

# Coordinating invasive alien species management in a biodiversity hotspot: The CAPE Invasive Alien Animals Working Group

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**Background:** The effectiveness of invasive alien species management in South Africa, and elsewhere, can be improved by ensuring there are strong links and feedbacks between science and management. The CAPE Invasive Alien Animals Working Group (CAPE IAAWG) was established in 2008 to enhance co-operation among stakeholders such as implementing agencies and researchers, and thereby improve the management of invasive animals in the Greater Cape Floristic Region.

**Objectives:** In this article we highlight where and how the working group has advanced our understanding of research and the implementation of management objectives and consider the working group's successes and failures.

**Methods:** We analyse the attendance of meetings by different stakeholders and the frequency of discussion topics on meeting agendas throughout the sequence of meetings from 2008 to 2019. We document insights based on published accounts or the experiences of the authors from eight different management projects.

**Results:** Meetings are attended by stakeholders from NGOs, universities, and local, provincial and national government agencies as well as private individuals. Topics of discussion ranged from details of specific alien animal invasions (e.g. the House Crow in Cape Town), to considering the risks posed by broad groups (e.g. earthworms), to specific management techniques (e.g. guidelines for trapping invasive alien birds). Through the eight projects described here the CAPE IAAWG has: (i) contributed to capacity building through funding and advising on post-graduate research projects; (ii) provided ad hoc support to staff of agencies that implement invasive alien animal control; (iii) acted as a focal point for a community of practice that is supportive of decision making and policy development; and (iv) played a vital role in linking research, management and policy in a manner accessible to a broader range of stakeholders. The projects undertaken by the group reveal several lessons for managing invasive animals: (i) the importance of logistics and contract efficiency, (ii) the need for effective stakeholder engagement by the project team, (iii) the need to effectively address conflicts between role players, and (iv) the importance of including ethical and animal rights considerations in the decision making processes.

**Conclusion:** The CAPE IAAWG has been a valuable forum to improve management effectiveness and support implementation decisions. Due to its small cost and time footprint, the

working group has remained viable and retained a core of committed members, ensuring ongoing institutional buy-in. The working group will remain successful so long as the group is supported by its members and their organisations.

**Keywords:** Status reporting; invasive alien species management; invasive alien species control; community of practice.

## Introduction

The gaps between scientific research, development of policy and implementation of management measures are often significant, and can negatively affect conservation outcomes (Knight et al. 2008; Catalano et al. 2019). This issue has been analysed specifically in terms of how society responds to biological invasions (Esler et al. 2010; Foxcroft et al. 2020). Weak links and feedback loops between research and implementation are a major factor reducing the effectiveness of invasive alien species management in South Africa (van Wilgen & Wilson 2018). Various mechanisms and frameworks have been proposed to strengthen such links [also termed 'translational ecology' (Schlesinger 2010; Enquist et al. 2017)]. Different approaches to linking research, policy and implementation have several features in common; of particular interest in this work is the need to ensure that stakeholders are engaged and work together to co-produce knowledge that is meaningful and accessible to a broad range of stakeholders.

One approach to achieve the co-production of knowledge is to establish multi-stakeholder working groups that deal with specific or cross-cutting issues – these become communities of practice in which different role players interact intentionally to produce integrated environmental solutions that take ecological, social and political contexts into account. However, there is a consistent knowing–doing gap regarding such working groups (Esler et al. 2010; Foxcroft et al. 2020), and reducing this disjunction requires the analysis and documentation of the structure, functioning and outputs of existing groups to provide insights and ensure the continuation of working knowledge and communities of practice.

In this article, we provide a case study of the formation and continuation through more than ten years of a working group established to provide science- and evidence-based decision making support to the management of invasive alien animals in the Cape region. Specifically, we review the history of the Cape Action for People and the Environment Invasive Alien Animals Working Group (hereafter CAPE IAAWG or the working group), and consider its successes and failures. We outline a number of projects tackled by the working

group, the key decisions made and the progress of each project to date, with the goal of highlighting where and how the working group has advanced our understanding of research and the implementation of management objectives.

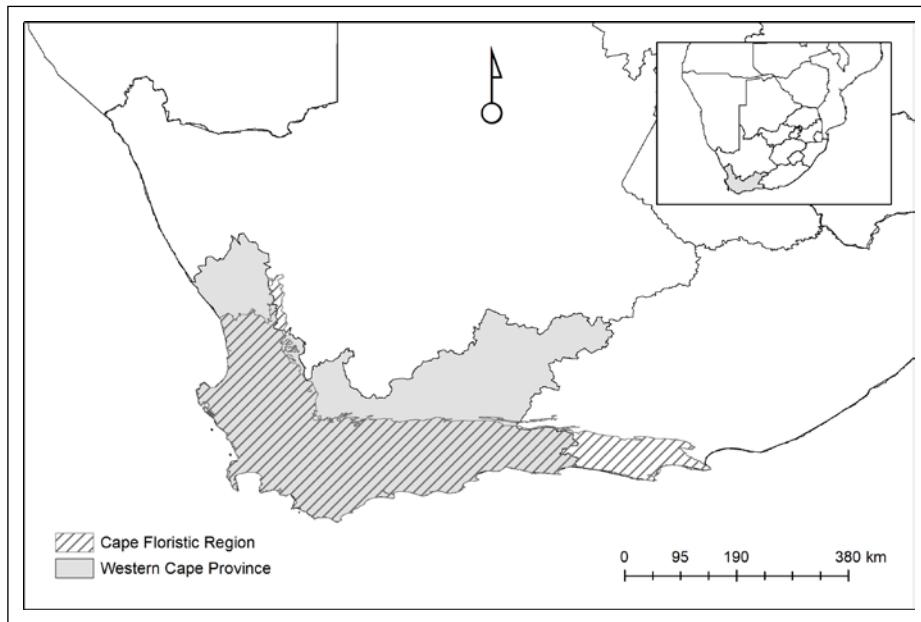
Since its establishment in 2008, the members of the working group have engaged in collective identification of priority invasive animal species in the Greater Cape Floristic Region (GCFR), devised species-specific strategies for managing populations, and provided a platform for collaborative management. By integrating new and existing research findings, the working group has advanced its understanding of invasive alien species management through applied research and adaptive management and the sharing of these lessons with the working group. We argue that the working group model has been successful in facilitating work on invasive alien animals in the GCFR, and aim to document not only project successes, but also challenges and failures that provide direction for future alien animal control projects.

## Methods of analysis

The authors analysed the agendas and minutes of all meetings of the working group since 2008. Attendees of meetings were classified by their host organisations, and organisations were clustered into sectors (local, provincial or national government agencies, non-government organisations (NGOs), private sector (e.g. a consultancy company) or research (e.g. university or research council). We used content analysis to analyse the frequency of discussion of taxonomic and selected other topics at full working group meetings and sub-group meetings. All analyses were conducted in R (R Core Team 2018) and plots produced using the *tidyverse* and *ggplot* packages (Wickham et al. 2019). Insights from management projects were based on published accounts or the experiences of the authors.

## Background to the working group

The Greater Cape Floristic Region (GCFR) (Born et al. 2007) is a region of extraordinary floral diversity and endemism defined broadly by the winter rainfall areas of the southwestern Cape, which mostly overlaps with the Western Cape Province, South Africa (Figure 1). High levels of endemism are also present in several faunal groups [e.g. aquatic invertebrates (Colville et al. 2014)], making much of this region a UNESCO Natural World Heritage Site (<https://whc.unesco.org/en/list/1007>). Communities of practice have been



**Figure 1.** Boundaries of the Greater Cape Floristic Region, in which the CAPE Invasive Alien Animals Working Group functions.

integral to the conservation of the GCFR for over 40 years (Gelderblom & Wood 2018). Starting in 2000, the Cape Action Plan for the Environment (CAPE, later renamed Cape Action for People and the Environment) produced a 20-year plan to conserve the biomes of the GCFR. The planning process involved more than 100 organisations and individuals who worked together to draft a plan to ensure the conservation of the ecosystems of the Cape Floristic Region by integrating and coordinating the management of the landscapes and biodiversity in the long term. Since 2000, the CAPE plan has provided context, justification, funding and material resources for many conservation actions in the region. One of the major aims has been to integrate the work of organisations involved in conservation and biodiversity research in the GCFR and management of the GCFR, ensuring that they do not duplicate each other's work. In this paper, we argue that the CAPE IAAWG is a good example of the kind of impact the programme has had, and provides lessons of local, regional and international relevance.

In 2003, the Global Environment Facility (GEF) approved a grant to CAPE to develop a strategy for invasive alien species management in the GCFR. The strategy was developed under the auspices of CapeNature, by the CAPE Invasive Alien Species Task Team leader employed at CapeNature, who then joined the City of Cape Town in 2007 and continued to coordinate the development of the strategy. The overall goals of the strategy were to: (i) conserve ecosystems through collaborative efforts in combating the damaging impacts of invasive alien species in the region; (ii) develop early detection and rapid response capability; and (iii) increase awareness and understanding, by organisations and the public of the potential negative impacts of invasive organisms (see Appendix 1 for details). The CAPE

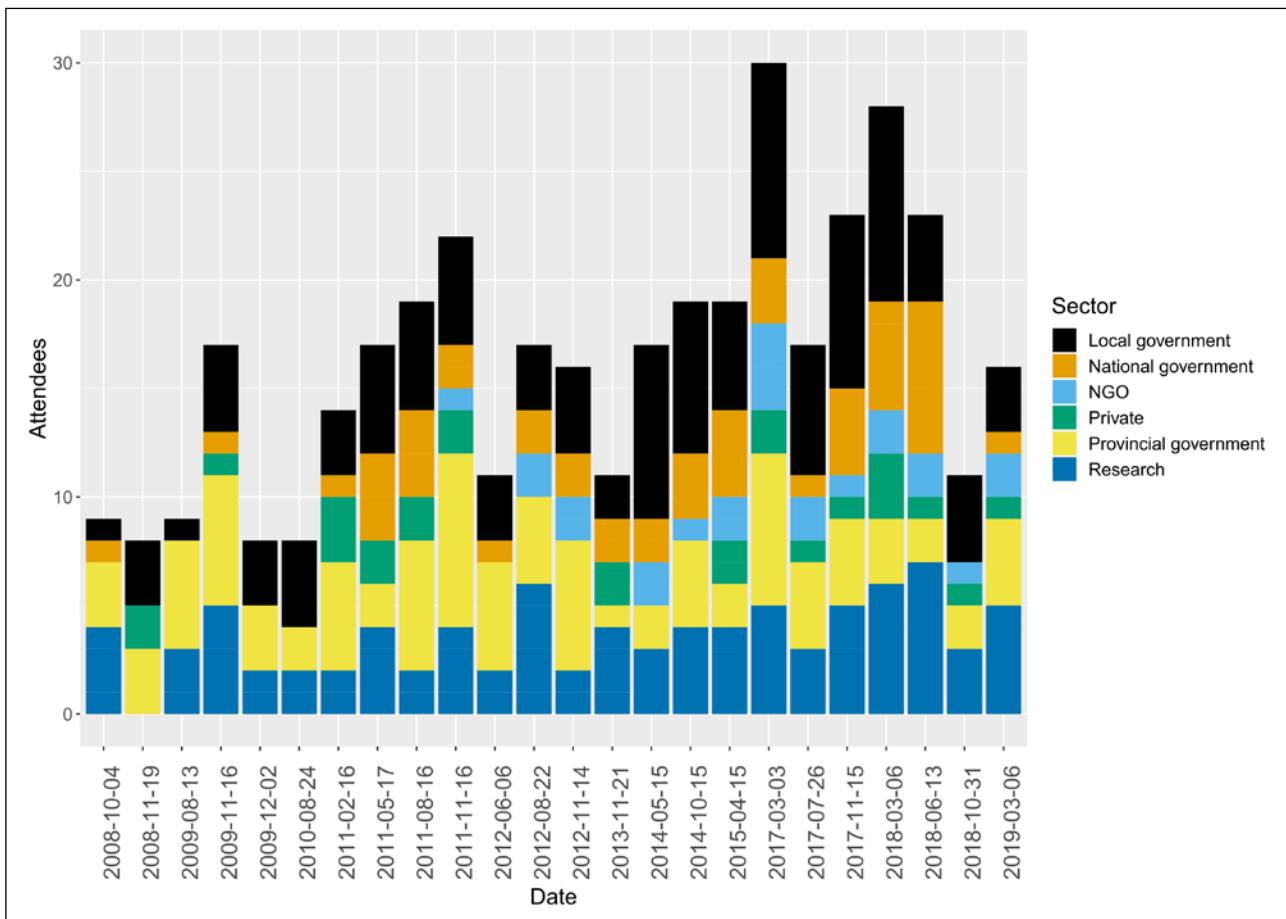
Invasive Alien Species Strategy was finalised in 2008 with the vision that 'by 2020, the GCFR's economic, environmental and social assets are secure from the negative impacts of invasive alien species'.

The CAPE IAAWG was established by the CAPE Invasive Alien Species Task Team leader early in 2008. The group meets two to four times a year on average (Figure 2) for approximately four hours. In parallel, the CAPE Invasive Alien Plants Working Group was established (also in 2008), but that forum was dissolved after a few years due to overlap with other fora such as the Department of Environmental Affairs Working for Water Programme implementation fora. In contrast, the CAPE IAAWG brought together a range of animal taxon experts and institutions that did not otherwise interact closely and were enthusiastic about the potential for collaboration. The working group rapidly developed a novel and productive way of working, and the participants put in considerable effort to maintain their involvement (Adelle 2019).

The working group does not replace or duplicate activities under existing institutional arrangements or mandates, but is intended to address coordination of knowledge sharing; research, monitoring and evaluation; awareness, institutional arrangements and capacity-building; prevention, early detection and rapid response; policy and best practice (Appendix 2).

## Composition

The CAPE IAAWG is composed of representatives of (i) national, provincial and local government agencies that have mandates related to invasive alien species control and management; (ii) private sector consultancies that take on contracts for invasive alien species control and management; (iii) tertiary education institutions and



**Figure 2.** Time-line and turnover of sector participants in the CAPE Invasive Alien Animals Working Group. Since 2008 there have been 24 meetings, with between one and four meetings a year except for a hiatus in 2016. The number of participants has fluctuated between 8 and 30 people per meeting, and includes 102 unique individuals over time. The relative representation from six main sectors is shown here.

science councils that conduct research on alien and invasive animals; and (iv) NGOs with a regulatory or advocacy interest in alien and invasive animals (Figure 2; Appendix 3). The individual members have a diversity of roles in their home organisations, including local authority and provincial officials, national parks staff and environmental ministry officials, nature conservation scientists, university academic staff, post-doctoral researchers, post-graduate students, NGO staff, animal welfare officers and private consultants. The working group has a core of organisational representatives (Figure 2; Appendix 3) and other members are co-opted as and when required to represent specific interests or provide input on a particular subject or taxon. Therefore, the structure at a particular time reflects the workflow of specific projects and any issues being addressed by the working group. However, this structure also ensures a high level of continuity, with the group developing a common understanding and shared experience. The co-option of additional participants means that the core of member organisations and individuals has grown substantially over the years due to strong interest in the work of the group and the increase in number and complexity of the projects addressed by the group

(Figures 2, 3). Permanent members sign the TOR on behalf of their organisations, which commit to implementing the recommendations of the CAPE IAAWG (Appendix 2). In turn, members are responsible for disseminating information from the working group to their structures or stakeholders.

The working group is formally located within the CAPE Programme, and its links to that programme are maintained through the co-chairperson of the working group who is employed by City of Cape Town and is a member of CAPE's Executive Committee. This linkage through the co-chair position ensures that the work of the group is integrated with other activities in the CAPE conservation programme. The CAPE IAAWG was originally chaired by the City of Cape Town Invasive Species Coordinator, but since 2017 it has been chaired jointly by senior staff at CapeNature and City of Cape Town's Biodiversity Management branch. The secretariat is supported by the City of Cape Town. This means that two of the largest implementers of invasive animal control projects in the GCFR have a shared official role in the working group.

Membership of the working group spans the Western and Eastern Cape provinces of South Africa, as both are host to significant areas of the GCFR (a small portion also enters the Northern Cape, but there have been no representatives from that province).

Expert sub-groups, such as the Guttural Toad Working Group, were formed when members felt it necessary to discuss issues in more depth than the broader group would be interested in or have time for, in particular to address particular problems or technical issues on a particular invasive alien species management project. These sub-groups meet separately when necessary and report back to the working group on their discussion and decisions.

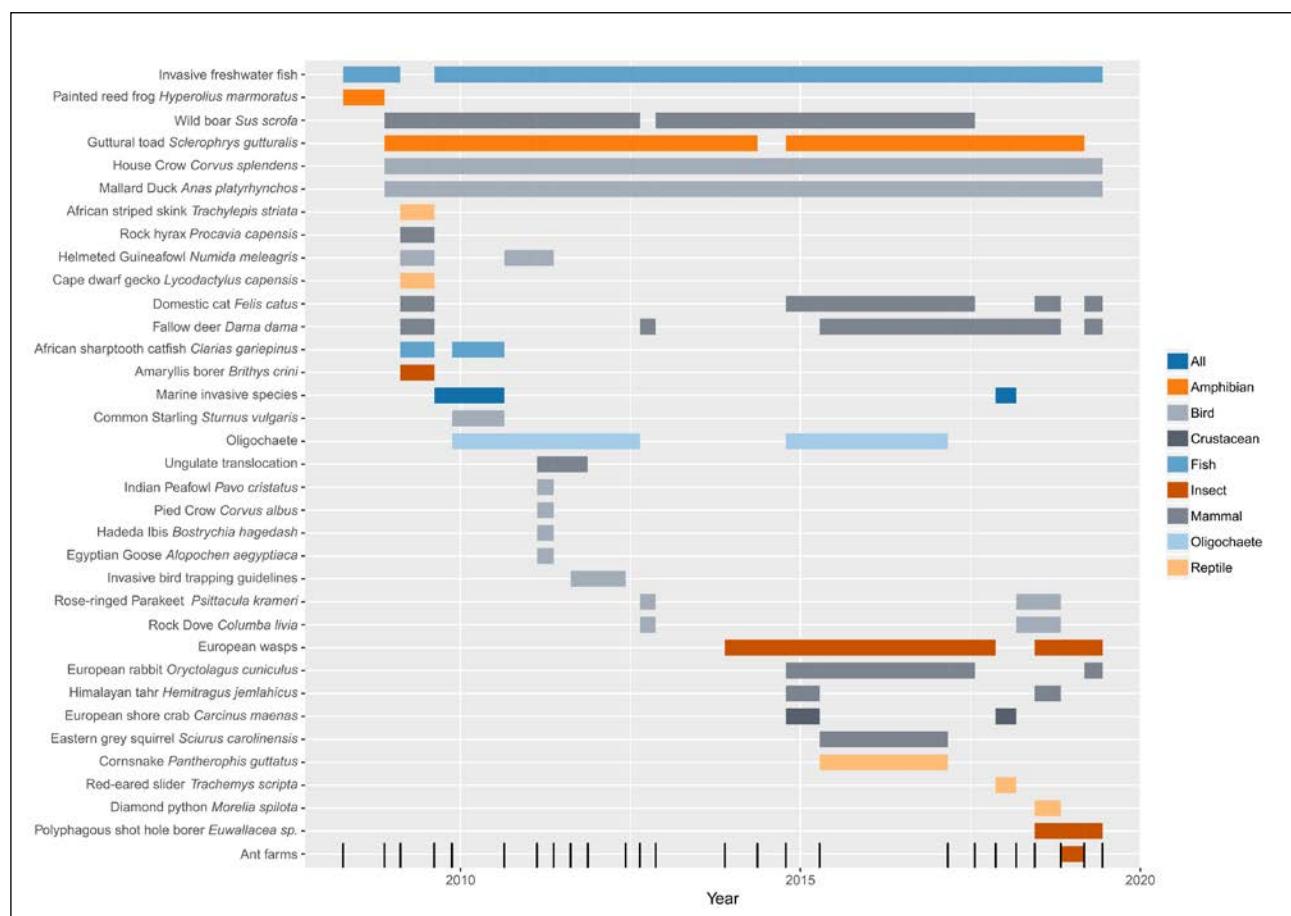
## Funding

The working group requires limited funding for its activities, as partner organisations cover the personnel and meeting costs. Although this has not been quantified, the continuity and regular attendance of the CAPE IAAWG indicates that member organisations experience benefits of participation (e.g. knowledge sharing, advice and information on best practice) that offset the costs

of participation. The costs of the projects discussed at CAPE IAAWG meetings are, however, often substantial (Table 1). These projects have generally been funded by the South African government through its Department of Environment, Forestry and Fisheries (DEFF; formerly the Department of Environmental Affairs).

## Links to legislation

When the CAPE IAAWG was inaugurated, there was no legislative framework that dealt with specific invasive alien animals and their control. Control projects carried out at the time were based on general commitments in high-level documents regarding a duty of care and the need to protect the environment for future generations (National Environmental Management Act, 1998 and the Constitution of South Africa, 1996); the legislative requirement to manage biological invasions (National Environmental Management: Biodiversity Act (NEM: BA), 2004; and provincial conservation ordinances). The need to actively control specific invasive animals was codified with the promulgation of the NEM: BA Alien & Invasive Species Regulations, 2014 and the accompanying Alien and Invasive Species Lists, which provide explicit requirements to control listed invasive



**Figure 3.** Taxa and topics discussed over time at the CAPE Invasive Alien Animals Working Group meetings. The bars span the period over which a species appeared on the agenda for discussion. Ticks on the X-axis represent the dates that meetings took place.

**Table 1.** The status of invasive alien management projects in the Greater Cape Floristic Region, where input was made by the CAPE IAAWG. Column names are based on the names used in the second national status report on biological invasions (Zengetya & Wilson in press) as per the indicators developed by Wilson et al. (2018), and where possible and indicated in alignment with the Darwin Core list of terms (Groom et al. 2019). The values are from the case studies or from the National Status Report on Biological Invasions (van Wilgen & Wilson 2018).

Taxon (dwc:vernacularName)	Native range	Introduction and pathways (pathway)	Status <sup>1</sup> (dwc:degreeOf Establishment)	Extent (RangeFreeText)	Abundance (dwc:organism Quantity and dwc:organism Quantity/Type)	Impact <sup>2</sup> (Impact EI/CAT or Impact SEI/CAT/Global)	Money spent <sup>3</sup>	Treatment and effectiveness	Role of CAPE IAAWG	Legislative category and management goal	Key references
House Crow ( <i>Corvus splendens</i> )	Indian sub-continent	Probably as stowaways on ships, in Durban 1972, Cape Town 1979 (TransportStowaway: HitchhikersOnShip Boat)	Naturalised (C3)	Localised; several suburbs within the City boundary	High of 10 000 but down to ~310 by October 2018	Aggressive to people native biota, damage crops, spread disease. Scored as MO globally	ZAR 8 500 000	Multiple, focus on chemical baiting and trapping, but House Crows can learn quickly. Different approaches will be needed at low densities	Review of methods and project progress. Support with ethical clearance	Category 1a. Nation-wide eradication	Oatley 1973; Berruti 1997
Cultural toad ( <i>Sclerophryns gutturalis</i> )	Eastern Africa from Ethiopia to Eastern Cape, South Africa	First noted 2000 possibly deliberately as a pet. (Escape:Pet)	Invasive in a restricted area (D2), though native to wetter regions with summer rainfall	Largely confined to one suburb of Cape Town	Numbers of adults likely to be in the 10 000s	Scored MO in Western Indian Islands due to predation	ZAR 1 800 000	Spread slowed, population numbers reduced.	Review project methods and project progress. Support with historical data. Initiated control operations. Formulated research project (PhD thesis) to inform control strategies	Listed as <i>Amietophryne gutturalis</i> (now <i>Sclerophryns gutturalis</i> ) as Category 1b in Western Cape, not listed elsewhere. Containment	Measey et al. 2017; Telford et al. 2019
Mallard Duck ( <i>Anas platyrhynchos</i> )	North America and Eurasia	1940s possibly as a pet or for food. (Escape:Agriculture  Escape:Pet)	Invasive (E)	All provinces in SA; largely in human modified landscapes including peri-urban and agricultural areas	Population highly mobile into Fynbos Biome from other regions of South Africa. Resident population likely to be low 1000s	Hybridisation with native species (globally MR)	ZAR 1 024 000	Effective step-wise methodology though conflicts with local people who feed the ducks (see text)	Recommendations on effective and ethical methods; a research Masters thesis addressed the evidence of hybridisation for the programme	Category 2. A Mallard Strategy for South Africa was drafted. Local extirpation	Stafford 2010, Stephens et al. 2020; SANBI unpublished
Feral pig <sup>5</sup> ( <i>Sus scrofa</i> )	Eurasia	1920s–1930s for forestry pest control (Release:Biological Control)	Invasive (E)	Unknown but particular foci in Swartland/ Boland.	Unknown but likely to in 100s.	Many recorded impacts, including predation on the Critically Endangered geometric tortoise <i>Psammobates geometricus</i> .	Unknown	Hunting and trapping. Effective for control. Local eradication requires sustained effort	Evaluation of progress. Discussion of new methods of control	Category 1b, not listed when not feral. Prioritise spread into protected areas and threatened species habitat.	Skead et al. 2011; Hofmeyr & Baard 2018
Invasive freshwater fishes <sup>5</sup>	Mostly North America	Many – see Weyl et al. 2020	20 species established (Weyl et al. 2014), of which 15 species are invasive (excludes translocated species)	All large river systems are invaded by multiple species.	Depends on inland water, but generally invasive fishes dominate ichthyofauna assemblies in invaded systems	Predation, competition and habitat degradation (carp <i>Cyprinus carpio</i> )	ZAR 3 000 000 for Rondegeat project	Rotenone used successfully in discrete areas where natural dispersal of invader species can be controlled due to barriers. Manual control where feasible and cost effective	Discussion of methods and priority areas. Continuous reporting on progress	Various	Impson et al. 2013; Weyl et al. 2014, Ellender et al. 2017

Taxon (dwc:vernacularName)	Native range	Introduction and pathways (pathway)	Status <sup>1</sup> (dwc:degreeOfEstablishment)	Extent (RangeFreeText)	Abundance (dwc:organismQuantity and dwc:organismQuantityType)	Impact <sup>2</sup> (impact EI/CAT or impact SE/CAT/global)	Money spent <sup>3</sup>	Treatment and effectiveness	Role of CAPE IAAWG	Legislative category <sup>4</sup> and management goal	Key references
European shore crab ( <i>Carcinus maenas</i> )	Europe	Not known, possibly through fouling or ballast water discharge (TransportStowaway: ShipBoatHullFouling   TransportStowaway: ShipBoatBallastWater). First detected in 1983 in Table Bay Harbour	Invasive (E), though currently restricted to transformed harbours	Table Bay and Hout Bay harbour and, occasionally, in intertidal area of the Cape Peninsula	Management in Hout Bay Harbour close to 40 000 individuals. Given the populations in Cape Town Harbour is at least an order of magnitude greater, the total population may be close to a million	Significant impacts elsewhere in the world, but negligible in South Africa to date	~ZAR 1 000 000	Crabs were caught in baited traps, although this might miss smaller and breeding crabs. Control using divers, traps for small individuals, and larval traps were trialled but were either too expensive or ineffective	Advice and support in getting approval for the method of euthanasia. Support for disposal of carcasses. Feedback to management and recommendations	Category 1b	Mabin et al. 2017, 2020
European paper wasp ( <i>Polistes dominula</i> )	Europe, North Africa and temperate Asia as far east as China.	Unknown (in Cape Town since 2008)	Invasive (E)	Common throughout the City of Cape Town and the Boland	Unknown	Impacts on human health; other (e.g. biodiversity) impacts have not been established	ZAR 1 500 000 for both vespid species combined	Nest removal with pesticide fogging	Advice and support for teams; attempt to find other sources of support (e.g. Dept. of Health)	Category 1b	Benedé et al. 2014; Van Zyl et al. 2018
German wasp ( <i>Vespa germanica</i> )	Europe, North Africa and temperate Asia as far east as China	Unknown (in Cape Town since 1974)	Invasive (E)	Most commonly found in the Southern region of the City of Cape Town and in Stellenbosch, Paarl, Banhoek and Franschhoek	Unknown	Impacts on human health; other (e.g. biodiversity) impacts have not been established	ZAR 1 500 000 for both vespid species combined	Physical nest removal	Advice and support for teams; attempt to find other sources of support (e.g. Dept. of Health)	Category 1b	SANBI 2019
Earthworms	Various	Various, probably in contaminated soil, and perhaps as deliberate introductions for vericulture. (so B2–B3)	It is not clear if there has been significant spread beyond cultivated areas	Widespread in transformed or previously transformed sites	Not known	Alien earthworms have caused profound ecosystem level changes (e.g. to forest dynamics) in areas where earthworms were previously absent (e.g. post-glaciation or islands like New Zealand)	NA	Development of recommendations, support for research	None are listed. Research the risks and limit use in natural areas as a precaution	Plisko 2001; Plisko & Nxole et al. 2015; -lanion-Scheepers et al. 2016.	

<sup>1</sup>Status as per Blackburn et al. (2011).<sup>2</sup>Impact category is aligned to the IUCN's Environmental Impact Classification of Alien Taxa, Hawkins et al. (2015).<sup>3</sup>Money spent is in South African Rand (ZAR) based on 2018 values.<sup>4</sup>Legislative category is as per the NEM: BA &IS Regulations (Department of Environmental Affairs 2014, 2016).<sup>5</sup>Twenty species of invasive freshwater fishes established, with the most severe impacts caused by smallmouth bass (*Micropterus dolomieu*), spotted bass (*M. punctulatus*) and largemouth bass (*M. salmoides*) and rainbow trout (*Oncorhynchus mykiss*).

species. Category 1a and 1b species are prohibited from use and must be controlled [Category 1a species require compulsory control, which has been interpreted to mean that the goal is nation-wide eradication (Wilson et al. 2013)]; permits can be issued to use Category 2 species, although outside of the specified permits or conditions these are regarded as Category 1b; Category 3 species can be kept without the need for a permit under certain conditions, but further breeding is prohibited, and outside of captivity or cultivation they are also regarded as Category 1b. Proposed revisions to the regulations and lists were published in 2018 for public comment, but as of July 2020 these had not been promulgated, and so throughout this paper we focus on the lists and regulations as last amended in 2016.

## Overview of projects tackled

This section describes eight projects established under the auspices of CAPE IAAWG, identifying key decisions and factors affecting the success of the project. Further details of the projects undertaken are shown in Table 1.

### House Crows

A decision was made in 2003 to extirpate the expanding population in Cape Town, and a pilot project was initiated. The project soon stopped due to lack of funding, then restarted with a three-year grant from the United National Development Programme and then halted a second time due to concerns raised by the Society for the Prevention of Cruelty to Animals (SPCA) and the need to register the control agent DRC1339 (Starlicide) for use in South Africa (Yeld 2010). Two years of stakeholder engagement ensued before stakeholders could agree to attempt to extirpate the House Crows, and during this period (2009–2010) the population grew from an estimated 2 600 to 10 000 birds. However, the hiatus also proved to be a useful trial period for testing DRC1339 (Starlicide) and gathering the data necessary for the registration of this corvicide in South Africa. Support was also mobilised through media campaigns, petitions and complaints from residents in Nyanga, the high density residential area of Cape Town where House Crows were concentrated (see Measey et al. 2020). In 2011, the City Council approved ZAR200 000 to control House Crows and sent the project manager to Dar es Salaam, Tanzania for training on trapping techniques.

The ongoing campaign has significantly reduced the House Crow population with an estimated 310 crows remaining in October 2019. Implementation has cost over ZAR8 500 000, as the House Crows have proved

to be very difficult to control; a number of approaches (mass baiting at roosting sites, spot baiting at feeding areas, trapping in pre-selected areas) yielded initial success, followed by diminished returns as populations shrank and House Crows learned to avoid each control approach. Alternative methods such as nest removal, egg collection and shooting have not yet been used due to high costs and security risks in the areas where the House Crows are found. At a CAPE IAAWG meeting in 2018, the group decided that additional funds should be sourced to increase the effort to reduce the House Crow population and investigate new techniques such as egg collection, egg substitution and falconry. On this basis, the City of Cape Town applied for and was granted additional funds from the National Resource Management Programme (NRMP) of the DEFF.

### Guttural toads

The CAPE IAAWG was first made aware of the rapid expansion of the guttural toad population in Constantia, Cape Town, at a meeting in 2008. A mapping effort showed toads were present along a 3 km stretch of the suburban green belt in Constantia. The working group then made a decision to attempt eradication, in part as it was thought that guttural toads may pose a threat to indigenous Endangered western leopard toads (*Sclerophrys pantherina*) through competition or hybridisation (Measey et al. 2014, 2017, 2020). The eradication programme was coordinated by the City of Cape Town Invasive Species Unit. The first service provider was appointed by the City for the 2009/2010 breeding season, however, sustained control efforts only commenced in the 2011 breeding season. Initial efforts at awareness raising and control were met with both resistance and enthusiasm from residents who resented nightly calls as an invasion of privacy, or appreciated the help to remove noisy invaders, respectively (see Novoa et al. 2017). Access to residential properties was a major issue that required persistent efforts by service providers to win over property owners.

In 2014, the working group members initiated a post-graduate research project and various investigations in support of the guttural toad control project took place between 2014 and 2018. Population modelling by Vimercati et al. (2017a) showed that the extirpation of this population from Cape Town would require access to over 99% of residential properties. Between 2010 and 2019, guttural toad control teams in Cape Town were only able to access a fifth of the low-density residential properties located in Constantia and Bishopscourt (783 out of 3 935). At the time the toads were detected, there was no legal basis on which to access properties and remove toads if the owners were reluctant to allow or refused access. The NEM: BA Alien and Invasive Species Regulations of 2014 provides the legal basis to compel access to identified properties, but this

facility has not been used yet and legal precedent still needs to be established. In all cases due process will need to be followed before access can be obtained and this increases the difficulty for the service providers. Concern has been expressed that access to properties will continue to limit the guttural toad control programme. While the need to access private property has been problematic in several other control campaigns [notably Mallard Ducks, *Anas platyrhynchos*, and House Crows] it has not formed as significant a barrier to operations as found in the guttural toad project (Vimercati et al. 2017a). The CAPE IAAWG has recognised the need for ongoing communication with initial stakeholders if eradication programmes are to succeed in the future.

Another important finding of the guttural toad research was that, in modelled populations, the removal of eggs and tadpoles had minimal impact on population numbers, and that it was more effective to remove juvenile and adult toads (Vimercati et al. 2017b). Thus, as a result of the research, project personnel have stopped removing eggs and tadpoles and focussed their efforts entirely on removal of juveniles and adults.

On 13 June 2018, the CAPE IAAWG acknowledged that extirpation of this population is currently unlikely, given the restricted access to private properties and insufficient removal rates. The CAPE IAAWG took the view, however, that containing the invasive population (i.e. focussing on monitoring and control at the known edge of the population) was worthwhile. Control measures during the breeding season are ongoing with some 10 517 adult toads having been removed to date (2010–2019) from 783 properties. City of Cape Town is committed to either containing or extirpating this population and received ZAR1 800 000 from DEFF: NRMP for this purpose in 2019.

## Mallard Ducks

Mallard Ducks have been observed to mate with native Yellow-billed Ducks (*A. undulata*), and are considered a potential threat to the genetic integrity of this species (Dean 2000; Owen et al. 2006; Stafford 2010). The City of Cape Town and CapeNature for many years have recognised the importance of controlling Mallard Ducks. The Mallard Strategy for South Africa was drafted and a formal control campaign was started by the City of Cape Town following a decision at the CAPE IAAWG in November 2008. The campaign received a lot of public opposition from residents who enjoyed feeding the Mallard Ducks and considered them as pets. There was a lack of public awareness of the threat that Mallard Ducks pose to native birds (Stafford 2010) until the 'Save our indigenous water fowl' initiative was developed by the working group. This public education campaign shifted the focus of controlling Mallard Ducks to saving our indigenous duck species and

thereby increased public understanding of the project's aims. The control project has experienced several delays in control efforts as a result of funding delays due to supply chain issues; for example, attempts to appoint a particular consultant as a sole provider of a specialist service in which they are very experienced often challenges financial rules and leads to extensive delays in project continuity. These disruptions allow population numbers to increase, reducing the efficiency of the control project. To date over 474 birds have been removed, and an estimated 200 remain in the target areas of Cape Town. The finally agreed method used to remove Mallard Ducks from residential areas involves the following step-wise methodology:

- Systematically traversing the target water bodies by rowboat and surrounding open natural space on foot to count all Mallard Ducks observed.
- Mapping and recording densities and distribution of Mallard Ducks observed per location in and around the target water bodies and surrounding open natural space.
- Habituating the ducks through prior baiting with bread.
- Hand-feeding the ducks with bread dosed with a sedative (Alphachloralose).
- Collecting the ducks once they had been sufficiently sedated (O'Hare et al. 2007); and
- Taking the ducks to an offsite location for euthanasia by a veterinarian (American Veterinary Medical Association 2013).

This process is monitored by the SPCA to ensure ethical treatment.

Samples from these Mallard Ducks were used to examine the degree and direction of genetic introgression with Yellow-billed Ducks (Stephens et al. 2020), which was shown to be primarily from Yellow-billed Ducks into Mallard Ducks, but is likely to lead to a hybrid population that is able to disperse widely.

## Feral pigs

The potential control of the feral pig populations in the Western Cape was presented to CAPE IAAWG at its second meeting in November 2008 (Figure 3). Several populations of boars and hybrids between boars and feral domestic pigs are present in the province and those in the Kasteelberg and Porseleinberg districts of the Bokland region are of most concern since they overlap the distribution of the geometric tortoise. CapeNature, the provincial conservation authority, produced a Feral Pig Management Strategy in 2011 with funding from DEFF: NRMP. The strategy covered effective control measures, monitoring the effects of control, and prevention of

reintroduction, and presented a comprehensive communication strategy to raise awareness of the presence and negative impacts of feral pig populations. In 2014 feral pigs were listed as Category 1b invaders under NEM: BA.

Starting in 2014, CapeNature, with support and advice from the CAPE IAAWG, conducted a pilot trial of feral pig control by using baited traps and Judas pigs (collared sows that establish contact with and attract other pigs for trapping or hunting – McIlroy & Gifford 1997). This programme resulted in the removal of over 1 200 feral pigs from two populations in Kasteelberg and Porseleinberg, in addition to the feral pigs removed by land owners. The working group provided expert input and advice to the project manager during the planning and pilot project stages, and monitored project achievements during the operational phase. The oversight and involvement from the CAPE IAAWG resulted in additional funding being secured from DEFF: NRMP.

## Invasive freshwater fishes

South Africa is one of six global invasive fish hotspots (Leprieur et al. 2008) and invasive fishes are the greatest threat to the native fishes of the Cape Fold Aquatic Ecoregion of South Africa, a conservation hotspot for freshwater fishes in southern Africa (Tweddle et al. 2009; Ellender et al. 2017; Weyl et al. 2020). The invasive alien species with the most severe impacts have been predatory species, especially three black bass species [smallmouth bass (*Micropterus dolomieu*), spotted bass (*M. punctulatus*) and largemouth bass (*M. salmoides*) (Weyl et al. 2014)], and rainbow trout (*Oncorhynchus mykiss*) in several headwater streams (Shelton et al. 2015). All four are native to North America, were imported into the Western Cape for angling purposes and are popular with the recreational angling sector and, hence, of significant socio-economic value (Ellender et al. 2014; see Weyl et al. 2020).

The river rehabilitation project, with its Rondegat River pilot project, was discussed at the first meeting of the CAPE IAAWG in 2008, and thereafter remained on the agenda as the project developed into a programme and gained further momentum after the successful treatment of the Rondegat River with rotenone in 2012 and 2013 (Impson et al. 2013). The project was the subject of an environmental impact assessment in 2007/8 and during this phase there was considerable controversy regarding the control of invasive fishes and the use of rotenone (Marr et al. 2012) including a number of critical articles in magazines, newspapers and blogs. Most criticism came from fly fishermen targeting *O. mykiss*, as one of the other four priority rivers had this species.

The support of this project by the CAPE IAAWG has played a major role in allowing it to proceed and achieve its goals, which included removal of the

*M. dolomieu* from the treatment area followed by rapid recovery of the threatened native fish and aquatic invertebrate communities (Weyl et al. 2014; Bellingan et al. 2019). Due to the success of this initial project, CapeNature has since undertaken further invasive fish control projects and more are planned in the near future. The cost of the project, including co-funding and monitoring the ecological outcomes was estimated at ZAR3 300 000 (Impson et al. 2013). It is now considered a flagship restoration project in South Africa (Ellender et al. 2017; Zengeya & Wilson in press).

## Marine invasions, including European shore crabs

The European shore crab (*Carcinus maenas*) was first discussed at the CAPE IAAWG in October 2014. In June 2014, a pilot management programme targeting the crab was initiated in Hout Bay harbour. Management ran until July 2015 and then the population was monitored for a further six months. The population was not extirpated, as there were several logistical challenges experienced during management including a hiatus in control efforts due to work contracts and research permits lapsing during the intervention, and because a molecular study (Mabin et al. 2020) showed the size of the population to be much larger than initially expected.

By providing links both to animal welfare organisations and to facilities for the disposal of carcasses run by the City of Cape Town, the CAPE IAAWG supported the project. However, with the formation of a National Marine Alien and Invasive Species Working Group, it is anticipated that the CAPE IAAWG will not have a major role in marine projects in future other than to note that research and implementation are continuing, and provide advice and support as appropriate.

## Social wasps

The European paper wasp (*Polistes dominula*) and the German wasp (*Vespa germanica*) both have wide native distributions including Europe, North Africa and temperate Asia as far east as China. Records of *V. germanica* from Cape Town date back to 1974 when it was first recorded in the suburb of Newlands. Both wasp species were first discussed at a meeting of the CAPE IAAWG in May 2013, and thereafter both the City of Cape Town and Stellenbosch Municipality initiated a nest removal programme as a service to homeowners who were experiencing a problem with invasive wasps. By March 2019, a total of 12 375 *P. dominula* nests and 57 *V. germanica* nests had been removed. German wasps build nests in sites with more greenery, more readily available food and a more reliable water source, which are scarce within the urban boundaries. Thus, the bulk of German wasp removals have been in the

south of the City; nests removed from the central urban areas have been much smaller as the resources in the area cannot support large nests. European paper wasps are less selective with regard to nest sites and thousands of nests have been reported and removed from the City. European paper wasps therefore pose a significant threat to human safety and have affected agricultural production and tourism by making some areas unsafe for humans. The CAPE IAAWG decided in 2017 that as the wasps cause more of a problem to human health than to the natural environment they should be managed by the Department of Health, in the same way that vermin control is carried out in the City. However, despite efforts to contact Department of Health representatives, and suggestions of initiatives, no resolution has been reached, and the problem continues to be managed by the City of Cape Town's Environmental Management Department. The CAPE IAAWG has supported applications for funding to the Departments of Agricultural and Health of the Western Cape, though as yet most funding is still either ultimately from the DEFF: NRMP and private landowners.

Currently, it is not feasible to eradicate *P. dominula* or *V. germanica* unless breakthrough technology such as gene drive mechanisms (currently being investigated in New Zealand) are developed into a viable control technique (Lester & Beggs 2019). The working group has suggested that there is reason to continue monitoring both species on the fringes of their invasive distributions to prevent further spread into other urban and rural areas.

## Earthworms

Around 7.7% of global earthworm diversity is found in South Africa (Janion-Scheepers et al. 2016), but only alien species are used commercially in South Africa for waste recycling (i.e. vermi-composting), as bait for fishing, or for soil remediation. Several queries were raised with committee members as to the invasion risk posed by using alien earthworms for composting, particularly given the desire of many stakeholders to use worms as an 'environmentally acceptable' option for fertiliser production and waste disposal. The issue was discussed at consecutive meetings from late 2009 to 2012 and from 2015 to 2017, and a presentation was hosted on research on earthworms. The working group concluded that the spread of alien earthworms from vermi-composting is not currently a major concern in the GCFR as most of the earthworms that are used for vermi-composting thrive only in very wet, humic soils that are quite different from the nutrient poor, acid sands of the GCFR (except perhaps for the Afromontane Forest patches in some riverine areas). However, the working group noted that there is not enough information to adequately quantify the risk and recommended that, as a precautionary measure, alien earthworms should not be used

in protected areas in the GCFR until such time as there is clear evidence that the risks of invasions are acceptable.

The requests for information from the CAPE IAAWG provided impetus for ongoing research on earthworms in South Africa. An earthworm sub-group was set up as a result of discussions at the CAPE IAAWG and SERG (Soil Ecosystem Research Group: SERG; <http://sergsa.org/>), which led to the development of standardised sampling protocols (e.g. Nxele et al. 2015), and now forms part of a larger collaboration on soil health. Earthworms continue to be discussed by the working group from time to time.

## Other taxa

During the meetings of the CAPE IAAWG, many other taxa have been discussed (see Figure 3). Some discussions did not progress to action because the taxa were native (e.g. striped skink, *Trachylepis striata*), and/or had increased their ranges through anthropogenic habitat modification – see Essl et al. (2019) (e.g. Hadeda Ibis, *Bostrychia hagedash*, painted reed frog, *Hyperolius marmoratus* and Egyptian Goose, *Alopochen aegyptiaca*). Other discussions have not been followed up because the group decided that the benefit of control would be outweighed by opposition or a lack of support from the general public (e.g. Rock Dove, *Columba livia* and eastern grey squirrel, *Sciurus carolinensis*). Over time, changes in public opinion or the Regulations might mean there will be more support for control of such invasive animals in future. In future, novel techniques (like gene-drives) might change decisions by presenting inexpensive and effective management options. Based on the impacts that such species have, the CAPE IAAWG might then have a role to play (e.g. see Novoa et al. 2018).

## Discussion and learning points

### Logistical and contract difficulties

Local and provincial level implementing organisations (e.g. municipalities, provincial nature conservation agencies) have experienced challenges with implementing invasive alien species control projects due to limited funding availability and constraints due to funding cycles, as well as delays in procurement arising from internal supply chain management procedures. These issues have adversely affected the House Crow, guttural toad, invasive fishes and European shore crab projects (see above). Funds not being available at the beginning of the financial year when needed by the projects have, on several occasions, delayed control efforts. Flexibility

and understanding from the working group and contractors have often ensured that the projects do not lose impetus, but the solution to such issues is essentially outside the scope of the working group. This situation is not unique to South Africa: Dana et al. (2019) analysed the factors that contributed to unsuccessful control operations conducted in Andalusia (southern Spain) from 2004 to 2018. The top factor determining project failure was the absence of funding at a crucial time for operational purposes, which occurred in 82% of cases analysed. Combined with other factors that frequently crop up in invasive species control operations (e.g. licencing of new control drugs), the unpredictability of funding renewals frequently leads to decreased operational efficiency. The question of whether funding is available at the time it is needed or whether contractors comply with supply chain management processes can halt the progress of a project during the onset of the breeding season when the animal is most detectable and demographically vulnerable. Clearly, a better alignment between the activities of the working group and relevant procurement policies is required. To give a specific example from the CAPE IAAWG projects, in 2011 and 2012, the lack of a signed contract or available funding at the beginning of the guttural toad breeding season between August and October, led to the loss of productive time (i.e. person days on the control operation), with concomitant feedbacks to operational efficiency. This could lead to the loss of skilled staff and to increased resources spent on training new operators and overall lengthened duration of the project.

Another area of concern is that the funding of projects is somewhat haphazard, more limited by bureaucratic processes than strategic prioritisation based on risk and impact. The National Invasive Alien Animals Forum was established in 2013 to assist DEFF with such issues. While the forum developed detailed recommendations for a funding allocation process (Jackson et al. 2015), these have not been implemented and the forum ceased activities in 2015.

## Stakeholder engagement

Stakeholder engagement is a very important issue in the management of invasive alien animals. The CAPE IAAWG has applied the latest research to communication campaigns, checking that the message is scientifically defensible. The working group benefitted from the appointment of a communications expert who regularly attended meetings to ensure that projects were effectively communicated to stakeholders, including the media. The working group attempts to identify all important stakeholders for each project and involve them to decide on project feasibility or improve the operations of the project. In this way, a representative sample of local stakeholders is consulted early in the process to assess issues of concern and information regarding the

history and nature of the particular biological invasion being investigated.

Stakeholder engagement is frequently perceived as too difficult to implement, too costly or too slow for management timeframes (Caceres-Escobar et al. 2019). However, systematic engagement processes have now been documented and have been employed with some success (Novoa et al. 2018). The initial phase of stakeholder identification does not replace the formal engagement process that occurs as part of most of the invasive species control projects. Formal engagement through focused meetings and invitations to participate in working group meetings has been exceptionally successful and has ensured that conflicts between stakeholders are resolved early on in the project life cycle. For example, regular participation of SPCA staff in the working group has improved project design and brought credibility to the programmes undertaken. Cape of Good Hope SPCA staff were present at the early Mallard Duck and House Crow control operations to ensure that the agreed upon procedures were implemented, and the ongoing interaction at working group meetings maintains an effective working relationship between the SPCA and the implementing agents.

## Conflict between stakeholders

Conflict between stakeholders is a theme that has recurred with many of the invasions, and while some conflicts are commonplace and predictable, they have often surprised the working group members in their diversity (Shackleton et al. 2020; Gaertner et al. 2016). For example, conflicts have occurred around control options for invasive freshwater fish (smallmouth bass, rainbow trout); ownership of carcasses that result from a control programme (feral pigs); rights to own invasive alien species as domestic stock or pets (Mallard Ducks, guttural toads); the right to stock, hunt and fish alien species on private land (invasive freshwater fish, feral pigs); and the environmental benefits of invasive alien species (e.g. alien earthworms).

## Input to regulations

The working group has not, to date, been formally involved in the identification and engagement of stakeholders, as such processes are the prerogative of individual organisations and projects. However, the working group offers a safe space to discuss issues and strategies, and by connecting multiple institutions it provides a route for communication in the initial stages of stakeholder engagement (Davies et al. 2020). We note that stakeholder engagement can shift not just opinions but the power of different stakeholders. In the case of the House Crow, it became clear through extension work that the crows were having significant negative impacts

on less affluent communities in Cape Town, and this fact was used to counter-balance arguments that control of House Crows was ethically unacceptable (cf. Figure 7.3 in Wilson et al. 2017).

The control of invasive alien animals can be highly controversial and emotive, to the extent that project workers are physically threatened both when carrying out their jobs and in their private lives. The CAPE IAAWG cannot, of course, resolve this, but does offer a space to learn from previous experiences in the region and globally as to how to limit conflicts arising and diffuse them as necessary.

## Ethics and animal rights

The control of animal species often relies on euthanising individual animals, although alternatives exist. For example, sterilisation and relocation can be an option, particularly for larger mammals. However, such options need to be weighed against the costs, and the difficulty and distress caused by trapping individuals, the cost of a veterinarian to conduct the procedure, and the subsequent logistical difficulty of relocating and rehabilitating animals in a way that ensures a continuing life of sufficient quality.

Many potentially effective campaigns have been hampered by concerns over ethical issues and the difficulty of reaching agreement on the correct method of euthanasia to be used. Appreciation that the health and welfare of individual animals are often compromised in the alien range raises the question whether these populations should be allowed to persist any longer. In the case of House Crows, ethical issues resulted in extensive delays (1–2 years) during which the population was exposed to the ongoing stresses of their novel environment, as well as the stress of the eventual control programme. In addition, the impacts of the crows on native birds via competition were extended in time. These two aspects demonstrate the increase in net harms (Fraser & MacRae 2011; Allen et al. 2019) attributable to project delays. Whether such debates can be reduced to an equation is a broad philosophical matter for society, but environmental management and conservation staff have to make hard decisions about how to act (or not act) to achieve environmental goals in the context of how different actions will affect both native and alien animals.

The representation of the national SPCA body on the CAPE IAAWG has significantly improved the appreciation of ethical methods that exist around the control of animals. The need to be alerted to these early on in the planning of any control operation is imperative, as is the rapid establishment of consensus on control options. When control methods e.g. drugs or pesticides that are not commonly used in the country are chosen, there can be considerable delay in registering

and obtaining them (e.g. Starlicide; tricaine methanesulfonate [TMS]). Such issues could be avoided by a nationally agreed document describing best practice on how to euthanise different categories of animals. Such documents exist in other countries, and could easily be adapted for South Africa by the national environmental authority (i.e. DEFF).

The CAPE IAAWG has, to date, not been directly involved in determining which species should be listed and regulated under the NEM: BA A&IS Regulations. It did, however, provide written comments to DEFF on the proposed 2018 changes to the regulations and lists, as it is important for the CAPE IAAWG to speak for the particular community of practice that it represents. As the process for developing recommendations for listing is becoming clearer and more transparent [in particular through the Alien Species Risk Analysis Review Panel and the development of a risk analysis framework (Kumschick et al. 2018, 2020)], the CAPE IAAWG will in future play a more direct role in providing scientific advice to underpin whether and how invasive alien animal species should be controlled. Risk analyses that provide supporting evidence for the listing of several species have been discussed by the working group after approval by the Alien Species Risk Analysis Review Panel (e.g. the Pacific oyster, *Crassostrea gigas*, and the Rose-ringed Parakeet, *Psittacula krameri*), and several risk analyses have been tabled at meetings before these were submitted and approved by the Alien Species Risk Analysis Review Panel (e.g. coypu, *Myocastor coypus*, Mallard Duck (SANBI, unpublished) and Red-vented Bulbul, *Pycnonotus cafer*). It is envisaged that such documents will in future be routinely tabled at CAPE IAAWG before recommendations are submitted to the decision making body (DEFF).

The CAPE IAAWG has also not, as yet, been substantially involved in the discussion of the implementation and enforcement of the Regulations. There is an opportunity for the CAPE IAAWG to assist in trying to find the appropriate balance between incentive-based and penalty-based approaches. The proposed White Paper on Biological Invasions in South Africa will hopefully provide an opportunity for the CAPE IAAWG to influence the vision of how the control of alien animal populations is conducted in the future (Lukey & Hall 2020).

## Success stories

The Mallard Strategy for South Africa was formulated by the working group's founder in 2008 and was subsequently adopted by Birdlife SA. Today this strategy guides the Mallard Duck project in the City of Cape Town and lays the foundation for similar projects as prescribed by national legislation (Mallard Ducks are listed as Category 2 in NEM: BA, though cf. SANBI unpublished).

The successful implementation of the Invasive Fish Project, including scientific credibility through a range of peer reviewed publications, culminated in two Water Research Commission reports that provided national guidelines for monitoring such projects and their ecological outcomes (Weyl et al. 2014; Marr et al. 2019).

The working group's discussions and interactions with stakeholders resulted in increased funding for invasive animal projects through the Natural Resources Management Programme of the DEFF (formerly Working for Water of the former Department of Environmental Affairs). To date four projects have been funded by DEFF: NRMP.

The working group was approached by the Wildlife and Environment Society of South Africa in 2009 to assist with a policy on earthworm cultivation using alien earthworms. In view of the scarcity of information on earthworm taxonomy and distributions in South Africa, the popularity of earthworm cultivation for compost, and accidental introductions through trade in soil and soil products, the group took a precautionary approach and declined to provide support to this enterprise. These discussions led to: (i) group members conducting an intensive sampling and mapping project of earthworm distributions in the Western Cape and KwaZulu-Natal; (ii) the formation of the Soil Ecosystem Research Group, a distributed network of South African researchers working on soil ecosystem and health; and (iii) the commissioning of a post-graduate research project on the threats, opportunities, costs and benefits of earthworm cultivation in South Africa. Unfortunately most of the research questions remain unanswered, and there is still a pressing need for foundational work to be conducted on alien earthworms in South Africa.

## A vibrant, productive community of practice

It is important to note that many of the questions posed to the CAPE IAAWG needed to be answered through original research, for example by post-graduate students as part of their degree projects. In some cases the time taken to complete these projects is perceived as slowing down control operations, but it also ensures that the approaches that are finally used are fully tested and documented before they are implemented. This was a critical factor in the Invasive Fish Project, as the high output of scientific research projects confirmed that the Rondekat River rehabilitation project had been a conservation success, not a conservation disaster as some project critics feared it would be.

The diversity of perspectives in the working group provides those working in implementing agencies with the chance to solicit feedback on operational issues and discuss and consider bigger picture issues beyond

their day-to-day concerns. In some cases, the feedback from working group members confirms that decision makers were already making appropriate and valued decisions, which is a very important, though hard to measure, component of building an effective community of practice. Pivotal to this was the development of trust between group members, and how this led to respect of the pressures and challenges of their different roles, facilitated by the person-to-person meetings of the group.

For researchers in the working group, the discussions provide valuable material for identifying research projects and anchoring them in real-world needs and priorities. When students working on invasive alien animal projects attend CAPE IAAWG meetings in person, they receive input, feedback and suggestions on the applied aspects of their work, as well as exposure to real world issues and insight into policy and management. Students also realise the importance of practical issues that need to be considered when research results are implemented. Their perspective on their work is broadened to include issues that many researchers do not become aware of until much later in their careers. Three post-graduate student research projects [Mallard Duck hybridisation with the native Yellow-billed Duck in Cape Town (Stephens et al. 2020); spread and adaptations of the guttural toad in the Western Cape (Vimercati et al. 2017a; 2017b; 2018; 2019); and the feasibility of marine eradication in South Africa with European shore crabs as a case study (Mabin et al. 2015; 2017; 2020)] have arisen from the working group. These projects were supervised by working group members and the students participated in the working group for the duration of their projects.

According to Dana et al. (2019), unsuccessful invasive alien animal control projects showed five characteristics: (i) the absence of funding during the necessary time to achieve the goals; (ii) the risk of reinvasion; (iii) an insufficient removal rate to achieve the specific objective; (iv) the absence of evidence reporting that the methodology applied is effective; and (v) the lack of adaptation of methodology to the expected population changes. The activities of the CAPE IAAWG helped to mitigate items (iii), (iv) and (v), but items (i) and (ii) are more challenging and lie partly beyond its remit. Biosecurity personnel working at a provincial and national level are increasingly involved in the working group, and this will ultimately help to address new invasions and the risk of re-invasion. Funding levels remain a serious challenge, as do the procedures required to release funds continuously and/or at short notice.

## Support to implementers

The working group plays an important role in providing knowledge-based and logistical support to

implementing agents (CapeNature, City of Cape Town, SANParks). For example, several of the control projects mentioned above (e.g. guttural toad control) were undertaken by private consultants, who, though skilled, do not always have an in-depth knowledge of the species being tackled at the commencement of a project. Contact with researchers and students who work on the target species provides a network of contacts that the implementers can draw on through the project life cycle. In turn, the information gathered by implementers has been valuable for later research on the species, which in turn improved outcomes. The CAPE IAAWG has also been involved with prioritisation of work programmes, helping implementers to identify the best approaches. Having the backing of an evidence-base is invaluable to decision makers. Personnel who have worked on this suite of projects are piloting the new techniques for the control of invasive alien populations of House Crow, guttural toads and Mallard Ducks. The City of Cape Town is planning to appoint a permanent professional officer to manage the House Crow and other invasive animal species projects, such as the guttural toad and mallard projects. This step aims to ensure the long-term sustainability of project activities, including monitoring invasion pathways and detecting new invasions.

## Conclusion

The CAPE IAAWG has played a key role in facilitating the control of a variety of invasive alien animal species, and its members feel it has played a vital role in linking research, management, and policy in a manner accessible to both researchers and implementers. The CAPE IAAWG is not unique in South Africa, and there are a variety of working groups that link research, policy and management at national and regional levels (Davies et al. 2020). For example, the Marine Alien and Invasive Species Working Group, the KwaZulu-Natal Invasive Alien Species Forum, and the Eastern Cape Invasive Alien Species Forum have specific taxon or geographic mandates, and a variety of working groups focus on specific plant taxa such as invasive grasses, Australian trees and shrubs, and Cactaceae at national levels (Kaplan et al. 2017; Visser et al. 2017). The Fynbos Forum (Gelderblom & Wood 2018) is a GCFR community of practice with a much broader mandate that includes natural scientists, researchers, planners, land managers, landowners and stakeholders and 'meets annually to discuss the collaborative production of knowledge that underpins regional conservation efforts in the fynbos biome, South Africa' (<https://fynbosforum.org.za/>). Each working group is designed around its particular context and working arrangements.

While formal quantification of value of the CAPE IAAWG is presently difficult to achieve, several broadly applicable lessons are evident:

1. Funding delays can have serious and long-term consequences for projects that are time-bound; to some extent the delay between the decision to control and implementation of a project is normal as there are inevitable processes that need to be followed, e.g. to prepare funding applications, to register drugs or obtain ethical and public approval. However, excessive delays during implementation are often detrimental.
2. Stakeholder identification and engagement should be conducted as early as possible and should have a broad reach to ensure that projects are correctly designed and employ the most suitable methods. This is closely linked to point 1 because unnecessary delays during the project need to be avoided.
3. Ethical and animal welfare are important factors that should be taken seriously and collaboratively in the design phase of projects (see points 1 and 2 above).
4. Stability of working group membership both in terms of organisations and individuals is a key attribute of a successful working group. Each project needs successful drivers or champions that need support at difficult times. The model of a stable core with a larger rotating periphery, who participate as needed, has worked well for this working group.

A successful community of practice for inter-disciplinary work such as invasive species control and management must have benefits for all parties involved—government agencies, NGOs, university researchers and students. Specifically, this working group has played an important role in research becoming translational, in policy development and implementation and has improved the efficiency and effectiveness of invasive alien species control projects in the Cape Floral Region. If a working group is perceived as only serving or contributing to one institution's mandate it will quickly dissolve. Similarly, if there is substantial overlap with other working groups or forums, it will not be valued. The CAPE IAAWG fills an important gap between the generation and application of knowledge as shown by the continued participation and enthusiasm of members and support from their employer organisations to do so.

Based on the experiences as outlined in this paper, working groups like the CAPE IAAWG can help to lessen the gap between the production of science, the development of policy, and the implementation of adaptive management (learning and doing; Knight et al. 2008), and so have a vital positive impact on conservation outcomes. The accumulated insights will be useful for establishing, building, and maintaining more such communities of practice.

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## Competing interests

The authors declare no competing interests.

## Authors' contributions

All authors conceived the idea of the paper; all authors edited the manuscript and contributed to written sections; SJD wrote the article; NJVW, JM and SJD drew the figures.

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## Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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## Supplementary material

### Appendix 1: Goals and objectives of the CAPE invasive species strategy

<b>Goal 1:</b> Invasive Alien Species in the Greater CFR managed within appropriate policy and legislative frameworks.	<b>Objective:</b> Ensure that the management of invasive species in the Greater CFR is consistent with the relevant legislation.
<b>Goal 2:</b> Actions of all role-players harmonised through strategic planning.	<b>Objective:</b> Provide a framework for a coherent regional action plan through the prioritisation of invasive species management at appropriate scales.
<b>Goal 3:</b> Appropriate awareness raising, institutional arrangements and capacity building implemented.	<b>Objective:</b> Raise awareness and increase buy-in to combat the invasive species problem; improve institutional arrangements for invasive species management in the Greater CFR; build institutional capacity in the Greater CFR to address invasive species problems and improve invasive species management.
<b>Goal 4:</b> Introduction and establishment of new invasive species prevented through early detection and rapid response.	<b>Objective:</b> Prevent the intentional and/or unintentional introduction of invasive species and prevent new invasive species establishing or spreading through early detection and rapid
<b>Goal 5:</b> Impact of existing invasive species reduced through the implementation of integrated control measures.	<b>Objective:</b> Give effect to the obligations on landowners i.t.o. NEM-BA Chapter 5; incorporate invasive species management into all land use decisions.
<b>Goal 6:</b> Adaptive management is informed by research, monitoring and evaluation.	<b>Objective:</b> Implement invasive species monitoring, evaluation and research programmes to enhance invasive species management.

## Appendix 2: CAPE Invasive Alien Animal Working Group Terms of Reference (2018)

### 1. Preamble

A Memorandum of Understanding (MoU) was entered into in September 2001 with government departments, municipalities, statutory bodies and accredited non-governmental organisations that will carry out the vision of C. A. P. E. This TOR is entered into under the CAPE MOU and establishes the C. A. P. E. Invasive Animal Working Group (C. A. P. E. IAA WG), the Terms of Reference (TOR) of which is elaborated here. Provision is also made here for the future of this working group after the expiry of the CAPE project as it fulfills a function that is not time bound.

### 2. Purpose

The C. A. P. E. IAA WG was established to enhance cooperation and synergy amongst stakeholders and implementing agents through strategic planning, monitoring progress and developing case studies to inform best practice of invasive alien species (IAAS) management in the Greater CFR. Until the end of 2020 the scope of the WG includes the Greater CFR but will expand to cover the Western Cape Province thereafter. The C. A. P. E. IAA WG will endeavor to monitor the impact of IAS control operations based on information provided by implementing agents.

The business of the C. A. P. E IAA WG includes the co-ordination of activities covering the following areas as they relate to IAAS and IAAS management:

- Knowledge sharing;
- Research, monitoring and evaluation;
- Awareness and capacity-building;
- Information dissemination;
- Prevention;
- Early detection and rapid response;
- Policy and best practice;
- Funding;
- Prioritizing projects.

The C. A. P. E IAA WG provides a forum for the exchange of views on the means of implementing best practice in the field of IAAS management for the purpose of facilitating and improving IAAS management.

Specific collaborative activities shall be carried out in accordance with the C. A. P. E. MOU and relevant legislation.

The C. A. P. E IAA WG is not intended to replace, inhibit or duplicate activities of other organizations or agreements.

### 3. Objectives

The C. A. P. E. IAA WG aims to achieve the following objectives:

- Share expert IAAS knowledge amongst institutions to improve implementation and alignment;
- Mobilise and/or lobby support for IAAS management programmes;
- Identify and prioritise research requirements and priority management interventions;
- Communicate research outcomes for implementation;
- Monitor implementation of IA strategic actions;
- Facilitate development and standardization of IAAS Policy;
- Harmonize policy towards dealing with IAAS with other provinces and working groups through relevant forums.

### 4. Structure

The C. A. P. E IAA WG consists of stakeholder representatives from appropriate tertiary, conservation, institutions and organs of state.

Membership of the C. A. P. E IAA WG will be issued to appropriate stakeholders who must send and appoint representatives for each meeting or activity of the WG.

There shall be a chairperson elected every two years by the members.

The election shall take place via an electronic ballot. Members will be given ten working days to cast their votes. After his period the person receiving the greatest number of votes will appointed chairperson.

The importance of consultation with other agencies and organisations is recognised. Representatives from specific academic institutions and conservation agencies may be invited to participate in technical discussions but will not become members of the C. A. P. E IAA WG. They may, however, become members of a working group established for a specific area of expertise or project.

The participating institutions commit to implementing decisions of the C. A. P. E IAA WG.

## Meetings of the CAPE IAA WG

The chairperson shall be responsible for organising meetings of the IAA WG and appointing meeting chairs when required.

The IAA WG shall endeavor to meet at least twice a year.

Minutes shall be prepared and provided to C. A. P. E IAA WG members within two weeks following the meeting. Secretarial support for these meetings is the responsibility of the chairperson.

## 5. Exchange of Information

Information shall be exchanged during IAA WG meetings by means of discussions, presentations, documentation attached to the minutes, or formalised and focused workshops to address particular issues of concern. The participants are responsible for disseminating information to their organisations and local stakeholders.

## 6. Status

This TOR constitutes guiding principles to coordinate C. A. P. E IAA WG activities between the participants. Any collaborative activities identified for investigation by the C. A. P. E IAA WG will be pursued in accordance with the terms and provisions of the C. A. P. E. MOU.

## 7. Effective Date.

This updated and amended TOR for the C. A. P. E IAA WG becomes effective on 1<sup>st</sup> of June 2018 and remains in effect until April 2022, unless terminated or extended

by the by mutual written consent of the C. A. P. E IAA WG participants to accommodate the termination of the CAPE MOU and new priorities that may arise.

## 8. Definitions and Acronyms.

### Definitions

**Participants:** Individuals representing their institutions in sharing and participating in the activities of the WG.

**Partnership:** A formal agreement between two or more parties that have agreed to work together in the pursuit of common goals.

**Implementing agents:** Government institutions implementing Invasive Animal projects in the Greater CFR.

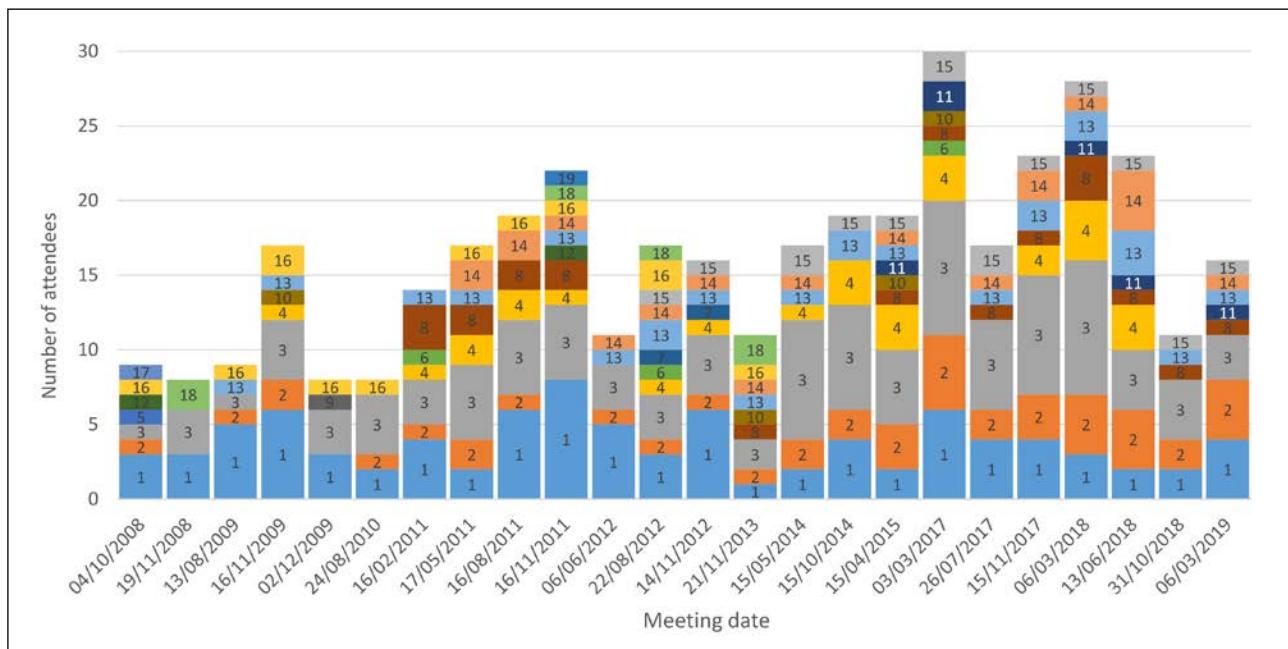
### Acronyms and abbreviations

<b>C. A. P. E. IAA WG</b>	CAPE Invasive Animal Working Group
<b>C. A. P. E.</b>	Cape Action Plan for People and the Environment
<b>CFR</b>	Cape Floristic Region
<b>CIB</b>	DSI-NRF/Centre of Excellence Centre for Invasion Biology
<b>Greater CFR</b>	Cape Floristic Region including the rest of the Western Cape Province
<b>IAAS</b>	Invasive Animal Species
<b>IAS</b>	Invasive Alien Species
<b>MOU</b>	Memorandum of Understanding
<b>SANBI</b>	South African National Biodiversity Institute
<b>TOR</b>	Terms of Reference
<b>WG</b>	Working Group

## PARTICIPANTS

Institution	Signature	Date
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### Appendix 3: Institutional attendance at CAPE IAAWG meetings.



Institution codes: 1. CapeNature; 2. Centre for Invasion Biology; 3. City of Cape Town; 4. Dept. Environment Affairs (now Dept. Environment, Forestry and Fisheries); 5. Department of Agriculture; 6. Eastern Cape Parks & Tourism Agency; 7. Intaka Island; 8. NCC Environmental Services; 9. Nelson Mandela University; 10. Private; 11. Robben Island Museum; 12. South African Institute for Aquatic Biodiversity; 13. South African National Biodiversity Institute; 14. South African National Parks; 15. SPCA; 16. University of Cape Town; 17. University of the Western Cape; 18. Visiting Scientist; 19. Wildlife and Environment Society of South Africa.