reptiles. Herpetologica 7:77-80.

Friend G. 1984. Relative efficiency of two pitfall-drift fence systems for sampling small vertebates. Australian Zoologist 21:423-434.

Friend G, Smith GT, Mitchell D, Dickman C. 1989. Influence of pitfall and drift fence design on capture rates of small vertebrates in semi-arid habitats of Western Australia. Wildlife Research 16:1-10.

Furlan EM, Gleeson D, Hardy CM, Duncan RP. 2015. A framework for estimating the sensitivity of eDNA surveys. Molecular Ecology Resources.

Garcia-Diaz P. 2015. University of Adelaide. Personal Communication.

Gibble R, Kapsch M, Bonneau M, Brandt L, Hart K, Irik K, Ketterlin-Eckles J, Klug P, Mitchell C, Olson R. 2014. Management response to the threat of Burmese pythons in Arthur R. Marshall Loxahatchee National Wildlife Refuge. A Case Study from the Structured Decision Making Workshop National Conservation Training Center, Shepherdstown, WV June 2-6:1-27.

Ginzinger DG. 2002. Gene quantification using real-time quantitative PCR: an emerging technology hits the mainstream. Experimental hematology 30:503-512.

Gragg JE, Rodda GH, Savidge JA, White GC, Dean-Bradley K, Ellingson AR. 2007. Response of brown treesnakes to reduction of their rodent prey. The Journal of Wildlife Management 71:2311-2317.

Groombridge B, Luxmoore R. 1991. Pythons in South-East Asia: A Review of Distribution, Status, and Trade in Three Selected Species. Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Report nr 288323003X. Lausanne, Switzerland. 127 pp.

Grzimek B, Schlager N, Olendorf D, McDade MC. 2004. Grzimek's animal life encyclopedia: Gale Publishing. Farmington Hills, MI.

Hawley NB. 2007. Custom trucks, radio snake jingles, and temporary tattoos: An overview of a successful public awareness campaign related to brown treesnakes in the Commonwealth of the Northern Mariana Islands. In: Witmer G, Pitt W, Fagerstone K, editors. Managing vertebrate invasive species: Proceedings of an international symposium.USDA-APHIS Wildlife Services, National Wildlife Research Center. Fort Collins, CO. pp 53-56.

Hayashi Y, Sawai Y, Tanaka H, Mishima S. 1999. Development of electric fence barriers for Habu, *Trimeresurus flavoviridis*, in the Amami Islands. In: Rodda G, Sawai Y, Chiszar D, Tanaka H, editors. Problem snake management: the Habu and the Brown Treesnake.Comstock Publication Associates, Cornell University Press. Ithaca, NY. pp 319–326.

Hayashi Y, Tanaka H, Wada Y, Mishima S. 1983. The electric fence for preventing invasion of Trimeresurus flavoviridis, Habu, the venomous snake. The Japanese journal of experimental medicine 53:165-172.

Henderson W, Bomford M. 2011. Detecting and preventing new incursions of exotic animals in Australia. Invasive Animals Cooperative Research Centre. Report nr 1921777168. Canberra, ACT.

Henke SE. 1998. The effect of multiple search items and item abundance on the efficiency of human searchers. Journal of Herpetology 32:112-115.

Human Ageing Genomic Resources. 2016. AnAge Database of Animal Ageing and Longevity.Human Ageing Genomic Resources. Liverpool, UK. http://genomics.senescence.info/species/ 24 February 2016.

Hunter ME, Oyler-McCance SJ, Dorazio RM, Fike JA, Smith BJ, Hunter CT, Reed RN, Hart KM. 2015. Environmental DNA (eDNA) sampling improves occurrence and detection estimates of invasive Burmese pythons. PloS one 10:e0121655.

Imler RH. 1945. Bullsnakes and their control on a Nebraska wildlife refuge. The Journal of Wildlife Management 9:265-273.

IPAC, (Invasive Plants and Animals Committee). 2015. Australian List of Threat Categories of Non-indigenous Vertebrates. Draft. Commonwealth of Australia Adelaide, SA. 45 pp.

Jerde CL, Mahon AR, Chadderton WL, Lodge DM. 2011. "Sight-unseen" detection of rare aquatic species using environmental DNA. Conservation Letters 4:150-157.

Katsuren S, Yoshida C, Nishimura M. 1999. A ten-year trapping program to eradicate Habu (*Trimeresurus flavoviridis)* from Minnajima, a small island in the Okinawa Islands, Japan. In: Rodda G, Sawai Y, Chiszar D, Tanaka H, editors. Problem Snake Management.Comstock Publication Associates, Cornell University Press. Ithaca, NY. pp 340-347.

Keogh J. 2004. Elapidae. In: Grzimek B, Schlager N, Olendorf D, McDade MC, editors. Grzimek's animal life encyclopedia.Thomas-Gale Publishing. Detroit, MI.

Kirkpatrick W. 2015. Department of Agriculture and Food, WA. Personal Communication.

Kraus F, Cravalho D. 2001. The risk to Hawai'i from snakes. Pacific Science 55:409-417.

Lardner B, Savidge JA, Rodda GH. 2007. Spotting cryptic animals in the dark: What light properties should a good headlamp have? In: Witmer G, Pitt W, Fagerstone K, editors. Managing Vertebrate Invasive Species: Proceedings of an International Symposium.USDA / APHIS Wildlife Services, National Wildlife Research Center Fort Collins, CO.

Leary S, Underwood W, Anthony R, Cartner S, Corey D, Grandin T, Greenacre CB, Gwaltney-Bran S, McCrackin MA, Meyer R. 2013. AVMA guidelines for the euthanasia of animals: 2013 edition. American Veterinary Medical Association. Schaumburg, IL. 102 pp.

Linnell MA, Engeman RM, Pitzler ME, Warren M, Whitehead GF, Miller RC. 1998. An evaluation of two designs of stamped metal trap flaps for use in operational trapping of brown tree snakes (*Boiga irregularis*). The Snake 28:14-18.

Madsen T, Shine R. 1996. Seasonal migration of predators and prey - a study of pythons and rats in tropical Australia. Ecology 77:149-156.

Mahon AR, Jerde CL, Galaska M, Bergner JL, Chadderton WL, Lodge DM, Hunter ME, Nico LG. 2013. Validation of eDNA surveillance sensitivity for detection of Asian carps in controlled and field experiments. PloS one 8:e58316.

Mallow D, Ludwig D, Nilson G. 2003. True vipers: natural history and toxinology of old world vipers: Krieger Publishing Company. Florida, USA. 359 pp.

Maritz B, Masterson G, Mackay D, Alexander G. 2007. The effect of funnel trap type and size of pitfall trap on trap success: implications for ecological field studies. Amphibia-Reptilia 28:321-328.

Massam M, Kirkpatrick W, Page A. 2010. Assessment and prioritisation of risk for 40 exotic animal species Department of Agriculture and Food, Western Australia. Department of Agriculture and Food, WAand Invasive Animals Cooperative Research Centre. Canberra, ACT. 116 pp.

McDiarmid RW, Campbell JA, Touré TSA. 1999. Snake species of the world: a taxonomic and geographic reference. Vol. 1: Herpetologists' League. Washington, DC

Mehrtens JM. 1987. Living snakes of the world in color.Stirling Publishing Co. New York, NY.

Moore RD, Griffiths RA, O'Brien CM, Murphy A, Jay D. 2004a. Induced defences in an endangered amphibian in response to an introduced snake predator. Oecologia 141:139-147.

Moore RD, Griffiths RA, Roman A. 2004b. Distribution of the Mallorcan midwife toad (*Alytes muletensis*) in relation to landscape topography and introduced predators. Biological Conservation 116:327-332.

NHMRC, (National Health and Medical Research Council). 2008. Guidelines to promote the well-being of animals used for scientific purposes: The assessment and alleviation of pain and distress in research animals. Australian Government. Canberra, ACT. 189 pp.

NHMRC, (National Health and Medical Research Council). 2013. Australian code for the care and use of animals for scientific purposes, 8th edition. National Health and Medical Research Council. Canberra, ACT. 96 pp.

NISC, (National Invasive Species Council). 2003. General guidelines for the establishment and evaluation of invasive species early detection and rapid response systems. Washington, DC. 16 pp.

Noble TH, Robson HL, Saunders RJ, Jerry DR. 2015. The utility of eDNA as a tilapia surveillance tool: PestSmart Toolkit publication, Invasive Animals Cooperative Research Centre. Canberra, ACT.

Page A, Kirkpatrick W, Massam M. 2008a. Risk assessments for exotic reptiles and amphibians introduced to Australia – Boa Constrictor (*Boa Constrictor*) (Linnaeus, 1758). Department of Agriculture and Food. South Perth, WA. 10 pp.

Page A, Kirkpatrick W, Massam M. 2008b. Risk assessments for exotic reptiles and amphibians introduced to Australia – Corn Snake (*Elaphe guttata*) (Linnaeus, 1766). Department of Agriculture and Food, WA. South Perth, WA. 16 pp.

Page A, Kirkpatrick W, Massam M. 2008c. Risk assessments for exotic reptiles and amphibians introduced to Australia – Puff Adder (*Bitis arietans*) (Merrem, 1820). Department of Agriculture and Food, WA. South Perth, WA. 13 pp.

Perry G, Campbell III EW, Rodda GH, Fritts TH. 1998. Managing island biotas: brown treesnake control using barrier technology. In: Baker R, Crabb A, editors. Proceedings of the

18th Vertebrate Pest Conference.USDA National Wildlife Research Center-Staff Publications. Davis, CA. pp 138-143.

Pough FH, Andrews RM, Cadle JE, Crump ML, Savitzky AH, Wells KD. 1998. Herpetology: Prentice Hall. New York, NY. 544 pp.

Rajeev S, Sutton D, Wickes B, Miller DL, Giri D, Van Meter M, Thompson E, Rinaldi M, Romanelli A, Cano J. 2009. Isolation and characterization of a new fungal species, *Chrysosporium ophiodiicola*, from a mycotic granuloma of a black rat snake *(Elaphe obsoleta obsoleta*). Journal of clinical microbiology 47:1264-1268.

Reed RN, Hart KM, Rodda GH, Mazzotti FJ, Snow RW, Cherkiss M, Rozar R, Goetz S. 2011. A field test of attractant traps for invasive Burmese pythons (*Python molurus bivittatus*) in southern Florida. Wildlife Research 38:114-121.

Reed RN, Rodda GH. 2009. Giant constrictors: biological and management profiles and an establishment risk assessment for nine large species of pythons, anacondas, and the boa constrictor. US Geological Survey. Report nr 2331-1258. 302 pp.

Ribeiro-Júnior MA, Rossi RV, Miranda CL, Ávila-Pires TC. 2011. Influence of pitfall trap size and design on herpetofauna and small mammal studies in a Neotropical Forest. Zoologia (Curitiba) 28:80-91.

Ribi WA. 1981. The phenomenon of eye glow. Endeavour 5:2-8.

Richmond JQ, Wood DA, Stanford JW, Fisher RN. 2015. Testing for multiple invasion routes and source populations for the invasive brown treesnake (Boiga irregularis) on Guam: implications for pest management. Biological Invasions 17:337-349.

Rodda G, Sawai Y, Chiszar D, Tanaka H. 1999a. Problem snake management: The Habu and the Brown Tree Snake: Comstock Publication Associates, Cornell University Press. Ithaca, NY.

Rodda GH, Fritts TH, Clark CS, Gotte SW, Chiszar D. 1999b. A state-of-the-art trap for the brown treesnake. In: Rodda GH, Sawai Y, Chiszar D, Tanaka H, editors. Problem snake management: the habu and the brown treesnake.Cornell University Press. Ithaca, New York, USA. pp 268-305

Rodda GH, Savidge JA, Tyrrell CL, Christy MT, Ellingson AR. 2007. Size bias in visual searches and trapping of brown treesnakes on Guam. The Journal of Wildlife Management 71:656-661.

Rovero F, Zimmermann F, Berzi D, Meek P. 2013. " Which camera trap type and how many do I need?" A review of camera features and study designs for a range of wildlife research applications. Hystrix, the Italian Journal of Mammalogy 24:148-156.

Savarie PJ, Shivik JA, White GC, Hurley JC, Clark L. 2001. Use of acetaminophen for large-scale control of brown treesnakes. USDA National Wildlife Research Center - Staff Publications Paper 580:1-11.

Savidge JA, Stanford JW, Reed RN, Haddock GR, Adams AAY. 2011. Canine detection of free-ranging brown treesnakes on Guam. New Zealand journal of ecology 35:174-181.

Schuett GW, Höggren M, Douglas ME, Greene HW. 2002. Biology of the vipers: Eagle Mountain Publishing. Eagle Mountain, UT.

Schumacher J, Jacobson ER, Homer BL, Gaskin JM. 1994. Inclusion body disease in boid snakes. Journal of Zoo and Wildlife Medicine 25:511-524.

Shea GM, Shine R, Covacevich JC. 1993. Family Elapidae. In: Glasby C, Ross G, Beesley P, editors. Fauna of Australia: Volume 2A Amphibia and Reptilia.Australian Government Publishing Service. Canberra, ACT. pp 439.

Shiroma H, Akamine H. 1999. Complete removal of habu (*Trimeresurus flavoviridis*) from a residential area by trapping. In: Rodda GH, Sawai Y, Chiszar D, Tanaka H, editors. Problem Snake Management: Habu and Brown Treesnake.Comstock Publication Associates, Cornell University Press. Ithaca, NY. pp 327-339.

Shiroma H, Ukuta H. 1999. Training a dog to detect Habu (*Trimeresurus flavoviridis*) In: Rodda G, Sawai Y, Chiszar D, Tanaka H, editors. Problem snake management: The

Habu and the Brown Tree Snake.Comstock Publication Associates, Cornell University Press. Ithaca, NY. pp 348-352.

Smith RB, Tuberville TD, Chambers AL, Herpich KM, Berish JE. 2005. Gopher tortoise burrow surveys: external characteristics, burrow cameras, and truth. Applied Herpetology 2:161-170.

Somaweera R, Somaweera N, Shine R. 2010. Frogs under friendly fire: how accurately can the general public recognize invasive species? Biological Conservation 143:1477-1484.

Stanford JW, Rodda GH. 2007. The brown treesnake rapid response team. In: Witmer G, Pitt W, Fagerstone K, editors. Managing vertebrate invasive species: Proceedings of an international symposium.USDA-APHIS Wildlife Services, National Wildlife Research Center. Fort Collins, CO. pp 175-217.

Stevenson DJ, Ravenscroft KR, Zappalorti RT, Ravenscroft MD, Weigley SW, Jenkins CL. 2010. Using a wildlife detector dog for locating eastern indigo snakes (*Drymarchon couperi*). Herpetological Review 41:437-442.

Swann DE, Hass CC, Dalton DC, Wolf SA. 2004. Infrared-triggered cameras for detecting wildlife: an evaluation and review. Wildlife Society Bulletin 32:357-365.

Taylor D, Katahira L. 1988. Radio telemetry as an aid in eradicating remnant feral goats. Wildlife Society Bulletin 16:297-299.

Tonge S. 1986. Collecting the Mallorcan midwife toad. Oryx 20:74-78.

Tyrrell CL, Christy MT, Rodda GH, Yackel Adams AA, Ellingson AR, Savidge JA, Dean-Bradley K, Bischof R. 2009. Evaluation of trap capture in a geographically closed population of brown treesnakes on Guam. Journal of Applied Ecology 46:128-135.

USGS, (United States Geological Survey). 2005. FORT identifies cargo stowaway as invasive brown treesnake.United States Geological Survey. Fort Collins, CO. https://www.fort.usgs.gov/news/fort-identifies-cargo-stowaway-invasive-brown-treesnake.

Vice DS, Engeman RM, Vice DL. 2005. A comparison of three trap designs for capturing brown treesnakes on Guam. Wildlife Research 32:355-359.

Vice DS, Pitzler ME. 2002. Brown treesnake control: Economy of scales. In: Clark L, Hone J, Shivik J, Watkins R, Vercauteren K, Yoder J, editors. Human conflicts with wildlife: Economic considerations.Proceedings, Third National Wildlife Research Center Special Symposium, National Wildlife Research Center. Fort Collin, CO. pp 127-131.

Vogt RC, Hine RL. 1982. Evaluation of techniques for assessment of amphibian and reptile populations in Wisconsin. Herpetological communities 13:201-217.

Walczak J. 1991. A technique for the safe restraint of venomous snakes. Herpetological Review 22:17-18.

Wasko DK, Sasa M. 2009. Activity patterns of a neotropical ambush predator: spatial ecology of the Fer-de-lance (*Bothrops asper*, Serpentes: Viperidae) in Costa Rica. Biotropica 41:241-249.

Wasko DK, Sasa M. 2012. Food resources influence spatial ecology, habitat selection, and foraging behavior in an ambush-hunting snake (Viperidae: *Bothrops asper*): an experimental study. Zoology 115:179-187.

Welbourne D. 2013. A method for surveying diurnal terrestrial reptiles with passive infrared automatically triggered cameras. Herpetological Review 44:247.

Wilson D, Heinsohn R, Legge S. 2006. Age-and sex-related differences in the spatial ecology of a dichromatic tropical python (*Morelia viridis*). Austral Ecology 31:577-587.

Wisniewski S. 2012a. Pre-incursion Plan PIP005 Pythons and Boas Department of Primary Industries, Biosecurity Victoria, Invasive Plants and Animals. Melbourne, Vic. 28 pp.

Wisniewski S. 2012b. Pre-incursion Plan PIP010 Vipers Department of Primary Industries, Biosecurity Victoria, Invasive Plants and Animals. Melbourne, Vic. 25 pp.

PESTSMART

www.pestsmart.org.au