

**CONSERVATION, SOCIETY AND INVASIVE SPECIES**

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## ABSTRACT

Invasive species pose a major environmental threat, and are frequently the subject of biodiversity conservation programmes. As stakeholder and public concerns surrounding invasive species have become increasingly recognised and better articulated, society has become more closely involved in invasive species management. This has resulted in the need to ensure that positive ecological outcomes, such as protecting native species and habitats, and positive social outcomes, for example public support and improved stakeholder relationships, are both achieved as a result of management interventions. Through identifying social factors affecting the relationship between conservation, society and invasive species, this thesis considers how both of these outcomes may be attained, in the context of invasive species management in Australia.

Three dimensions of this relationship were analysed- stakeholder participation, social and political mechanisms and context, and public attitudes. This involved interview questionnaires, in-depth interviews, and postal surveys, respectively. The studies revealed three main social factors affecting the relationship - social associations with species, conflict over wildlife-related values, and conflicts between humans and invasive species. Social associations were related predominantly to species characteristics and their position in the environment, and may affect policy and legislation. Conflicts over wildlife-related values were related to management approaches, animal rights and welfare, and were also revealed to be a legacy of political history. The type of conflict between humans and invasive species was shown to affect management approaches. Stakeholder participation was shown to be essential in achieving both social and ecological outcomes, through conflict resolution, responsiveness to social factors, and justification of management approaches.

This thesis provides a novel approach for analysing how social factors may influence both ecological and social outcomes of invasive species management. Although the focus of the thesis is on invasive species, the conclusions are also likely to be relevant for other conservation programmes.

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## **AUTHOR'S DECLARATION**

I declare that the work contained in this thesis is my own and has not been submitted for any other degree or award.

**Adriana Ford-Thompson**



## CHAPTER I

### INTRODUCTION

#### 1.1 Invasive species as an environmental and social challenge

##### *1.1.1 Causes of biological invasions*

Biological invasion refers to the movement of species from one bio-geographical area to another, as a consequence of a break down in long-standing biological or physical barriers (Vermeij 1991). These biological invasions have been a natural occurrence over the last 25 million years, for example due to tectonic activity affecting physical barriers between species (Vermeij 1991). However, the rate of invasion has increased significantly due to human activity, creating an unprecedented form of global change (Ricciardi 2007). Humans have been involved in transporting species to new environments throughout history, as far back as ancient Egyptians, Greeks and Romans (Hughes 2003). The end of the Middle Ages, at around 1500AD, marks a defining period in increased rate of introductions, coinciding with global exploration and colonialism (Preston *et al* 2004; Hulme 2009). Similarly the Industrial Revolution in the 18<sup>th</sup> and 19<sup>th</sup> centuries, with the construction of trading routes and high rates of European migration to other continents, marks the second defining period for species introductions (McNeeley 2006; Hulme 2009). However, the greatest impact on the rate of biological invasions has occurred in recent decades as a consequence of globalisation, which has resulted in a significant increase in transport networks, trade and tourism (McNeeley 2006; Hulme 2009). The introduction of species to new environments by humans may be either deliberate or accidental, and the introduced species may become existent in the wild through several different pathways (Hulme *et al* 2008). For example, biocontrol agents or game species may be deliberately released, pets or garden plants may escape, parasites may be introduced accidentally as a contaminant, some species may act as a stowaway on transport vectors and be unintentionally released, for example in ballast water, and non-native species already present may disperse to new environments either through natural dispersal or through human created corridors and infrastructures (Hulme *et al* 2008). The extent of these introductions of ‘alien’ (or ‘non-native’ or ‘exotic’) species, and the effects that they can have when established, has presented a significant environmental and social challenge for the 21<sup>st</sup> Century.

### ***1.1.2 Invasive species establishment and effects***

Although the rate of introduction of alien species to new communities has increased as a result of human activity, not all of these become established in the new environment (Mack *et al* 2000). Establishment and success depends on many factors, including the availability of resources, the physical environment, and occurrence of natural enemies (Shea & Chesson 2002). Alien species may thrive because they are no longer restricted by native parasites or predators, or if the new environment has become disrupted due to human-induced disturbances, which may provide increased opportunities for the alien species (Mack *et al* 2000). Climate change may contribute to their success, for example through changing the maximum and minimum temperatures occurring in the environment, which may be more favourable to the alien species (Stachowicz *et al* 2002). Mutualism (a close interaction between two species whereby both benefit) and flexibility in behaviour may also increase the success of aliens (Mooney & Cleland 2001). Furthermore, success may be influenced by the number of release events (propagule number) and the number of individuals being introduced (propagule size), along with the health of the introduced individuals (Lockwood *et al* 2007). The concept of niche opportunities, related to community ecology theory, has been used to help understand success of biological invasions (Shea & Chesson 2002). Establishment of an alien species is therefore affected by many factors.

However, even when a non-native species becomes established, only some will become what may be termed ‘invasive’ (McNeely 2006). This term refers to species that conflict with or impact upon human interests and values (McNeely *et al* 2001) i.e. a form of human-wildlife conflict. Human-wildlife conflict arises from negative impacts by wildlife on human interests, such as livelihoods, property and human safety (Treves *et al* 2009), along with other human values, such as the conservation of native or threatened species (White & Ward 2010) – the term ‘invasive’ therefore encapsulates negative environmental effects as well as negative social and economic effects. Human-wildlife conflict also refers to the retaliation of humans against the species doing the damage (Treves *et al* 2009). The term ‘invasive’ may occasionally be used to describe native species that have become overabundant, for example those which colonise a new area and monopolise biological resources (e.g. Thompson *et al* 2001; De la Cretaz & Kelty 1999), thus having negative impacts on other native species that are more sensitive and adapt less readily to

anthropogenic land use changes (Garrott *et al* 1993). However, the term is more typically used to describe alien species, in particular those deemed to cause negative effects, which may be environmental, economic or social in nature.

Invasive species are believed to have contributed to extinctions of native species across the globe (Clavero & García-Bertho 2005), and are often considered to be the second greatest threat to biodiversity, after habitat destruction (Wilcove *et al* 1998). Islands are particularly susceptible to the effects of invasive alien species, which are considered to be the leading cause of native species extinction and population declines in such environments (Reaser *et al* 2007). Although the degree of the role of invasive species in native extinctions is debated by some scientists (Gurevitch & Padilla 2004), invasive species also have other evolutionary impacts on native species. For example, hybridization and introgression, competitive exclusion and niche displacement, and predation, may change their evolutionary pathway (Mooney & Cleland 2001). Invasive species may disrupt ecosystem functioning or services, for example seed dispersal (Dolman and Wäber 2008) or nutrient flow (Clout & Russell 2008), and a number of other regulating services, such as pollination, climate regulation, water purification, soil stabilization, disease regulation and flood mitigation, although not all effects are negative (Pejchar & Mooney 2009). Invasive species therefore have environmental impacts that range from genetic effects and impacts at the individual level, to effects on populations and communities, through to landscapes, including ecosystem functioning, and ultimately an impact on a global level (Lockwood *et al* 2007; White *et al* 2008).

In addition to environmental effects, an alien species may be considered 'invasive' due to economic and social effects. Simberloff *et al* (2005) describe several categories of economic effects, including predators or pests impacting on forests, crops and fisheries, pathogens affecting humans and livestock, and termites causing structural damage, although impacts on tourism can also be important (Bax *et al* 2003; Reaser *et al* 2007). Economic costs from damage and control measures associated with invasive species are estimated to be over US \$300 billion per year (Pimentel *et al* 2011). Social effects of invasive species are typically harder to quantify (e.g. McLeod 2004), however they may still be substantial. For example, the effects that invasive species have on ecosystem and regulatory services, described above, are social as well as environmental in nature – such regulatory services are essential for human well-being, such as livelihoods, health and security (Pejchar & Mooney 2009). Impacts to human safety and health are particularly

important, for example due to the effects of invasive pathogens (Vitousek *et al* 1997). There may also be other, less critical, social effects, such as restrictions or impacts on recreational outdoor activities (Soulé 1990). Alien species may therefore be termed invasive for any one or combination of these types of environmental, economic or social effects.

### ***1.1.3 Society and invasive species management***

#### *Overabundance and subjectivity*

The environmental, economic and social effects of invasive species outlined in 1.2.2 usually equate to the species being considered overabundant in that environment, and therefore in need of some sort of management. However, establishing whether a species is overabundant or not is more difficult to determine than whether a species is endangered, as overabundance is a subjective term, based on different values and experiences of impact or conflict (Garrott *et al* 1993). While for some stakeholders a species may be considered overabundant because it impacts negatively upon something of value to that stakeholder (whether from an economic, environmental or social perspective), for other stakeholders, the species may have no such negative impact and may not be considered overabundant. Furthermore, stakeholders may consider some invasive species to have positive impacts, including economic benefits, for example through provision of employment or economic resources (Bax *et al* 2003), recreational (such as game species) and aesthetic value (White *et al* 2011) and cultural benefits, including food, cultural traditions and ethnobiological practices (Pfeiffer & Voeks 2008). There are also arguments surrounding the positive impacts that invasive species may have for conservation, for example through acting as a resource (e.g. food or habitat) for rare or endangered species, and fulfilling functional roles in the ecosystem where species have become extinct (Schlaepfer *et al* 2011). Where an alien species has solely, or predominantly, positive benefits, they may not be subject to management intervention, as is exemplified by the use of alien species as crops and livestock (Pimentel *et al* 2005). However, when some stakeholders experience positive benefits, or do not experience negative impacts, from an alien species which is considered by other stakeholders to be invasive or overabundant, human-human conflict is likely to ensue. This arises when two or more stakeholder groups experience a different level of impact and/or have different attitudes towards the species and management interventions

(White & Ward 2010), for example how, and indeed whether, invasive species management should be implemented.

An additional conflict relating to the management of invasive alien species surrounds the concept of a native-alien dichotomy, concerning whether a distinction should even be made between native and non-native species (Davis *et al* 2011). Colautti & MacIsaac (2004) propose that biological invasions should be described as a bio-geographical process rather than based on taxonomy, and therefore not making a distinction between native and alien species. Some arguments have even suggested that this dichotomy may stem from racist or xenophobic attitudes (Peretti 1998). Counter-arguments cite the considerable impacts that alien species can have, both environmentally and economically, and that invasion ecologists are concerned with mitigating these impacts, rather than removing alien species *per se* (Simberloff 2003). The fact that overabundant native species are sometimes subject to lethal management intervention (Treves & Naughton-Treves 2005) may also suggest that although a ‘native-alien dichotomy’ in wildlife management may indeed exist, this dichotomy may not be the only, or even the dominant, motive behind managing invasive alien species.

### *Managing invasive species*

As described above, different perceptions of whether a species is overabundant or beneficial, or whether there should even be a distinction between native and alien species, contributes to human-human conflict. In addition to this, the method of management is a common cause of contention (Garrott *et al* 1993; Fraser 2006), and can affect the level of support for management programmes (Bremner & Park 2007), particularly because management intervention to reduce the impacts of invasive species typically requires lethal control. The ideal solution to the global challenge of invasive species is to avoid the invasion in the first place, which may be assisted through appropriate international trade law and the implementation of the precautionary principle (Burgiel *et al* 2006), although greater investment into preventative measures is needed (Leung *et al* 2002). Although prevention is desirable, and is likely to be the most cost-efficient and socially acceptable approach, this does not solve the problem of already established alien species that have become invasive, or those that will continue to be introduced despite controls that might be in place to avoid their introduction. In such cases, the typical approach to their management is removal, either through eradication, sustained control (usually where

eradication is not possible), or containment (Zavaleta *et al* 2001). Where eradication has been successful, improvements in native biodiversity are often seen, although there may be unexpected effects such as mesopredator release (Zavaleta *et al* 2001). Approaches to eradication and control of invasive species predominantly rely on lethal control measures, including shooting (either by professionals or through hunting, and either from the ground or aerially), baiting (from either the ground or aerially) trapping and warren ripping or fumigation (Reddiex *et al* 2006), and some forms of biocontrol, such as the use of exotic predators, diseases or viruses (Thresher & Kuris 2004), although the technical viability of these techniques is dependent on the species in question. Sometimes non-lethal methods may be used, such as fertility control (Fraser 2006), genetic modification of pest or native species (Thresher & Kuris 2004), translocation (Webb & Rafaelli 2008) or containment (e.g. wild dog-proof fences, Fleming *et al* 2001). Although this can be carried out by wildlife professionals on public land, for effective invasive species control collective action is often required across multiple land tenures, necessitating the cooperation and participation of landowners in control efforts (Rockloff & Moore 2006).

Controlling invasive species can often be carried out with minimal public concern, however, in some cases, public or interest group opposition to the use of lethal control has led to considerable conflict over invasive species management, and has affected the ability of the programme to achieve its objectives (e.g. Bertolino & Genovesi 2003). Thresher & Kuris (2004), investigating invasive species in a marine context, even revealed an inverse relationship between stakeholders' perception of acceptability with perception of effectiveness, suggesting new, or improved, control methods may need to be developed. Fraser (2006) proposed three characteristics that shape public attitudes towards control methods – specificity, humaneness and degrees of uncertainty. Both specificity and humaneness may be considered ethical considerations - while humaneness relates to the quality of death, specificity relates to the ability of the control method to act specifically on the target species. For example, poisoning of non-target native species is of public concern (Fraser 2006), and is a major limiting factor in the use of baits for invasive species control (e.g. De Tores *et al* 2011). Degree of uncertainty relates to public perception of risk (environmental, economic or social) associated with the control method (Fraser 2006). The inability of control methods to meet these three criteria- specificity, humaneness and a low degree of uncertainty - limits their acceptability by the public, and therefore reduces their viability as a realistic measure. Both Fraser (2006) and Bremner & Park (2007) identified poisoning as the least preferred method of invasive species control,

as poisoning typically does not fulfil the three criteria. However, attitudes towards the suitability of a particular control technique appears to also vary depending on a number of other factors, including socio-demographics (Sharp *et al* 2011), severity of impacts (Reiter *et al* 1999), type of impact (Philip & Macmillan 2003) and the characteristics of the species (Fraser 2006; Bremner & Park 2007). It is also likely that value orientations towards wildlife, for example those identified by Teel & Manfredi (2010), could also affect attitudes towards different control methods of invasive species.

### *Political and societal influences*

As a consequence of these different impacts and attitudes surrounding invasive species, the subject of invasive species has become both a political and a social one (Robbins 2004), and in some cases can be described as a value-laden ‘wicked’ policy problem (Nie 2003; Chapple 2005). In the first instance, trade politics can affect the introduction of a species into a new environment (Margolis *et al* 2005). Invasive species are linked to political economic systems (Robbins 2004), for example politics has been argued as contributing to the challenge of invasive species in the USA, due to the desire to encourage free trade and commercialisation, resulting in political influence in the risk assessment process and the underestimation of risks of the invasive species (Simberloff 2005). Following introduction, politics may influence whether an alien species is defined in the state as invasive or not, and consequently affecting the response to its presence (Robbins 2004). This can also apply to overabundant native species, for example some extermination campaigns against native species appear to be based on political, rather than scientific premise (Ferreira & Delibes-Mateos 2012). Efforts to remove an invasive species can result in a political struggle with those who prefer the species to stay and those who do not (Robbins 2004), thus political and societal demands are closely linked. Similarly political and public acceptability of control methods are also closely related (Thresher & Kuris 2004). The political implications of choice of control methods can be considerable, for example exposure to herbicides can have negative social outcomes, which potentially may lead to concerns over environmental justice (Norgaard 2007). Media and interest group pressure surrounding control methods can also result in a reactive political response and policy changes (Chapple 2005). The social and political context of invasive species management may therefore be just as relevant as the ecological context

Many of the political actions taken on invasive species management are influenced by increasing expectations and demands by citizens to be involved in decisions surrounding environmental issues (Jackson 2001). Furthermore, involving citizens in conservation is increasingly seen as a necessity, despite challenges that may arise – the question has become not whether to do so, but how (Adams & Hulme 2001). This involvement of citizens is termed ‘stakeholder participation’, or some variation, for example citizen, community, or public engagement, involvement or collaboration (Bracht & Tsouros 1990). Bracht and Tsouros (1990 p201) define citizen participation as “*the social process of taking part (voluntarily) in either formal or informal activities, programmes and/or discussions to bring about a planned change or improvement in community life, services and/or resources.*” Since the 1960s the use of and approach to participation has progressed (Reed 2008). Historically, participation in environmental policy was limited predominantly to awareness raising (Reed 2008), although public pressure was also evident, for example citizen campaigns in Europe eventually led to the adoption of the Birds Directive in 1979 and similarly the Habitats Directive in 1992 (Rauschmayer *et al* 2009). Since then there has been growing emphasis on citizens having a more prominent involvement, and having a democratic right to such involvement, leading to the United Nations Economic Commission for Europe’s Aarhus Convention which went into force in 2001, imposing obligations regarding participation and environmental justice. More recently, in the Convention of Biological Diversity (CBD) strategy plan for 2011-2020, one of the five strategic goals relates closely to participation - “*Enhance implementation through participatory planning, knowledge management and capacity building*” (CBD 2010). Policy for invasive species management has also shown recognition of the importance of participation, for example ‘The Invasive Non-Native Species Framework Strategy for Great Britain’ (Defra 2008) which emphasizes the need to build public awareness and understanding of invasive species.

The changing emphasis of participation in environmental policy exemplifies the different levels of participation that exist, which were first defined by Arnstein (1969). Arnstein (1969) described participation as eight rungs on a ladder of citizen participation, ranging from non-participation at the bottom, such as manipulation and therapy, through to degrees of tokenism, such as informing, consultation and placation, to higher levels of participation, or degrees of citizen power, including partnership, delegated power and, at the top of the ladder, citizen control. Reed (2008) provides a detailed history of how participation theory has developed since this initial typology. Various adaptations of levels



of participation have been proposed, for example Dorcey (1994) argues the importance of lower levels of participation along side higher levels, and Pretty (1995) defined different levels in the context of development programmes, including passive, functional and interactive participation, participation for material incentive and self-mobilization, amongst others. Lawrence (2006) suggested the levels consultative, functional, collaborative and transformative participation, building upon other typologies that had been developed.

The potential benefits associated with participation are numerous (see Reed 2008). For example it may contribute to citizen empowerment, including for marginalised communities, it may result in increased public trust in and support for decisions, and promote social learning, it may increase the adoption of environmental interventions and the robustness and quality of decisions, and help to ensure that social needs are met (Reed 2008). Bracht & Tsouros (1990) also describe several benefits, including the testing out of new ideas, gaining support, incorporating local knowledge and values, gaining access to resources, providing a platform for coordination between organisations, conflict negotiation and mitigation, providing opportunities for new skills to be learnt by local people, and creating sense of local ownership and responsibility. Although there are many potential benefits, there are also some challenges associated with the participation process, which has left some environmental managers disillusioned (Reed 2008). McMullin & Nielsen (1991) describe four main challenges - difficulties in having a genuine representation of the public, increasing conflict rather than resolving it, undermining the role of wildlife managers, and the inability of the public to make good decisions due to being ill-informed on the issue. Other challenges may include dysfunctional group dynamics, consultation fatigue, slowing down of decision-making and action, and cynicism over credibility of the process, for example if decisions can be vetoed (see Reed 2008).

Given the value of participation, but the problems that can arise, several best practice guidelines for participation have emerged in the environmental literature. For example, Reed (2008) highlights the need for a philosophy emphasising empowerment, the use of participation from the outset, systematic analysis and representation of stakeholders, appropriate level of engagement and participation methods, skilled facilitation, integration of local and scientific knowledge, and institutionalisation of participation. Buchy and Hoverman (2000) propose four principles to be addressed – commitment and clarity, time

and group dynamics, representativity and transfer of skills. Rockloff & Moore (2006) focus on representation, identifying seven desirable qualities in a representative, for example functionality in multiple roles and having established social networks. These guidelines, and others that have been produced, aim to assist the participation process in achieving management outcomes in environmental challenges.

### *Combining social and ecological outcomes*

The previous sections provide an argument that invasive species management can be as much a societal matter as an ecological one. This dual dimension is not restricted to invasive species matters- it has been recognised as important in environmental and conservation issues at a generic level, based on recognition that conservation intervention is itself a human value, affected by human behaviour (Mascia *et al* 2003). Conservation interventions by definition have some sort of ecological objective, which if met may lead to positive ecological outcomes. Ecological outcomes typically relate to maintaining or increasing the levels of biodiversity, including genetic diversity, individual species or populations (typically threatened or endangered native species) and ecological communities or habitats (Redford & Richter 1999). This may be achieved through various different approaches, for example restoration projects (Brawn 2006), sustainable use of biodiversity (Callicott & Mumford 1997), invasive species management (Zavaleta *et al* 2001) and captive breeding and reintroduction programmes (Griffiths & Pavajeau 2008), and may often involve reducing human-induced threats. Koontz *et al* (2004) also consider environmental education and planning documents as environmental outcomes, as these may be considered necessary environmental tools, although environmental education is also a social process.

Conservation initiatives may also have social objectives, either as a desired outcome in its own right, or as a means to achieve ecological outcomes – in a similar way to how stakeholder participation may be seen as a utilitarian effort, i.e. a cost-effective method of achieving other objectives, or an empowerment tool (Morgan 2001). Indeed, potential social outcomes in conservation initiatives may relate to the social benefits associated with stakeholder participation, described in the previous section, including building trust and public support in management decisions, social learning and improved democracy (Reed 2008). Koontz *et al* (2004) describe social outcomes as relating to social capital, for example improved relationships between stakeholders and building societal capacity to

tackle environmental challenges. Developing clear objectives in a conservation initiative, both in terms of social and ecological objectives, may facilitate reaching these outcomes, which may be further aided by developing indicators, as is used in sustainable environmental management programmes, to gauge progress towards the outcomes (Fraser *et al* 2006).

Specific ecological and social objectives and outcomes in invasive species management are dependent on the particular conservation or conservation-development initiative; however, achieving a combination of both ecological and social outcomes is likely to be critical for long-term success in most cases. This requires the input of social research along with ecological research (Mascia *et al* 2003), although until recently there has been little attention given to the human component of invasive species management, despite the considerable social influence on their management, with most research focusing on the ecological processes involved (García-Llorente *et al* 2011). There is therefore a real research need in this field. Larson *et al* (2011) provide one of the few truly integrated approaches to invasive species management, through reviewing the invasive species literature and developing a framework for sustainability based on environmental, social and economic pillars. However empirical analyses that examine social factors in invasive species management, and how these may relate to management strategies, are relatively sparse. Research into public attitudes towards invasive species has been increasing in the last few years (e.g. Fraser 2006; Bremner & Park 2007, García-Llorente *et al* 2011; Sharp *et al* 2011), although links to management strategies are on the most part generalised, for example by stating the need for community engagement and consultation to achieve public support (García-Llorente *et al* 2011). This thesis therefore considers social factors in a management context that can inform the development of more effective and inclusive management interventions for invasive species.

#### *Theoretical approaches to social contexts of environmental management*

The behavioural and social sciences provide a number of potential theoretical approaches for analyzing the social contexts of environmental problems. Two theoretical approaches that help to address this social dimension are, from the social psychological sciences field, the four foci (the four Is) for effective intervention design for environmental protection (Van Vugt 2009), and from the social pedagogical field, the concept of social learning.

Van Vugt (2009) identifies four foci of management intervention for environmental protection: (i) information, (ii) identity, (iii) institutions, and (iv) incentives. Whilst these four foci may be particularly relevant to environmental problems exhibiting ‘tragedy of the commons’ (Van Vugt 2009), they may also be applicable to other environmental problems, including invasive species management, through providing management direction from a social perspective. The first focus of intervention, *information*, reflects stakeholders’ need to be informed of and understand the social and physical environment (Van Vugt 2009). Knowledge exchange, including science communication, is recognised as an important process for effective environmental management and biodiversity conservation (Bickford *et al* 2012). The exchange of knowledge and information also forms an essential part of social learning (Reed *et al* 2010). The second focus of intervention, *identity*, is linked to the core motive ‘belonging’. This reflects the effect that social identity can have on environmental behaviour and attitudes, thus influencing environmental outcomes (Van Vugt 2001; Van Vugt 2009; Whitmarsh & O’Neill 2010). Van Vugt (2009) describes the third focus, *institutions*, as linking to the motive of trust, reflecting stakeholders’ need to build trusting relationships to achieve environmental management objectives. Trust is recognized as one of the core elements contributing to social capital, encouraging cooperation, reducing transaction costs and liberating resources (Pretty & Ward 2001). The fourth focus of intervention identified by Van Vugt (2009), *incentives*, reflects the need to increase or enhance resources, or facilitate other personal improvement. Incentives may be provided through incentive schemes, for example in the form of subsidies or other economic incentive mechanisms (Van Vugt 2009). Such incentives have the potential to lead to more effective invasive species management (Fernandez 2011). Incentives may also be apparent through the intended environmental, economic or social outcomes of invasive species management programmes, thereby not necessitating an incentive ‘scheme’ e.g. an environmental incentive of improvements to endangered species populations, or an economic incentive of a decrease in agricultural loss, as a result of invasive species management. Thus incentives can be integral to environmental management programmes. Each of these four foci of management interventions – information, identity, institutions and incentives - relate to stakeholder motives, which can influence participation in, and support for, environmental management programmes, thus impacting upon ecological and social outcomes. The ‘four Is’ may therefore provide a useful theoretical basis for meeting the social challenges of environmental problems, particularly if considered alongside other theories, such as social learning.

Reed *et al* (2010) define social learning as ‘*a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks*’. Learning has been described as occurring at three levels – single, double and triple-loop. Single-loop corresponds to learning about consequences of actions and correcting for error, without altering underlying values; double-loop learning corresponds to the alteration of actions as a result of reflection on the governing variables or assumptions underlying the actions; and triple-loop learning is considered to be a higher order process, challenging the values and norms underpinning assumptions and actions (Argyris 1999; Reed *et al* 2010). Each of these levels can play an important role in the learning process, and Tosey *et al* (2011) argue that triple-loop learning is not necessarily more beneficial than double or single-loop learning. Each level can also contribute to social learning, if it leads to a change in understanding beyond the individual. Social learning can be an important part of building social capital (Pretty & Smith 2004), which consists of trust, reciprocity, norms, and connectedness, and which can play an important part in achieving environmental objectives (Pretty & Ward 2001). Social learning can allow stakeholders to develop the necessary skills that can meet local needs through a collaborative and adaptive process (Krasny & Lee 2002). It can also be particularly beneficial where the audience is not uniform, consisting of different stakeholder groups, and where active involvement in environmental management is required (Maarleveld & Dangbegnon, 1999; Krasny & Lee 2002). As invasive species management often involves multiple stakeholders, requires on-the-ground management, and requires stakeholders to transfer and adapt knowledge for local context, often in a collaborative setting, social learning has potential to be a useful approach to invasive species management (Krasny & Lee 2002), facilitating stakeholder involvement and public support.

Theoretical approaches to understanding social context of environmental problems, such as the four ‘Is’ and the concept of social learning, can provide a useful starting point for interdisciplinary research aiming to bridge ecological and social dimensions. This thesis therefore draws upon these, and other behavioural and social science theories, to help direct and contextualize the social dimension to invasive species management.

## 1.2 The thesis

This thesis investigates the relationship between conservation, society and invasive species in the context of invasive vertebrate management in Australia, with a specific focus on the management of deer in New South Wales (NSW), particularly rusa deer (*Cervus timorensis*) in the Royal National Park (RNP). Invasive vertebrate management in Australia epitomises the social issues summarised in section 1.1 and therefore provides a suitable case study to examine the relationship between conservation, society and invasive species. The findings of this thesis may also be applicable to invasive species management programmes in other parts of the world. The history and current status of invasive species in Australia are outlined in 1.2.1. The case study of deer management in Australia and the Royal National Park is outlined in 1.2.2. The thesis aim is then presented in 1.2.3 along with an explanation of the thesis structure and specific objectives of each chapter.

### *1.2.1 Invasive species in Australia*

Invasive alien species cause considerable environmental, economic and social effects in Australia. The cost of invasive plant species on crops alone is estimated at Au\$1.271 billion per year, with additional costs relating to damage to pasture land and horticulture (Groves 2011), and invertebrates are estimated to cost Au\$5.3billion per year in damage and cost of control (Canyon *et al* 2011). Over 80 alien vertebrates are thought to be established in the wild in Australia, with at least 30 being considered invasive (Bomford & Hart 2002). Invasive vertebrates, which are the focus of this thesis, cost an estimated total of Au\$720million per year (McLeod 2004). Economic costs of invasive vertebrates, from loss of agricultural production, for example predation, damage and competition with crops, as well as costs of control methods, amount to an estimated Au\$370million per year (McLeod 2004). Au\$350million per year has been attributed to environmental costs, based on impacts on biodiversity, although valuation data is only available for three species, whilst social costs of invasive vertebrates have not been quantified (McLeod 2004).

Many of the invasive species present in Australia were introduced, both intentionally and unintentionally, during the settlement of Europeans in the 19<sup>th</sup> and 20<sup>th</sup> centuries, compounded by acclimatisation societies which purposefully introduced species from Europe to provide a connection to their home country (Williams & West 2000). Australia has suffered considerable native species extinctions and population declines in the last 200

years since European settlement, some of which can be attributed at least in part to invasive species (Short & Smith 1994). Of the 245 identified mammal species, 16 mammal species have become extinct, particularly rodents and marsupials (Short & Smith 1994). For example, predation by the European red fox (*Vulpes vulpes*) has played a significant role in the extinction of rat-kangaroos (*Potoroidae* family) from New South Wales (NSW) (Short 1998). Threats to the Australian environment may be listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*, which in some cases leads to a national network to coordinate management across the country, termed Threat Abatement Plans. These have been used to assist in managing the effects of several invasive vertebrates, including predation by the European red fox and feral cats (*Felix catus*), biological effects of cane toads (*Bufo marinus*), predation, disease transmission, competition and habitat degradation caused by feral pigs (*Sus scrofa*), and competition and land degradation by goats (*Capra hircus*) and the European rabbit (*Oryctolagus cuniculus*) (Department of Sustainability, Environment, Water, Population and Communities 2011), although the impacts of other invasive vertebrates are also subject to management intervention across the country.

Although the management of all invasive species is a matter for society, the management of some species either requires, or elicits, greater involvement from society than others. Due to the continental scale of the problem, and the existence of many of these invasive species over multiple land tenures, stakeholder involvement in their management is often important for achieving reduction in impacts. For example landowners can play a crucial part in the management of foxes, through participating in coordinated baiting programmes (Saunders & Mcleod 2007). However, for some species, management has become a source of contention, due to a combination of reasons identified in 1.1 – subjectivity over impacts, which may be considered positive as well as negative, different attitudes towards methods of control, and the political and social context of the management intervention. The management of horses (*Equus caballus*) and deer, of which there are six established species in Australia – rusa, red (*Cervus elephus*), sambar (*Cervus unicolor*), fallow (*Dama dama*), chital (*Axis axis*), and hog deer (*Axis porcinus*), are particularly contentious (Moriarty 2004<sup>a</sup>). The management of deer, which is a focus of this thesis, particularly in the Royal National Park in NSW, is described further below in 1.2.2.

### ***1.2.2 Invasive deer in Australia and the Royal National Park***

Contention surrounding the management of deer arises predominantly due to their multiple roles or impacts on society, which may be both positive and negative - as well as having harmful ecological, economic and social and impacts, they are a charismatic species and are considered a hunting resource (Moriarty 2004<sup>a</sup>; White & Ward 2010). Historically deer were used for sport hunting in Australia, but in many states then became a protected species, although changes were then made following the rise of the deer farming industry (Jesser 2005). Currently, there still remains different legislation in the various states surrounding the management of deer in Australia; they are managed in some states predominantly as a pest, and others primarily as a game species (Hall & Gill 2005, Moriarty 2004<sup>a</sup>). Conflict surrounding invasive deer is exemplified in the management of rusa deer in the Royal National Park (RNP), which has been a cause of considerable contention, and indeed attention, in part due to the high-profile status, and location, of the park.

The RNP is the world's second oldest national park, and the oldest in Australia, dating back to 1879. It is located in NSW on the eastern coast, approximately 32km south of Sydney, and occupying approximately 15000ha (National Parks and Wildlife Service 2000). Rusa deer were introduced to the RNP intentionally in 1906 by the acclimatisation societies into an enclosed area, however following escape their population grew considerably (Moriarty 2004<sup>b</sup>). Due to environmental degradation and herbivory, deer have been identified as a Key Threatening Process in NSW under NSW *Threatened Species Conservation Act 1995*, and thereby may be considered invasive. The RNP contains threatened ecosystems and is floristically diverse, as well as being rich in native fauna (National Parks and Wildlife Service 2000), therefore the presence of deer in the park now conflicts with conservation objectives. Managers of the RNP are thus obligated under legislation to minimise negative impacts of the deer on the native fauna and flora. The deer have also been identified as having social and economic impacts on residents living on the park boundary, such as deer-vehicle collisions and property damage, however they are also seen by some sections of society to have heritage or aesthetic value (Shephard 2002). This, combined with conflicts and differing attitudes over control methods, has affected the ability of managers in the RNP to achieve positive social and ecological outcomes in relation to deer management.



### ***1.2.3 Thesis aims, objectives and structure***

Recognising that society has an important stake and influence in invasive species management and biodiversity conservation (see Section 1.1), the following research question was developed:

**What key factors shape the relationship between society, invasive species and conservation; and how might understanding these factors inform the management of invasive species in terms of achieving social and ecological objectives?**

This research question is addressed through answering three sub-questions. The sub-questions form the basis of three individual research papers, each analysing a specific social dimension of the relationship between society, invasive species and conservation. These dimensions are – stakeholder participation, social and political mechanisms and context, and public attitudes. These dimensions were chosen because (a) they were identified as being central for achieving ecological and social outcomes in invasive species management and (b) they provide avenues for exploring the theoretical concepts discussed in 1.1, specifically the four ‘I’s of management intervention and social learning, as described below.

Stakeholder participation is an important process for information and knowledge exchange (Jackson 2001), thus linking to the *information* focus of management intervention (Van Vugt 2009) and to social learning. For example, community participation in collaborative monitoring can help cultivate social learning and other social benefits (Fernandez-Gimenez *et al* 2008). Stakeholder participation in environmental programmes is also likely to be affected by *incentives* (e.g. whether there is some personal benefit to participating), trust in *institutions* (for example, the perceived risk of expectations being met, or not, due to quality of governance), and *identity*, either as part of a stakeholder group or within a community (for example a geographically defined community facing invasive species management problems). Social and political context and mechanisms, the second dimension addressed by this thesis, is also important for understanding social learning. Tosey *et al* (2011) explain that the *context* of learning reflects the meaning behind behaviour, which is emphasised in the double-loop learning concept. *Identity* is also an important element of social and political context and mechanisms, as socio-political processes involve interactions between stakeholder groups (which can be

considered as a form of identity), including between *institutions*. Cooperation (or lack therefore) between stakeholder groups and institutions will be influenced by social and political *incentives* to do so. *Information* exchange can also play a considerable role in social and political mechanisms, both between stakeholder groups and with the public. Public attitudes, the third dimension of this thesis, also relate to these criteria. Social learning may influence attitudes and support for environmental programmes (Fernandez-Gimenez *et al* 2008), as may social *identity* (Whitmarsh & O'Neill 2010). The information deficit model proposes that it is the public's deficit of scientific knowledge that predominantly leads to lack of support for and negative attitudes towards science (Sturgis & Allum 2004). *Information* therefore helps inform individual decision-making on environmental issues and can facilitate public support. However, there are also arguments that the information deficit model is too simplified, as attitudes are not only affected by scientific 'facts' (Brown 2009); attitudes are also affected by the context, including the social and political context, in which public understanding is taking place (Sturgis & Allum 2004).

Addressing these three dimensions - stakeholder participation, social and political context and mechanisms, and public attitudes - through the three papers presented in this thesis, provides an opportunity to understand what factors can inform the management of invasive species in terms of achieving social and ecological objectives, whilst building upon social theories. Preceding each paper, a preface is provided which outlines the relevance of the paper in answering the thesis research question. The objectives of each paper, and the chapter to which this relates to, are outlined below.

**Chapter II** analyses *stakeholder participation*. It aims to answer the following research question: **what are the different features in participatory conservation programs that can enhance ecological and social outcomes?** The chapter has two main objectives:

- (i) To identify key typologies and participation features thought to affect conservation.
- (ii) To identify relationships between these features and with ecological and social outcomes.

The approach taken involved an interview based questionnaire administered to managers of participatory invasive species programmes across Australia.

*Chapter III* explores *social and political mechanisms and context*. It aims to answer the following research question: **what social and political mechanisms are used for encouraging appropriate management of invasive species and what are the opportunities and limitations of these mechanisms in a social and political context?**

The chapter has two main objectives:

- (i) To identify key social and political mechanisms in invasive deer management
- (ii) To identify social and political context themes which relate to these mechanisms, through either providing limitations or opportunities for achieving management objectives.

The approach taken involved in-depth interviews with key stakeholders, using a case study of invasive deer in New South Wales, with a specific focus of deer management in the Royal National Park.

*Chapter IV* investigates public attitudes. It aims to answer the following research questions: **what are the different key factors shaping public attitudes towards invasive species and their management in a protected area and what is their relative importance; and how might these factors be influenced to achieve greater support and thereby minimise conflict and maximise beneficial outcomes?** The chapter has three main objectives:

- (i) To identify the key factors shaping public attitudes towards deer and their management in a protected area, and express this as a conceptual framework.
- (ii) To examine the different attitudes related to these key factors and assess their relative importance to the local public.
- (iii) To propose relevant management strategies for responding to these public attitudes to help achieve ecological and social outcomes.

The approach taken involved a postal survey delivered to residents living on the boundary of the Royal National Park, using invasive deer management in the park as a case study.

In Chapter V, the objectives of each paper and the key findings are briefly summarised, and are then discussed in reflection of the core research question of the thesis. Key factors affecting the relationship between conservation, society and invasive species, and how these factors may relate to improving ecological and social outcomes, are highlighted. Chapter V consolidates the three studies and considers the findings in a broader context.

## CHAPTER II

### STAKEHOLDER PARTICIPATION

#### Preface

Stakeholder participation has become a widely used process in environmental management, with potential benefits for both the environment and society (Jackson 2001; Reed 2008). It can help to achieve ecological or conservation objectives, while building up social capital, for example through improving stakeholder relationships (Koontz *et al* 2004). The approach may range from lower level participation, such as education, through to higher level participation, for example decision-making and collaboration (Arnstein 1969, Dorsey 1994). It can also be essential for carrying out on-the-ground activities to help achieve conservation outcomes, which can be particularly important for management over multiple land tenures (Rockloff & Moore 2006). Invasive species management in Australia is a continental challenge, involving many different alien species and stakeholders. However, although there are guidelines for improving stakeholder participation in invasive species management (e.g. Braysher & Saunders 2003), there is little empirical research on the participatory processes involved.

This chapter therefore aims to answer the following research question: What are the different features in participatory conservation programmes that can enhance ecological and social outcomes? Key typologies and participation features thought to affect conservation were first identified, from the initiation of the programmes through to outcomes. This was used as a basis of an interview questionnaire that was administered to managers of participatory invasive vertebrate management programmes across Australia. Relationships between the participation features and ecological and social outcomes were then identified. The study provides the first empirical investigation into the relationship between participation features and management outcomes of invasive species programmes in Australia. The paper presented in this chapter thereby helps to answer the research questions posed in the thesis through: (a) identifying key participation features; (b) examining links between these features, thus helping to understand the processes surrounding societal involvement in invasive species management; and (c) exploring how these features relate to ecological and social outcomes. This paper is written in the style of, and has been published in the journal *Conservation Biology*, with reference: *Conservation Biology* 26(2), 345–356.

## Stakeholder Participation in Management of Invasive Vertebrates

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## **Abstract**

Stakeholders are increasingly involved in species conservation. We sought to understand what features of a participatory conservation program are associated with its ecological and social outcomes. We conducted a case study of the management of invasive vertebrates in Australia. Invasive vertebrates are a substantial threat to Australia's native species, and stakeholder participation in their management is often necessary for their control. First, we identified potential influences on the ecological and social outcomes of species conservation programs from the literature. We used this information to devise an interview questionnaire, which we administered to managers of 34 participatory invasive-vertebrate programs. Effects of invasive species were related to program initiator (agency or citizen), reasons for use of a participatory approach, and stakeholder composition. Program initiator was also related to the participation methods used, level of governance (i.e., governed by an agency or citizens), changes in stakeholder interactions, and changes in abundance of invasive species. Ecological and social outcomes were related to changes in abundance of invasive species and stakeholder satisfaction. We identified relations between changes in the number of participants, stakeholder satisfaction, and occurrence of conflict. Potential ways to achieve ecological and social goals include provision of governmental support (e.g., funding) to stakeholders and minimization of gaps in representation of stakeholder groups or individuals to, for example, increase conflict mitigation. Our findings provide guidance for increasing the probability of achieving ecological and social objectives in management of invasive vertebrates and may be applicable to other participatory conservation programs.

## **Introduction**

Increasingly, stakeholders are participating in environmental management as a consequence of their expectations and demands, managers' realization of the potential benefits of stakeholder participation, and a shift of emphasis of participation in environmental policy from awareness raising and consultation to shared power and democratic rights of citizens (Jackson 2001; Reed 2008). The objectives of stakeholder participation in conservation initiatives are ecological (e.g., conservation of endangered species and their habitats) and social (e.g., community satisfaction and support, social cohesion, conflict mitigation, increased capacity for problem solving [Koontz et al. 2004], and improved economic conditions). Ecological and social outcomes are often interdependent (Mascia et al. 2003; Koontz et al. 2004). Because the processes influencing ecological and social success of conservation programs are potentially quite different, it is challenging to achieve both ecological and social goals. We sought to identify the different features in participatory conservation programs that can increase the probability of achieving ecological and social objectives

Invasive vertebrates (native and non-native) in Australia threaten native species through predation, competition, reduction in habitat quality, and disease transmission (McLeod 2004; Reddiex et al. 2006), and some invasive species have considerable economic and social effects (McLeod 2004; Gong et al. 2009). Stakeholder participation in implementation of and decision making related to invasive-vertebrate management may be necessary to achieve management objectives (White et al. 2008), particularly given the large geographic ranges of many invasive vertebrates (Forsyth et al. 2004), funding and staff limitations, and the occurrence of invasive species on both private and public land. Ecological outcomes may therefore be limited by social outcomes, and successful management of invasive vertebrates may depend on a better understanding of relations between these outcomes.

We examined features of participatory programs to manage invasive vertebrates that may affect outcomes of those programs. Arnstein (1969) developed the first typology of stakeholder participation, describing a "ladder of citizen participation" that ranges from manipulation and therapy (i.e., dishonesty in intentions, or "curing" of participants of their viewpoints) at the bottom of the ladder to partnership and citizen control at the top. Since the emergence of Arnstein's ladder, many other typologies have been proposed (Reed

2008), several of which are built on the concept of levels of participation. For example, Lawrence (2006) proposes the following levels of participation: consultative, functional, collaborative, and transformative. Margerum (2008) transformed this concept of levels into a more process-based classification that he based on the level at which collaborative partnerships operate: action, organization, and policy. Other typologies address the theoretical bases and make a distinction between pragmatic and normative participation (Reed 2008) and consider, for example, participation a utilitarian effort with the aim of achieving project objectives more cost effectively or of empowering people (e.g., Morgan 2001).

In addition to defining typologies of participation, some researchers have examined the relation among typologies and features of participation and management outcomes. For example, some have studied collaborative management, a type of stakeholder participation in management. Project activities are completed more often by partnerships that represent a greater number of interests (Bidwell & Ryan 2006), and governments function as both institutions and actors in achieving environmental and social objectives (Koontz et al. 2004). Identifying typologies and features of participation and determining the relations between these features and management outcomes can inform the design and implementation of environmental projects (Moore & Koontz 2003; Margerum 2008). However, one needs to examine the influence of participation features beyond collaborative partnerships and consider diverse management approaches (Koontz et al. 2004).

To determine which features and relation may have the greatest effect on ecological and social outcomes of managing invasive vertebrates, we drew on features of participation identified in previous studies. We used these features of participation to devise an interview-based questionnaire that we administered to managers of invasive-species programs across Australia. These programs aim to reduce the undesirable effects of invasive mammals, birds, and amphibians, typically through lethal control.



## **Methods**

### **Questionnaire Design and Use**

We used the literature to develop a list of participation features of programs that manage invasive vertebrates that may potentially affect ecological and social outcomes (Table 1 & Supporting Information). We selected typologies that: relate to on-the-ground conservation efforts, as opposed to efforts aimed at, for example, changing policy (Margerum 2008); cover diverse aspects of public participation, from initiation of a program through different management processes; and are composed of different levels or types of participation. We adapted some features from the original typologies or combined them to increase their applicability to on-the-ground programs managing invasive vertebrates (Supporting Information). Our list of participation features is not exhaustive.

We devised a semistructured questionnaire (Supporting Information) on the basis of the features thought to influence the outcomes of participatory conservation programs (Table 1). We used it to evaluate stakeholder participation in programs managing invasive vertebrates across Australia. The questionnaire was tested on one program manager and reviewed by an expert in stakeholder engagement and management of invasive vertebrates. The questions (Table 2) focused on management-program characteristics, type of effects of invasive species, program initiator, stakeholder participation, and ecological and social outcomes.

We selected the management programs with purposive sampling. We used networks of stakeholders in invasive species management (e.g., Invasive Animals Cooperative Research Centre [CRC]) and referrals from government agencies (e.g., Department of Industry and Investment New South Wales) to identify potential programs and relevant people to participate in the study. We also posted requests for participants in newsletters (including the CRC newsletter and the Australian Wildlife Management Society newsletter). Interviewees had to be involved in a program, the objective of which was either partially or wholly to manage one or more invasive vertebrate species and participants in the program had to include stakeholders or community members. A wide variety of stakeholder-participation approaches, including decision making, information sharing and collection, and fieldwork, qualified for inclusion. We identified 52 potential programs. One program manager explicitly declined to participate due to concerns over

public sensitivity to aerial culling in their program. We did not include 17 others because contact information was not available, there was no response to our request for an interview (10), or the same respondent managed several programs but completed an interview for only one program (5). We did not include 2 programs because they were research projects, not management programs. The final sample size was 34.

From April to October 2008, we used the questionnaire in interviews of one manager or key employee of each program. Although not random, we believe our sample was representative of invasive-species management programs throughout Australia. Thirty-one interviews were conducted over the telephone and 2 were conducted in person and 1 questionnaire was completed in writing

## ANALYSIS

We examined the relations among the participation features of 7 variables: effects of invasive species, program initiator, governance level, motivations for use of a participatory approach, stakeholder composition, participation methods, and management outcomes (Table 1). We used Kruskal–Wallis tests for multiple comparisons (rankings of the different invasive species effects; different features of level of governance and program initiator; rankings of the different motivations for use of a participatory approach; and rankings of the motivations for use of participation methods). We used Mann–Whitney U tests for pairwise comparisons of program initiator (citizen initiated or agency initiated) with effects of invasive species, level of governance, motivations for use of a participatory approach, participation methods, stakeholder composition, and social and ecological outcomes; level of governance (citizen governed or agency governed) with motivations for use of a participatory approach; stakeholder composition (heterogeneous or homogenous composition) with social outcomes; rankings between each of the different effects of invasive species; rankings between each of the different motivations for use of a participatory approach; and rankings between each of the different participatory methods). We used Spearman’s rank correlations to analyze relations among variables in which both variables consisted of rankings, including those derived from the questions about invasive species effects, motivations for use of a participatory approach, and ecological and social outcomes. We identified causes of underrepresentation of stakeholders in the management programs, causes of conflicts, other challenges to management of invasive species, and solutions to these challenges and conflicts with Atlas.Ti (Scientific Software Development,

Berlin), which codes responses to open-ended questions into themes and assigns them to categories (Bryman 2008). Sample sizes were 34 unless otherwise noted.

**Table 1.** Features that may affect the outcomes of participatory conservation programs, with specific reference to management of invasive vertebrates.

Variable	Participation feature <sup>a</sup>	Description <sup>b</sup>
Effects of invasive species	Environmental	effects of invasive species on either the environment or humans (emphasis on negative rather than positive effects) predation on and competition with native species, disruption of ecosystem function, and loss of genetic diversity (e.g., through hybridization with native species)
	Economic	financial loss (e.g., effects on agriculture and livelihood)
	Social	risk to human health (e.g. disease, animal-vehicle collisions), stress or anxiety, and property damage
	Stakeholder conflict	human-human conflict (e.g., management objectives vary among stakeholder groups)
Program initiator	Agency initiated	level at which the program is initiated (i.e., due to whose concerns instigated management action) government departments or nongovernmental organizations with strong links to government
	Citizen initiated	community groups, individuals, or nongovernmental organizations
	Joint initiated	combination of government agencies and citizens or community groups
Level of governance	Agency governed	level of program administration state government departments or nongovernmental organizations with strong links to government
	Citizen governed	community groups, individuals, or nongovernmental organizations
	Joint governed	combination of government and communities
Geographical extent	Broad Regional District Local	operational area of the program <sup>c</sup>
Motivations for using a participatory approach	obligation <sup>d</sup>	Reason for involving stakeholders; listed in order from low level of participation (limited power of participants) to high level of participation (considerable power). The different motives can be understood as the following: legislative or funding requirement
	social and political pressure <sup>d</sup>	demands by stakeholders to be involved
	community resource	input of resources from participants needed (e.g., time or labor)
	education and informing	increase awareness among participants of the issues or program
	gathering information	collect information (such as public attitudes) or data (e.g., citizen science)
consultation	presenting and contesting ideas	
decision-making	deliberating and coming to an agreement that will be implemented	
Stakeholder composition	Homogenous composition	number of different groups of stakeholders participating in the programs; natural break in number of interests identified on the basis of Bidwell and Ryan (2006) ≤ 4 stakeholder groups
	Heterogeneous composition	> 4 stakeholder groups

**Table 1 continued**

Representative voice		relative presence of stakeholder groups in the participation process (Catt & Murphy 2002)
	Controlling	all participants are from the same interest group
	Proportional	participation of interest groups is proportional to their presence in the population
	Symbolic	presence of all relevant interest groups assured but not proportional to their presence in the population
	Underrepresented	interest groups or individuals that would ideally be participants but currently are not
Participation methods		way participation is implemented in the programs and the specific techniques used
	Activity-based	on-the-ground activities, including culling invasive species, deterring or increasing the probability of presence of species, and monitoring or reporting (e.g., citizen science)
	Consumerist	primarily survey of service delivery (e.g., satisfaction and opinions, including attitude surveys, satisfaction surveys, and complaints and suggestion)
	Traditional	primarily informing participants (e.g., public meetings, question & answer sessions, consultation documents)
	Innovative	extracting local knowledge, ideas, and expertise, including appraisals, exercises in visualising environmental problems, and community indicators (measurements of issues that are important to the community)
	Deliberative	deliberative discussion & strategic planning, including focus groups, workshops, and field days or forums
	Democratic	democratic decision-making and transparency, including citizen panels, referendums and citizen juries (for providing a structured and transparent way to involve citizens in decision-making, particularly over controversial issues)
Management outcomes		changes that occur as a result of management
	Ecological outcomes	changes in invasive species abundance, changes in environmental condition including changes in species richness or abundance of threatened species and habitat quality, changes in agricultural condition (e.g. productivity)
	Social outcomes	changes in stakeholder interactions, changes in participation numbers, stakeholder satisfaction, and occurrence of conflict

<sup>a</sup> The majority of classifications are not mutually exclusive.

<sup>b</sup> Descriptions refer to how these types of participation features have been interpreted for use in this study. The basis of these features, including the original classifications with reference to the literature, are explained further in Supporting Information.

<sup>c</sup> Classes based on estimated operational areas (not administrative boundaries):  $\leq 1000$  km<sup>2</sup> (local); between 1001 and 9999 km<sup>2</sup> (district), between 10,000 and 50,000 km<sup>2</sup> (regional), and  $>50,000$  km<sup>2</sup> (broad-scale)

<sup>d</sup> not necessarily representative of low level of power, rather that participation is a necessity, due to political or legal requirements

**Table 2.** Topics and format of questions arising in a questionnaire used to assess the relations among participation features and management outcomes in programs targeting invasive vertebrates in Australia

Questionnaire section	Question summary* and format
Program characteristics	composition of invasive species targeted by program (open-ended question) spatial extent and location of the program (open-ended question)
Invasive species effects and program initiator	level of effect (environmental, economic, social, and stakeholder conflict) of invasive species that program addresses (scale of 1-5, where 5 is the highest) program initiator (closed question: concern of community, relevant authorities, or both)
Stakeholder participation level of governance and funding	who runs the program (closed question: the government, a nongovernmental organization, or a community group). receipt of external funding (yes or no), source of funding (closed question: local government authorities, catchment management authority, state, commonwealth (national), other; open question: percentage for each source)
motivation for use of participatory approach	obligation, social and political pressure, community resource, education and information, gathering information, consultation, decision making (scale of 1-5 for each motivating factor, where 1 is “not an objective,” and 5 is a “high-priority objective”)
stakeholder composition	who and how many members in each stakeholder group (open-ended question)
representative voice	method of selecting participants (open-ended question) underrepresented stakeholders (open-ended question)
participation methods	activity based, consumer based, traditional (i.e., primarily informing participants), innovative (i.e., novel methods for extracting local knowledge, ideas, and expertise), deliberative, democratic (yes or no for each method) frequency of engagement (open-ended question)
Social outcomes	changes in number of participants (closed question: large number drop out to large number become involved) changes in stakeholder interactions (scale of -2 to 2, where -2 is increased conflict and 2 is increased cooperation) occurrence of conflict: conflict over pest control methods, land tenure, or other conflicts (yes or no and description) provision of feedback to stakeholders (yes or no and description) assessment of stakeholder satisfaction (yes or no and description) stakeholder satisfaction with the program (scale of -2 to 2, where -2 is very dissatisfied and 2 is very satisfied)
Ecological outcomes	monitoring: abundance of invasive species and environmental and agricultural effects monitored or quantified (yes or no) changes in invasive species abundance (scale of -2 to 2, where -2 is a substantial decrease and 2 is a substantial increase) changes in environmental condition (e.g., habitat quality, species richness, abundance of threatened species) (scale of -2 to 2, where -2 is a substantial decrease in and 2 is a substantial improvement in habitat quality, species richness or abundance of threatened species) changes in agricultural condition (e.g., productivity) (scale of -2 to 2, where -2 is a substantial decrease and 2 is a substantial increase)

\* *Excluding auxiliary questions not used in the analyses.*

## Results

### PROGRAM CHARACTERISTICS

Across the 34 programs, 12 invasive species were identified as the target of control (Table 3), either as a single species or as part of an effort to control multiple species. Every state except Tasmania was represented. Programs occurred in New South Wales (12), Western Australia (9), Victoria (5), Queensland (3), South Australia (3), Northern Territory (1), and Australian Capital Territory (1). The estimated area managed in each of these programs ranged from  $\leq 1,000$  to  $>50,000$  km<sup>2</sup> (47%  $\leq 1,000$  km<sup>2</sup>; 26% between 1,001 and 9,999 km<sup>2</sup>, 15% between 10,000 and 50,000 km<sup>2</sup>, and 12%  $>50,000$  km<sup>2</sup>;  $x[SE] = 25,000$  km<sup>2</sup> [12,000]).

### INVASIVE SPECIES EFFECTS AND PROGRAM INITIATOR

Respondent rankings of the magnitude of the different effects of invasive species varied significantly among programs ( $\chi^2 = 14$ ,  $df = 3$ ,  $p < 0.01$ ). Environmental effects were considered more substantial overall than economic, social, and stakeholder-conflict effects ( $U = 390$ ,  $n_1 = 35$ ,  $n_2 = 35$ ,  $p < 0.01$ ;  $U = 360$ ,  $n_1 = 35$ ,  $n_2 = 35$ ,  $p < 0.01$ ; and  $U = 340$ ,  $n_1 = 35$ ,  $n_2 = 35$ ,  $p = 0.001$ , respectively). These latter 3 effects had similar rankings (Table 3). Sixteen (47%) of the programs were citizen initiated, 9 (27%) were agency initiated, and 9 (27%) were jointly initiated by citizens and agencies (Table 4). Economic effects of invasive species were ranked significantly higher by citizen-initiated programs than by agency-initiated programs ( $U = 40$ ,  $n_1 = 17$ ,  $n_2 = 9$ ,  $p = 0.05$ ) (Table 3).

**Table 3.** Importance of different motivators (environmental, economic, social and stakeholder-conflict effects) in the establishment of participatory management programs for different invasive vertebrates and program initiators (citizen or agency-initiated), on a scale from 1-5 (1 unimportant; 5, very important).

Target species and program initiators	n	Motivators			
		Environmental Effect	Economic Effect	Social Effect	Stakeholder Conflict
<b>Species</b>					
Fox ( <i>Vulpes vulpes</i> )	12 <sup>b</sup>	4.8	2.4	2.3	2.3
Wild dog ( <i>Canis lupus dingo</i> and <i>C. l. familiaris</i> )	7 <sup>b</sup>	1.7	4.4	4.4	3.7
Fox and cat ( <i>Felis catus</i> )	1	4.5	1.5	1	1
Fox and wild dog	0 <sup>b</sup>				
Deer ( <i>Cervidea spp</i> )	1	1	3	3	1
Pig ( <i>Sus scrofa</i> )	3	4.3	4	2	3.3
Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	3	2	4
Deer and goat ( <i>Capra hircus</i> )	1	2.5	1	2	3
Cat, fox and rabbit	1	5	1	1	1
Cat, deer, goat and pig	1	5	3	4	2
Cat, fox, goat and rabbit	1	5	2.5	3.5	3.5
Bell miner <sup>c</sup> ( <i>Manorina melanophrys</i> )	1	5	4	2	4.5
Common myna ( <i>Acridotheres tristis</i> )	1	5	3	5	1
Rainbow lorikeet <sup>c</sup> ( <i>Trichoglossus moluccanus</i> )	1	3	3.5	3.5	2.5
Starling ( <i>Sturnus vulgaris</i> )	1	4	4	4	2
Cane toad ( <i>Bufo marinus</i> )	2	4	2	3	3.5
Total mean ratings	35	3.9 [SE 0.23]	3.0 [SE 0.24]	2.8 [SE 0.25]	2.8 [SE 0.23]
<b>Program initiator</b>					
Citizen initiated	17	3.5 [SE 0.42]	3.4 [SE 0.33] <sup>a</sup>	3.3 [SE 0.38]	3.1 [SE 0.36]
Agency initiated	9	4.7 [SE 0.15]	2.2 [SE 0.36] <sup>a</sup>	2.2 [SE 0.50]	2.1 [SE 0.38]

<sup>a</sup> Economic effects rated significantly higher for citizen-initiated programs than for agency-initiated programs ( $p=0.05$ ).

<sup>b</sup> Participant scored the motivators separately for fox and wild dog; therefore, the scores were added to the individual species categories, increasing n from 34 to 35.

<sup>c</sup> Rainbow Lorikeets and Bell Miners are both native to Australia, but are considered invasive in some areas.

**Table 4.** Correlations between level of governance and program initiator (percentage of total).

Level of governance	Program initiator			Total ( <i>n</i> )
	citizen ( <i>n</i> )	agency ( <i>n</i> )	agency and citizen ( <i>n</i> )	
Citizen	20.6 (7)	0 (0)	0 (0)	20.6 (7)
Agency	17.6 (6)	20.6 (7)	20.6 (7)	58.8 (20)
Joint	8.8 (3)	5.9 (2)	5.9 (2)	20.6 (7)
Total	47.1 (16)	26.5 (9)	26.5 (9)	100 (34)

## STAKEHOLDER PARTICIPATION

Sixty percent of the programs were agency governed. Of the 16 citizen-initiated programs, 6 were solely agency governed, whereas none of the 9 agency-initiated programs were solely citizen governed. Level of governance appeared to be associated with program initiator ( $\chi^2 = 8.7$ ,  $df=2$ ,  $p=0.01$ ). Significantly more citizen-governed programs than agency-governed programs were citizen initiated ( $U = 21$ ,  $n_1 = 7$ ,  $n_2 = 20$ ,  $p < 0.01$ ) (Table 4). Funding of the programs was either all from government sources (53%) or a mixture of government and community or nongovernmental organization sources (47%). No respondents reported a program funded solely by the community.

Motivations for using a participatory approach differed significantly among programs ( $\chi^2 = 28$ ,  $df = 6$ ,  $p < 0.001$ ). The motivations “community resource” and “education and informing” were ranked as significantly stronger than other motivators (except for education and informing and “social and political pressure”) (Table 5). The motivation “decision making” was ranked significantly stronger by citizen-governed than by agency-governed programs ( $U = 33$ ,  $n_1 = 7$ ,  $n_2 = 19$ ,  $p = 0.05$ ). Motivations for using a participatory approach and invasive-species effects also were significantly correlated (Table 5). The rankings of environmental effects were positively correlated with education and informing ( $r_s = 0.359$ ,  $n = 35$ ,  $p = 0.03$ ), economic effects were positively correlated with decision making ( $r_s = 0.38$ ,  $n = 34$ ,  $p = 0.03$ ), social effects were positively correlated with “obligation” and social and political pressure ( $r_s = 0.34$ ,  $n = 35$ ,  $p = 0.04$  and  $r_s = 0.38$ ,  $n = 35$ ,  $p = 0.03$ , respectively), and stakeholder conflicts were positively correlated with “consultation” ( $r_s = 0.34$ ,  $n = 34$ ,  $p = 0.05$ ).



There was a significant difference in the use of participation methods ( $\chi^2 = 96$ ,  $df = 5$ ,  $p < 0.001$ ). Activity-based and traditional methods were used in significantly more programs than other methods (Table 5). Activity-based methods were used significantly more by citizen-initiated programs than agency-initiated programs ( $U = 39$ ,  $n_1 = 16$ ,  $n_2 = 9$ ,  $p = 0.03$ ), and innovative methods were used significantly more by citizen-governed than agency-governed programs ( $U = 30$ ,  $n_1 = 7$ ,  $n_2 = 20$ ,  $p = 0.02$ ) (Table 5).

State government and rural landholder (farming) interests were the most commonly represented in the programs (Supporting Information). The stakeholder composition (total number of stakeholder interests) and number of individual participants in the 34 programs varied considerably ( $x[SE] = 11 [2]$  and  $x = 900 [600]$ ). Thirty-two percent of the programs were homogenous in stakeholder composition ( $\leq 4$  stakeholder groups), and 68% were heterogeneous ( $>4$  stakeholder groups). Composition was not associated with the level of governance; however, programs prioritizing social effects of invasive species were more likely to be heterogeneous in composition ( $U = 61$ ,  $n_1 = 11$ ,  $n_2 = 24$ ,  $p = 0.01$ ). There was also a significant positive correlation between the number of stakeholder groups represented and the number of participants ( $r_s = 0.48$ ,  $n = 34$ ,  $p < 0.01$ ).

The principal approach to “representative voice” was to establish a committee or working group with representatives from many stakeholder groups (“symbolic voice”) and wider participant involvement in on-the-ground management activities. Stakeholders, including government bodies, conservation groups, animal welfare groups, law enforcement, indigenous communities, students, and urban communities, were underrepresented in 68% of programs. Respondents indicated that the representation was limited by program or stakeholder resources, stakeholder lack of interest or awareness, stakeholder objection to program activities, conflict (present, past, and fear of conflict), and initial lack of recognition of some groups as stakeholders (Supporting Information).

## SOCIAL OUTCOMES

Seventy-four percent of programs assessed stakeholder satisfaction (80% informal assessment and 20% formal or a combination of both). Stakeholders in 31 programs were perceived to be satisfied ( $x[SE] = 1.3 [0.13]$ ). In general, participation levels increased ( $x = 0.76 [0.17]$ ); representatives of only 3 programs reported a decrease in number of

stakeholder participants. Stakeholder satisfaction was positively correlated with change in number of participants ( $r_s = 0.38$ ,  $n = 28$ ,  $p = 0.05$ ) and negatively correlated with abundance of invasive species ( $r_s = -0.45$ ,  $n = 25$ ,  $p = 0.03$ ) (Table 5). Change in stakeholder interaction was perceived as mostly positive ( $x[SE] = 1.2 [0.12]$ ,  $n = 33$ ). Citizen-initiated programs had significantly greater cooperation than agency-initiated programs ( $U = 34$ ,  $n_1 = 15$ ,  $n_2 = 9$ ,  $p = 0.03$ ) (Table 5). Similarly, programs with a heterogeneous stakeholder group had a larger positive change in interaction than homogeneous groups ( $U = 5.9$ ,  $n_1 = 13$ ,  $n_2 = 20$ ,  $p = 0.02$ ). Nevertheless, most (88%) respondents reported some type of conflict, including conflict related to land tenure (56%), invasive species control methods (62%) and other issues (44%).

Occurrence of conflicts was negatively correlated with change in number of participants ( $r_s = -0.37$ ,  $n = 34$ ,  $p = 0.03$ ). Conflict over land tenure occurred primarily between government bodies and landowners. For example, stakeholders sometimes refused to allow control to be applied on their property. Some stakeholders thought there should be no control because the species had intrinsic, recreational, or economic value. Others were opposed to control methods they believed were inhumane (e.g., shooting) or were concerned about the death of non target species (e.g., pets) and access to rights and resources, particularly government funding or support (Supporting Information). Other challenges concerned resources (e.g., maintaining a funding source when the program was successful), public relations (e.g., negative portrayals of the program activities in the media), and public education and awareness (Supporting Information).

Respondents also suggested solutions to some of the social challenges (Supporting Information). Use of community coordinators and improving working conditions and structure (e.g., through providing wages where applicable and a fixed duration for leadership roles) helped motivate stakeholders to continue to participate in the programs. Methods of conflict avoidance included the “nil tenure approach” (not considering ownership boundaries in the decision-making process), training of management personnel in community engagement, participation of social scientists, and increasing public support through education. Stakeholders who were resistant to programs were dealt with in various ways, from integration into the program to take advantage of their expertise and to avoid future conflict to exclusion from the program to avoid conflict. Scientific data, as a justification for program actions, was mentioned by only one respondent.

**Table 5.** Relations among motivations for use of participatory conservation, stakeholder composition, participation methods, and social and ecological outcomes.

Variable	Feature of participation	Mean, SE, <i>n</i> (unless otherwise stated)	Variable	Relation
Motivations for using a participatory approach	community resource	4.0, 0.20, 34 <sup>a</sup>		ranked more important as a motivator than <i>consultation</i> ( $p=0.04$ ), <i>decision making</i> ( $p=0.01$ ), <i>gathering information</i> ( $p<0.001$ ), <i>obligation</i> ( $p=0.002$ ), and <i>social and political pressure</i> ( $p=0.05$ )
	consultation	3.5, 0.20, 33 <sup>a</sup>	effects of invasive species	positively correlated with <i>stakeholder conflicts</i> ( $p=0.05$ ); ranked more important as a motivator than <i>gathering information</i> ( $p=0.03$ ) and <i>obligation</i> ( $p=0.05$ )
	decision-making	3.2, 0.23, 33 <sup>a</sup>	effects of invasive species; level of governance	positive correlation with <i>economic effects</i> ( $p=0.03$ ); rated higher for <i>citizen governed</i> than for <i>agency governed</i> ( $p=0.05$ )
	education and informing	4.0, 0.14, 34 <sup>a</sup>	effects of invasive species	positive correlation with <i>environmental effects</i> ( $p=0.03$ ); rated more important as a motivator than <i>consultation</i> ( $p=0.05$ ), <i>decision making</i> ( $p=0.02$ ), <i>gathering information</i> ( $p<0.001$ ), and <i>obligation</i> ( $p=0.001$ )
	gathering information	2.9, 0.18, 34 <sup>a</sup>		
	obligation	2.1, 0.28, 34 <sup>a</sup>	effects of invasive species	positive correlation with <i>social effects</i> ( $p=0.04$ )
	social and political pressure	3.4, 0.23, 34 <sup>a</sup>	effects of invasive species	positive correlation with <i>social effects</i> ( $p=0.03$ )
Stakeholder composition	heterogeneous	68% of programs	effects of invasive species; change in stakeholder interaction	program driven by <i>social effects</i> more likely to be heterogeneous in composition ( $p=0.01$ ); more positive <i>change in stakeholder interaction</i> (i.e., greater cooperation) in programs with heterogeneous compared with homogenous stakeholder composition ( $p=0.02$ )
	homogenous	32% of programs		

**Table 5 continued**

Participation methods	activity-based	34 <sup>b</sup>	program initiator	used in a greater number of citizen-initiated than agency-initiated programs ( $p=0.03$ ); used in a greater number of programs than <i>consumerist</i> ( $p<0.001$ ), <i>innovative</i> ( $p<0.001$ ), <i>deliberative</i> ( $p<0.003$ ), and <i>democratic</i> ( $p<0.001$ ) methods
	consumerist	24 <sup>b</sup>		used in a greater number of programs than <i>democratic</i> methods ( $p<0.001$ )
	traditional	32 <sup>b</sup>		used in a greater number of programs than <i>consumerist</i> ( $p<0.001$ ), <i>innovative</i> ( $p<0.001$ ), <i>deliberative</i> ( $p<0.001$ ), and <i>democratic</i> ( $p<0.001$ ) methods
	innovative	25 <sup>b</sup>	level of governance	used in a greater number of citizen-governed than agency-governed programs ( $p=0.02$ ); used in a greater number of programs than <i>democratic</i> methods ( $p<0.001$ )
	deliberative	30 <sup>b</sup>		used in a greater number of programs than <i>innovative</i> ( $p=0.01$ ) and <i>democratic</i> ( $p<0.001$ ) methods
	democratic	3 <sup>b</sup>		
Social outcomes	stakeholder satisfaction	1.3, 0.13, 31 <sup>c</sup>	social outcomes; ecological outcomes	positive correlation with change in number of participants ( $p=0.05$ ); negative correlation with change in abundance of invasive species ( $p=0.03$ )
	change in stakeholder interaction	1.2, 0.12, 33 <sup>d</sup>	stakeholder composition; program initiator	more positive <i>change in stakeholder interaction</i> in programs with heterogeneous compared with homogenous stakeholder composition ( $p=0.02$ ) and in citizen-initiated compared with agency-initiated programs ( $p=0.03$ )
	change in number of participants	0.76, 0.17, 34 <sup>e</sup>	social outcomes	positive correlation with stakeholder satisfaction ( $p=0.03$ ); negative correlation with occurrence of conflict ( $p=0.03$ )
Ecological outcomes	change in abundance of invasive species	-0.90, 0.18, 28 <sup>f</sup>	program initiator; social outcomes	greater decrease in agency-initiated than citizen-initiated programs ( $p=0.03$ ); negative correlation with stakeholder satisfaction ( $p=0.03$ )
	change in environmental condition (e.g., species richness, abundance of rare species, habitat quality)	0.69, 0.18, 16 <sup>g</sup>	NA	not tested, small sample size
	change in agricultural condition (e.g., productivity)	0.73, 0.28, 13 <sup>g</sup>	NA	not tested, small sample size

<sup>a</sup> On a scale of 1 (unimportant) to 5 (very important) as a motivator for use of a participatory approach.

<sup>b</sup> Number of programs that used at least one technique relating to that participation method ( $n=34$ ).

<sup>c</sup> On a scale of -2 (very dissatisfied) to 2 (very satisfied).

<sup>d</sup> On a scale of -2 (increased conflict) to 2 (increased cooperation).

<sup>e</sup> On a scale of -2 (large decrease) to 2 (large increase).

<sup>f</sup> On a scale of -2 (large decrease) to 2 (large increase). Six respondents were unable to answer this question ( $n=28$ ); however, 6 respondents provided separate values for each targeted invasive species in their program (2-4 species each). The mean rating of change in abundance of invasive species for each program was therefore calculated before conducting statistical analyses.

<sup>g</sup> On a scale of -2 (large deterioration) to 2 (large improvement).

## ECOLOGICAL OUTCOMES

Most (85%) programs monitored abundance of invasive species either directly or indirectly, and overall a decrease in abundance was reported ( $x[SE] = -0.85 [0.17]$ ,  $n=38$ ) (Table 5). A significantly greater decrease in abundance was reported for agency-initiated than citizen-initiated programs ( $U = 19$ ,  $n1 = 13$ ,  $n2 = 7$ ,  $p = 0.03$ ). Sixty-two percent (21) of programs monitored environmental condition (i.e., habitat quality, species richness, and abundance of threatened native species), and in general, the values of these variables increased ( $x[SE] = 0.69 [0.18]$ ,  $n = 16$ ) (Table 5). Respondents associated with 12% of programs stated these variables were not monitored because reducing ecological effects of the invasive species was not a priority of the program. Forty-four percent (15) of programs monitored agricultural conditions (i.e., productivity of agriculture that had been affected by the invasive species), and overall these conditions improved ( $x[SE] = 0.73 [0.28]$ ,  $n = 13$ ) (Table 5). Respondents associated with 24% of the programs stated agricultural conditions were not monitored because reducing undesirable agricultural effects was not a program objective. Lack of data prohibited further analysis of ecological outcomes as a function of other variables (e.g., motivations for using a participatory approach, stakeholder composition, and participation methods).

Respondents reported monitoring was limited. Respondents based many of their ratings of environmental condition on anecdotal evidence or on data sets that did not provide the information needed to determine whether the program was having a clear ecological outcome. In some cases the lack of quantitative data was due to the early stage of the program. Respondents reported monitoring was limited. Respondents based many of their ratings of environmental condition on anecdotal evidence or on data sets that did not provide the information needed to determine whether the program was having a clear ecological outcome. In some cases the lack of quantitative data was due to the early stage of the program. Respondents also said lack of data was due to the inaccessibility of some locations and low abundance of rare species, which makes it difficult to detect changes in abundance (e.g., brush tail rock wallaby [*Petrogale penicillata*]). Respondents also said the effects of climatic change, such as bushfires, impeded the ability to detect whether the program was affecting invasive species abundance and ecological condition.

## Discussion

Examination of participatory invasive-species programs revealed possible relations between different participation features that may affect whether the programs' ecological and social objectives are achieved. Direct causes of management outcomes were difficult to identify and many variables were associated with program success (e.g., Duram & Brown 1999). However, our results provide an empirical overview of the relation between stakeholder participation and outcomes of management of invasive vertebrates in Australia.

Previous studies highlight that government provides considerable resources and infrastructure, especially on federal lands (e.g., McKinney & Field 2008). Government issues mandates and provides information, funding, and other support (e.g., convening and promoting participation) in collaborations, including those in which government institutions act as facilitators rather than governing or dominating the process (Koontz et al. 2004; McKinney & Field 2008). Government was the greatest source of funding of programs in our study; no program was funded solely by citizens or community groups, although the majority of the programs were citizen initiated. Furthermore, citizen-initiated programs were often governed by the government, which may be a necessity where extensive cooperation and considerable funding is needed and where citizen empowerment alone may not be sufficient to achieve ecological and social outcomes. The infrastructure of and resources available to government authorities may contribute to the greater reported reduction in abundance of invasive species in agency-initiated programs than in citizen-initiated ones. The effect of the invasive species appeared to be strongly associated with this relation. Environmental effects were ranked as the strongest motivator of stakeholder participation regardless of program initiator. However, economic effects were ranked as stronger motivators of citizen-initiated than agency-initiated programs. This may be because responsibility for controlling invasive species that have been legally declared pests resides with the landowner (e.g., Rural Lands Protection Act 1998, New South Wales). Therefore, agricultural communities, not the government, are the primary initiators of programs to manage invasive species that affect agricultural livelihoods, although some respondents noted that government intervention might be required where public lands adjoin private properties (Supporting Information).

Satisfaction with the participatory process may be affected by management outcomes (McKinney & Field 2008). Respondents who reported a greater reduction in abundance of invasive species tended to report higher stakeholder satisfaction. Perception of environmental outcomes may be more positive than the reality where there are higher levels of interpersonal trust (a social outcome) in a partnership (Leach & Sabatier 2005). Whether managers we interviewed, who have access to data on ecological outcomes, have unrealistically high positive perceptions is unclear because it is possible that their rankings of social outcomes (i.e., stakeholder satisfaction) were exaggerated if they presumed greater participant satisfaction when ecological objectives were achieved.

Our determination of the relation between social outcomes and other variables was limited by reliability of data and measures of success. We focused on managers' perceptions of ecological and social outcomes rather than analyzing the views of stakeholders themselves. However, managers' perceptions are likely to be affected by their role in the programs. Participant satisfaction as a measure of social outcomes has been criticized. For example, satisfaction of participants does not necessarily equate with effectiveness of policy at achieving outcomes and addressing public interests (Coglianese 2003). In our study, stakeholder satisfaction was assessed in the majority of programs. Some assessments were formal, for example through stakeholder surveys, but most were informal, through discussions with stakeholders and personal observations of managers. The reliability of informal methods may be limited. Other measures of social outcomes, such as participation rate, can be used to validate inferences about stakeholder satisfaction.

Change in number of participants was correlated positively with stakeholder satisfaction and negatively with occurrence of conflicts. Participation rate may not be a reliable measure of social outcomes and program success because stakeholders may stop participating, not because of dissatisfaction with the specific program, but to gain benefits from the program without incurring the costs of active participation (free-riding) (Focht & Tractenberg 2005). Trust of authorities or other stakeholders may also influence decisions in whether to participate (Focht & Tractenberg 2005; Leach & Sabatier 2005), and stakeholders may not participate for other reasons (e.g., limited resources due to drought [Supporting Information]).

If data from monitoring demonstrate that the ecological outcomes are achieved, the probability of achieving social outcomes may increase (Braysher & Saunders 2003).

Monitoring also provides accountability to the public and funders (Field et al. 2005). Monitoring data collected through the programs in our sample were often insufficient for determining ecological outcomes of the programs, despite stakeholder participation in monitoring of animals, and gathering information was one of the least important motivators of participation. Monitoring by participants has the potential to provide reliable data. Data collection by participants can also increase public understanding and appreciation of science and the environment, and can lead to changes in lifestyle (Lawrence 2006; Bonney et al. 2009).

Contrary to observations of collaborative partnerships in watershed management in which partnerships with agencies represented fewer interests (Bidwell & Ryan 2006), we found that the level of governance and program initiator were not related to stakeholder composition. However, respondents reported a greater increase in cooperation in programs in which stakeholder composition was heterogeneous. Similarly, although conflict in heterogeneous groups may initially be greater than in homogeneous groups, heterogeneous groups more frequently produce tangible outcomes, such as action plans, and improve their group interactions over time (Bidwell & Ryan 2006). This result is consistent with best-practice guidelines for inclusivity in participatory programs (Jackson 2001; Reed 2008). However, underrepresentation of stakeholders occurred (also reported by Bidwell and Ryan [2006] and Leach [2006]) (Supporting Information). Leach and Pelkey's (2001) review of collaborative watershed studies showed that adequate funding is the biggest obstacle to collaborations in watershed projects and a diverse membership is important for success. Conflict among stakeholders was identified as a common problem in our study. Increasing participation of stakeholders from different groups and reducing conflict among participants may be encouraged by improving the community-engagement skills of program staff, which is likely to be particularly important for agency-initiated and agency-governed programs. For these types of programs, improvements in stakeholder interactions and the use of innovative methods were lower than for citizen-initiated and citizen-governed programs.

Involving stakeholders in upper-level program administration (e.g., in decision making) is considered beneficial for relations between different stakeholders because it builds trust and improves communication (McKinney & Field 2008). In our study, involvement of stakeholders in decision making in agency-governed programs was significantly lower than in citizen-governed programs. Participation theory suggests that low-level participation is



effective at early stages of a program, when stakeholders are poorly informed on an issue. However, when the community is aware, higher levels of participation become effective (Jackson 2001). We found that environmental effects of invasive species, which were a stronger motivator in agency-initiated programs, were positively correlated with “education and informing” (low-level participation). Education may be a more relevant approach to stakeholder participation than decision making if landowners are not participating in control efforts due to lack of awareness or interest in conservation (Supporting Information). Economic effects, which were stronger motivators for citizen-initiated programs, were positively correlated with decision making, which is an effective level of engagement in situations where stakeholders are already aware of the issues (e.g., loss of agricultural productivity due to invasive species).

Consistent with the results of other studies, including those on watershed management in the United States, we found that government had a large role in providing funding for participatory programs (e.g., Koontz et al. 2004; McKinney & Field 2008) and in governing citizen-initiated programs. Similar to the results of other studies (e.g., McKinney & Field 2008), participants were reported to be mostly satisfied with the program outcomes. We also found that the ecological outcome of decreased abundance of invasive species and the social outcome of stakeholder satisfaction were linked. The similarities between our results and those of Koontz et al. (2004) and McKinney and Field (2008) likely reflect that these researchers assessed environmental management over large geographic extents in which lands were owned by multiple people. We believe our findings may be applicable to a wide range of participatory species conservation programs.

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## **Supporting Information**

The interview-based questionnaire (Appendix S1), basis of classification of participation features (Appendix S2), stakeholder groups participating in the programs (Appendix S3), causes and examples of underrepresentation of stakeholders (Appendix S4), causes and examples of conflicts and challenges (Appendix S5), and solutions to conflicts and challenges (Appendix S6) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the materials) should be directed to the corresponding author.

## CHAPTER III

### SOCIAL AND POLITICAL MECHANISMS AND CONTEXT

#### **Preface**

The previous chapter investigated the relationships between different features of stakeholder participation, in the context of invasive species management across Australia. The analysis used pre-defined typologies to describe the different processes of stakeholder participation, and revealed several important relationships to help explain how and why different processes take place, and what effect this may have on management outcomes. However, the approach to invasive species management may also be influenced by other factors not addressed in Chapter II. In particular, the context in which environmental management takes places - not only the ecological, but also the social and political context - is important for determining the most appropriate conservation 'tools' or mechanism to achieve conservation objectives (Brechin *et al* 2002). This may be particularly true for invasive species management, which can be highly influenced by political and social factors (Robbins 2004), and which in some cases may be described as a 'wicked' policy problem due to the conflicting values and political influence in the management process (Nie 2003; Chapple 2005). The management of invasive deer in Australia may be considered as one of these 'wicked' policy problems, with a pervasiveness of stakeholder conflict surrounding their management, as a result of different values and opposing perceptions of the positive and negative impacts of deer (Moriarty 2004<sup>a</sup>; Finch & Baxter 2007). Conflicts may also be compounded by complications surrounding legislation and the management of deer as a game species (Jesser 2005). Deer management in New South Wales exemplifies these conflicts and the influence of society and politics on management, particularly due the state's unique governing body for licensed volunteer hunting, the Game Council NSW.

Failing to respond to the social and political context can hinder the achievement of positive ecological and social outcomes- conservation objectives may not be met, and stakeholder relationships may break down (e.g. Chapple 2005). Therefore, the links between context and mechanisms used in invasive species management need to be further explored if management objectives are to be met.

This paper aims to answer the following research question: what social and political mechanisms are used for encouraging appropriate management of invasive species and what are the opportunities and limitations of these mechanisms in a social and political context? In-depth interviews were conducted with key stakeholders relating to the management of deer in the Royal National Park in New South Wales. Social and political mechanisms were identified along with several ‘context themes’ - social and political factors that relate to the implementation of the mechanisms, using a ‘bottom up’ approach based on the principles of grounded theory (Bryman 2008). Opportunities and limitations of these context themes on the mechanisms were identified, thus providing direction for responding to the complex social and political context to help achieve management objectives.

This paper thereby helps to answer the core question of the thesis through: (a) identifying mechanisms that are predominantly social or political in nature (as opposed to ecological mechanisms), but that may help to achieve both ecological and social outcomes; (b) identifying social and political factors in invasive deer management which relate to these mechanisms; and (c) examining how they limit or provide opportunities in achieving management objectives.

# **Implications of social and political context for mechanisms in invasive species management**

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**Running title:** Social and political context for mechanisms in invasive species management

## **Abstract**

Conflicts in conservation are a result of differing values, experiences and perceptions. This provides a challenge for managers as there will inevitably need to be compromise by some (if not all) stakeholder groups. To minimise conflict and improve outcomes, management mechanisms need to be in place that are appropriate to the social and political, as well as ecological, context. We aimed to identify such mechanisms in relation to invasive species management, which provide a classic example of value-laden conflicts in conservation. We used a case study of invasive deer in New South Wales, Australia, with a particular focus on a high-profile national park with a history of conflict over deer. Given the central role of stakeholders in conflicts, we used qualitative analysis of interviews with key stakeholders, using an approach based on grounded theory where emerging themes were identified. Three key mechanisms emerged - *legislation, cooperative arrangements* and *community engagement* - along with two facilitating mechanisms, *funding and resources*, and *knowledge, research and development*. We reveal how several different ‘context-themes’ are related to these mechanisms, for example how community engagement may be used to change culture, how managers need to respond to core values of society, the effectiveness of political action in changing legislation and management approaches, and the importance of relationships with interest groups for maintaining continuity of management and public support. Our analysis highlights the need to consider social and political context in conservation programmes, and to incorporate this into communication at all stakeholder levels, in order to achieve ecological and social objectives.

## **Introduction**

Conflict over biodiversity conservation often arises because values and ideologies can differ between stakeholder groups, and decisions may be made (or perceived to be made) in favour of certain interests over others (Bennett *et al* 2001). Different experience and perception of wildlife impacts can also contribute to conflict, however such ‘human-wildlife conflicts’ can be also influenced by other underlying factors including culture, power and wealth (Dickman 2010). Such conflicts are often argued to be as much about managing humans as about managing wildlife (Mascia *et al* 2003, Peterson *et al* 2010). This creates a challenge in conservation- how to develop mechanisms for achieving social and ecological outcomes that are appropriate and effective, given that there are diverse groups of stakeholders involved and that inevitably compromises will be necessary.

Managers need to develop a response within the social, political and ecological context if the approach is to be effective (Brechin *et al* 2002).

Invasive species provide a classic example of how different stakeholder groups can have considerably different values, perceptions and knowledge, often resulting in conflict (García-Llorente *et al* 2008, Webb & Raffaelli 2008). Invasive species are a significant threat to biodiversity in many parts of the world, often combined with economic and social impacts (Pimentel 2011). As a result, invasive species are frequently the subject of lethal control and eradication programmes (Mack *et al* 2000). Public attitudes differ towards the type of species and the control methods used (Fraser 2006), affected by different value orientations (Sharp *et al* 2011), demographic factors and awareness (Bremner & Park 2007), and external influences such as the media (Webb & Raffaelli 2008). Social benefits (such as hunting) and cultural associations can influence attitudes (White *et al* 2011), and there are also moral arguments surrounding making a distinction between native and non-native species (e.g. Peretti 1998; Davies *et al* 2011; Simberloff 2011) and potential conservation benefits (Schlaepfer *et al* 2011). Attitudes towards invasive species and their management have become more understood through such studies, but questions still remain on how to achieve effective management given such diverse viewpoints and influencing factors. There are some studies addressing the broader social and political context of invasive species, for example in relation to feral horse management (Chapple 2005; Nimmo & Miller 2007). These studies have illustrated the detrimental result of failing to account for the social and political context when managing invasive species, creating an obstacle for achieving ecological goals. The studies also highlighted the need for appropriate mechanisms to minimise conflict and improve management, such as community consultation (Chapple 2005), and education (Bremner & Park 2007; García-Llorente 2008).

In this paper, we examine possible social and political mechanisms for encouraging appropriate management of invasive species, and we evaluate the opportunities and limitations of these mechanisms in the social and political context. We focus our study on the management of invasive deer in New South Wales (NSW) in Australia, with particular reference to rusa deer (*Cervus timorensis*) management in Royal National Park (RNP), due to the park's ecological, political and social importance in Australia (NSW National Parks and Wildlife Service 2000). Australia suffers from significant environmental, economic and social impacts from invasive species, including numerous extinctions

(McLeod 2004, Reddiex *et al* 2006, Gong *et al* 2009). In Australia, six species of non-native deer have formed wild herds, having been introduced by acclimatisation societies in the 19<sup>th</sup> and 20<sup>th</sup> centuries, typically for hunting (Bentley 1998). Conflict surrounding deer management is a growing problem in Australia (Moriarty 2004<sup>a</sup>), and indeed worldwide (Côté *et al* 2004). Conflict arises primarily because deer are often considered an important hunting resource (White & Ward 2010) and a charismatic species, in addition to having negative ecological, social and economic impacts (Moriarty 2004<sup>a</sup>). Although our analysis focused on deer management in the RNP, deer management issues on a broader scale in NSW and Australia emerged. The links between, and responses to, social and political context and management strategies may also have applicability to other invasive species management programmes.

## **Methods**

### CASE STUDY

#### ***Background legislation***

Legislation relating to deer differs across Australia, with Victoria, Tasmania and NSW listing deer as a game species (therefore partially or fully protected), whilst in other states deer are largely controlled as a pest (Hall & Gill 2005, Moriarty 2004<sup>a</sup>). In NSW deer are also listed as a Key Threatening Process (KTP) under the *Threatened Species Conservation Act 1995*, due to herbivory and environmental degradation, and are thereby managed as a pest in national parks, under the *National Parks and Wildlife Act 1974*. This typically involves culling using professional shooters employed or contracted by NSW National Parks and Wildlife Service (NPWS), which is under the authority of the NSW Office of Environment and Heritage (OEH). Game hunting is prohibited in national parks in NSW, however deer are managed as a game species under the *NSW Game and Feral Animal Control Act 2002*. This allows restricted hunting by licensed volunteer hunters on public land that has been declared for hunting (including some State Forests and Crown Land), and private property (with permission) under authority of the Game Council NSW. Additionally, the *Deer Act 2006* provides legislation on the ownership and control of deer on private lands (including deer farms) under the authority of NSW Department of Industry and Investment.



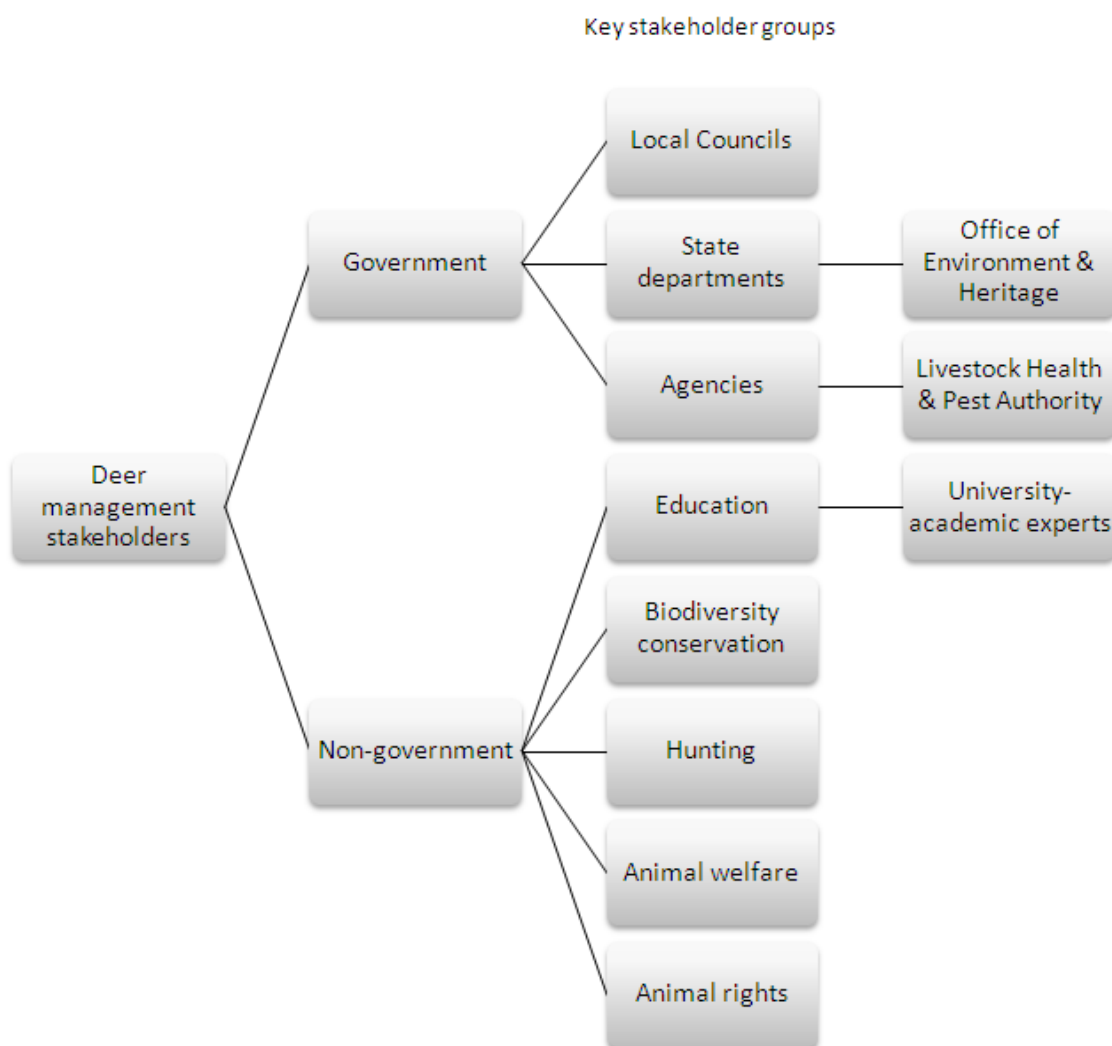
## ***Royal National Park***

Situated on the eastern coast of New South Wales (NSW) in Australia, approximately 32km south of Sydney, The Royal National Park (RNP) is important ecologically (containing threatened ecosystems), socially (listed in Australia's National Heritage List, and receiving high visitation), and politically (being Australia's oldest national park, and the second oldest in the world) (NSW National Parks and Wildlife Service 2000). Escaped rusa deer from an enclosure, constructed inside the RNP in 1906, eventually resulted in deer-related ecological and social impacts within and around the park (including property damage and deer-vehicle collisions) (NSW National Parks and Wildlife Service 2005). There has been a history of community division on the issue of deer culling in the park, leading to court action and suspension of activities following bushfires in 1994/1995 (Shephard 2002). Following this, a Deer Working Group (established in 2000) implemented community engagement strategies and developed deer management plans for the park. Ground shooting by trained NPWS staff is currently used to manage the deer population, and in 2007 a Memorandum of Understanding between Sutherland Shire Council and NSW NPWS was developed for the management of deer migrating onto adjacent council land, using contracted shooters.

## **INTERVIEWS**

We mapped the key stakeholder groups relating deer management in NSW, with a particular interest in the RNP, using the stakeholder groups present in the RNP Deer Working Group as a basis (Figure 1). This included government and non-government stakeholders, covering a range of interests including hunting, conservation and 'pest management', animal welfare, and education. Although not present on the Deer Working Group, we also included animal rights groups, due to their past and potential influence on deer management (Shephard 2002). These categories are not mutually exclusive and some respondents fell into more than one category (e.g. conservationists who hunt recreationally), however the purpose of the analysis was not to make direct comparisons between interest groups but to gain a wide perspective of the issues. Between February and July 2009 we identified and contacted at least one stakeholder from each stakeholder group. All stakeholders contacted, bar one, responded to the request, and all who responded agreed to the interview, however one stakeholder was subsequently unable to

participate. We interviewed a total of 18 key stakeholders. All interviews were conducted in person and recorded, except one which was completed in writing. The consultations were semi-structured, using a topic guide to prompt discussion but which was used adaptively, encouraging elaboration on issues of interest and concern to the participant. The topic guide covered views on deer management strategies, conflicts and challenges, and collaboration and partnerships, in order to address a range of angles that might link to the social and political context.



**Figure 1.** Visual representation of key deer management stakeholder groups

## ANALYSIS

Interviewees were assigned ID codes, relating to the stakeholder group to which they predominantly fell. This was done for purpose of clarity, but was not intended for analytical comparisons between different stakeholder groups. The coding used was as follows: H1-H5 (hunting stakeholders, including Game Council and hunting non-government organisations (NGOs)); CA1-5 (conservation authorities (OEH) including managers and rangers); CN1 (conservation NGO); P1-2 (pest management stakeholders, which included local council and Livestock Health and Pest Authority respectively); AR1-2 (animal rights activist and NGO respectively); AW1-2 (animal welfare NGO); and E1-2 (academic and veterinarian deer experts respectively). The data were analysed using Atlas-Ti<sup>®</sup>. We began the analysis with two pre-defined families of social context and political context, and within this we identified emergent sub-themes which we termed 'context-themes'. This was done using a grounded theory approach (Strauss & Corbin 1990; Bryman 2008). As well as context-themes, we also identified emergent key mechanisms that were aimed at improving ecological and social outcomes. The final part of the analysis involved identifying links between the mechanisms and context-themes and implications for management.

## Results

Three key mechanisms emerged in the analysis- legislation, collaborative arrangements and community engagement. Two facilitating mechanisms also emerged - funding and resources, and knowledge, research and development. For each key mechanism, benefits and limitations are presented, followed by the social and political context, described as context-themes (Table 1).

**Table 1.** Social and political context of key social mechanisms for the management of invasive deer.

Mechanism	Context-theme	Examples of relationship between context and mechanism
Legislation	Political action	Legislation changes as a result of hunting interests represented in parliament, and political strategy for establishment of government body to facilitate hunting (Game Council NSW).
	Alignment with society	Incorporation of deer control policy into a broader ‘feral animal’ policy more acceptable to society; non-legislative measures used for discouraging trophy hunting, where legislation may be opposed or ineffective.
	Political history	Influence of peace and environmental movements of the 1960s on firearm and hunting legislation, and reactionary legislative responses to firearm use following specific events e.g. Port Arthur massacre in Tasmania.
Collaborative arrangements	Political ideologies	Political cooperation limited by differing political ideologies on managing deer as a pest vs. resource, and different stances on the role of national parks.
	Interest group relationships	Value of political cooperation with interest groups, for example due to continuity of knowledge and experience in environmental issues (e.g. National Parks Association) and to help gain public support (e.g. RSPCA); counter-intuitive political alliances can form for strategic gain (e.g. animal rights and hunting group alliance).
	Social context of participation	Participation in collaborative management hindered due to perceived association of licensed hunters with illegal poachers, and due to trophy hunting culture; community cooperation to reduce poaching can facilitate participation.
Community engagement	Political sensitivity	Political sensitivity to public attitudes limits use of control methods (e.g. licensed volunteer hunting, aerial shooting); political sensitivity facilitates conservation objectives where public demand management action.
	Core values	Satisfying core values, such as animal welfare and human safety, and effective communication of protocols for achieving these values is necessary for public support.
	Political history and culture	Community engagement strategies used to change culture of trophy hunting and to alter negative public perception of hunting.

## LEGISLATION

As well as having an obvious role in facilitating and restricting management approaches, legislation was also reported as being supportive through indirect means, such as increasing available *funding and resources*. For example, the listing of deer as a Key Threatening Process (KTP) was stated to have increased the funding made available for

regeneration of deer-impacted ecological communities. The listing (as a KTP) was also stated to have helped reduce conflict over the degree of ecological impact of deer [P1], thereby helping to achieve positive social outcomes. The main limitations of legislation fell into three themes - design, foundation and necessity:

- i) *Design*: Legislation can act as a limiting mechanism if it is complex or contradictory, for example the legislative status of deer was criticised for the different statuses in different legislative acts [E2]. Related to this, deer not being listed as a ‘pest’ in NSW was stated as a limit to effectiveness [P1, C3-5]. Poor design and implementation was also of concern. This was particularly apparent with the *Deer Act 2006*, where it was argued that was a case of poor timing, “closing the gate after the horse has bolted” [P2], highlighting the need for a precautionary rather than reactionary approach to invasive species legislation. It was also described as lacking power and the resources for it to be enforced effectively [P2, C3].
- ii) *Foundation*: Legislation may also be considered inappropriate if the knowledge-base is contested, for example the decision to include all species of deer in Australia as a KTP based predominantly on research into impacts of just one species [E2, H2].
- iii) *Necessity*: Too much legislation was also considered as an impediment [H5], and may result in inefficient use of resources. This can apply both at a bureaucratic level, where it was argued that excessive bureaucratic processes are costly and leads to inefficiencies [H3, C1], but also on the ground, where it was argued that legislation prohibits the use of end-products from invasive species control (such as venison), and restrictions to obtaining shooting permits can have indirect animal welfare issues, by leading to an increase in poisoning of invasive species [H1].

Three context-themes emerged relating to legislation - political action, alignment with society, and political history:

**i) Political action.** A pro-active and vocal political approach facilitated changes in political direction and legislation, and was considered an important factor in achieving objectives. This was demonstrated with hunting interests, which had gained representation in parliament [H2] and access for hunting on some public land [H1, H3, H5, P1, C3, C5]. The existence of the Game Council NSW was considered to play a vital role in initiating and maintaining this political direction and legislative changes [H1, H3-4], along with the

promotion of a more open and vocal hunting culture [H3], as expressed in the quotation below:

*“Hunters have traditionally slipped under the radar, don’t say too much, be nice and quiet about it, slip under the radar and no one will know we are there and we’ll just keep on doing what we are doing. But lately we’ve realised in this state, that’s no good, we’ve got to stand up, get political, get some representation in parliament, put forward good aims, and get some runs on the board. Prove what you want to do is good for society. That’s what the Game Council is achieving now, through its recreational hunters, its licensed hunters.”*

[H3]

**ii) Alignment with society.** In terms of forcing social change, limitations of legislation were evident. However, efforts to align legislation with social context, where feasible, was thought to facilitate its implementation. This was exemplified by differing attitudes towards established and emerging ‘pests’, affected by cultural associations formed primarily through on-going public education (thus linking to *community engagement*). This was demonstrated by the relative acceptance of the lethal control of rabbits, which had been historically depicted as a pest in Australia, compared to deer control [P1]. To tackle this, strategic design of policy was required to gain public support, drawing upon the acceptance of invasive species control on a generic level, as illustrated below:

*“They adopted a feral animal policy. We couldn’t get deer through by themselves- we tried the first time with a deer policy, but it still seemed like they were cute and cuddly, no one would want to shoot deer, but when we wrapped it up in a feral animal policy, people are more used to it... rabbits, even though rabbits are cute and cuddly, we’ve had generations of education and things on TV that rabbits have done all this damage, so people are like ‘oh yeah, we know’. But they haven’t been educated about deer yet”* [P1]

Poor alignment between society and legislation was also exemplified by aerial culling, which was supported legislatively but not by the public [CN1]. Poor alignment was also argued by one stakeholder with respect to hunting:

*“However long man has been on this planet, they have hunted. So if you think you are going to legislate and pass a piece of paper over the table that’s going to remove that desire from a significant proportion of the population, you are not being real.”* [H4]

Where social acceptance of legislation is problematic, it was recommended that other intervention may be used as an alternative to legislation (at least initially), as one stakeholder suggested for reducing the practice and culture of trophy hunting:

*“I don’t think we want to be legislating at this stage. It’s a gradual thing. Australian hunters are only just getting used to having to buy a licence to hunt, and that’s only to hunt game animals on public land. I don’t think we ready to force them into ‘you will take this,*

*you won't take that', instead 'if you want to be a member of this game management group, that's what you must do to stay in the group. If you want access to good hunting, you've got to do the right thing.'"*[H3]

**iii) Political history.** Political history, and a reactionary approach to legislation has helped shape legislation surrounding firearm use and deer hunting, along with the government approach to national park management (see also *political ideologies*). For example, the 1960s Peace Movement was described as being linked with an anti-gun movement occurring on an international level, and with the Green Movement within Australia, as illustrated below, aided by the ability of these movements to gain public and financial support [H3, H5]:

*"I think back in the 40s, people would travel around town with a rifle over their shoulder, heading out to Campbelltown to shoot some rabbits. It was quite accepted. I think it's probably since the 60s- the Vietnam War, the Peace Movement- because there were no Greenies prior to the Peace Movement in the mid 60s, late 60s. [H3]*

Legislative changes were also thought to be accelerated by specific events. For example, a fire-arm related massacre at Port Arthur in Tasmania in 1996 led to reactionary legislative changes to firearms use within Australia [H1].

## COOPERATIVE ARRANGEMENTS

Cooperative arrangements included political cooperation, collaborative decision-making, and collaborative management. Several advantages of cooperative arrangements emerged. For example, committees aimed at collaborative decision-making (such as the Deer Working Group for the RNP) were thought to have contributed to a reduction in stakeholder conflict, a gaining of wider public support [AW1], sharing of viewpoints [AW1, H3], improved knowledge transfer [P2] and acknowledgement of responsibilities [CN1]. The range and choice of representatives was thought to be important for successful collaboration [H3, CN1], particularly the involvement of RSPCA [C5], along with maintaining regular feedback to members [AW1, CN1]. Collaborative management typically involved deer management over different tenures including private and public land [C5]. The necessity of such cooperation appeared to come from migration of deer across different land tenures, combined with formation of new populations [H2, C1, C5]. New populations were described as forming from illegal releases of deer into the wild (an issue of concern in Australia [P1, C1-2, C4-C5, H5, CN1]) which was attributed to both

hunters and to the deer farming industry, combined with economics and climate. For example, the declining value of deer, combined with the effect of droughts, was stated as leading to the failure of deer farms and consequently deliberate release of their herds [E1-2, H1, P1, C4-5]. Political factors also contributed to the need for collaborative management, in particular legislative responsibility over deer in different jurisdictions, particularly with regard to deer migration out of national park estate onto neighbouring property [P1, C1, C4-5]. Although collaborative management may be an effective mechanism [H1, H3-5, P1, C5], it was considered as a gradual process [C2].

Three context-themes emerged relating to collaborative arrangements - political ideologies, interest group relationships, and social context of participation:

**i) Political ideologies.** Political cooperation was described as being hindered by conflicting political and management ideologies [H1-5, C4], therefore compromises may be necessary for cooperation to succeed. In particular, the different approach of managing deer as a 'pest' and as a sustainable resource appeared to limit prospects for political collaboration or partnerships [P1-2, C1, CN1], creating a political "*stand-off*" [C1], and compounded by Game Council's opposition to listing deer as a pest in NSW [P1]. National Park management was also described by some stakeholders as having a 'lock-it-and-leave-it' approach, focused solely on conservation objectives with an entrenched 'green' ideology [H1-3, H5]. Societal benefits from the environment appeared to be increasing in importance as a management objective in NSW [P1, CN1, C4], although this was also met with resistance by some stakeholders [P1, CN1]. However, these changes did not extend to permitting licensed volunteer hunting in national parks, which would have required a legislation change, and one stakeholder suggested it would require a 'top-down' political-cultural change [H5]. As well as ideological and practical arguments (such as impact of hunting on other recreational activities on public land [P1, C1, CN1]), distrust appeared to limit political cooperation, compounded by various factors, including misrepresentation of facts [H4, AR1, C4], and using the media to make public 'snipes', which was said to exemplify the need for a united approach to deer management [H5]. To achieve political cooperation where there are conflicting ideologies, communication, understanding and trust is therefore needed. For example, despite the problems, political cooperation between OEH and Game Council NSW had been successful in some cases, aided by mutual respect, and a compromise by Game Council of managing deer as a pest rather than game [C5].



**ii) Interest group relationships.** Informal political cooperation resulted from interest group pressure, alliances and collaborative partnerships such as working groups. Such cooperation appeared to be a valuable management tool as interest groups may be influential and resourceful, although there was some indication that such relationships may need to be managed carefully. For example, alliances between some conservation groups (such as National Parks Association (NPA)) and OEH were well recognised, having an often powerful influence on national park policies, particularly through an advocacy role [H1-2, C1, CN1]. Interest groups were stated as being of particular value due to their continuity of involvement in environmental issues, whereas government departments may have frequent turnarounds, as described in the following quotation:

*“...groups such as NPA...who have had long term attachment to these issues, and have cultural knowledge to what has happened, are in fact the keepers of the knowledge of what has happened over a long period of time in an area. ... I have more faith in community groups being the conscience of government and bureaucrats as to ways of approaching deer problems and pest problems in ways that have continuity... So, I don't put my faith in any government to be able to see this sort of thing through. A lot of the advances in pest management have come through hard work and continual advocacy by community groups.”*

[CN1]

Relationships between interest groups and government appeared dynamic, but were facilitated by collaborative decision-making and partnerships. For instance, the relationship between OEH and RSPCA progressed from RSPCA previously taking out injunctions, to working in collaborative decision-making [AW1], which was important for gaining public support. Informal political cooperation may also have occurred between interest groups. Alliances between interest groups revealed a counter-intuitive political process, whereby alliances were made between interest groups with ultimately conflicting objectives. This was demonstrated by the alleged alliance between animal rights and hunting groups, both having an objective of maintaining a deer population in the RNP yet with obviously conflicting ideologies with regards to the killing of animals [P2, C5], as illustrated in the quotations below:

*“...you had the animal liberation, so those people who were against any of them being killed, actually aligned with the hunters, who wanted to kill them; they actually became allies against anything being done about the deer.”* [P2]

**iii) Social context of participation.** Participation in collaborative management was in some cases hindered by social context. Landowners were said to be at times reluctant or

sceptical about cooperation and participation [H1, H4-5, C5], restricting access to their property for deer management [H1, H3, P1-2], due to the social context of hunting. In particular, illegal poaching was stated as creating a negative reflection on legal licensed hunters [P2, H3, H4], resulting in a lack of trust which can hinder collaboration, as described below in relation to licensed hunting on private properties:

*“There’s a lot of lies told...what we are finding with the illegal hunters, the poachers, the blokes that have got the place locked up, spreading a lot of rumour. It’s very hard, mud sticks... They sneak out in the night-time, and use silencer firearms and there’s a bit of archery here. It gives hunters generally a terrible name. Because if a deer wanders out with an arrow stuck out of it from a poacher...”* [H3]

However, cooperation within communities, in conjunction with improved *legislation* and enforcement, was suggested as a method of combating illegal activities, as expressed in the quotation below, thus potentially reducing the disincentive to participate:

*“It [illegal hunting] is something that you can target, but it’s got to be a community based response to it, it can’t just be us, it’s got to be the landowners as well as us and the police.”* [H5]

Participation was also thought to be hindered by the culture of trophy hunting, which was practiced on some private properties [H3, C5]. Hunter and landowner education may therefore be required to change this practice (see *community engagement*).

## COMMUNITY ENGAGEMENT

Community engagement emerged as an important mechanism for assessing and gaining public support for deer control programmes, and for achieving collaborative management [AW1, P1, C1, C4, H5]. It may have been particularly vital as public attitudes towards deer and their management were described as being polarised [H1-2, H4 AW1, P1, E1, C1, C5]. Different experience and perception of impacts contributed to this polarisation, for example negative social impacts such as property damage [P1, C2, C4-5], and positive impacts including aesthetic value of deer [E1-2, H1, C1, AR1], and their role as an iconic species hunting [H5]. Community engagement was considered as a democratic function, through management *“on behalf of the community”* [C1], and necessary for breaking down communication barriers [C1]. However community engagement was also thought to be limiting, for example involving wider society (rather than just those affected by deer impacts) was described as increasing debate [P1] and public opinion was thought to not reflect the best approach for achieving outcomes [H4]. Several strategies for effective community engagement emerged. These included pilot assessments of community

attitudes before undertaking an engagement strategy [P2, C5], and concentration on the core majority of the public who are still persuadable (rather than the already converted or the opposition) [P2, H1, C4]. Transparency of operations was stated as important [C4-5], along with pitch, requiring communication at an appropriate level and limited complexity [H4, P2]]. A strategy of “*talk with actions*” [H3] also emerged, including demonstration of successful examples of licensed volunteer hunting [H3] and demonstrating shooting procedures first-hand to key stakeholders (e.g. RSPCA and government ministers) [C4]. Media was also stated as being a useful community engagement tool [H5, C5] although it was also recognised as sometimes having unfavourable affects for social acceptance [P1, C1] and can be used to present inaccurate information [C4]. Those who have not experienced direct negative social impacts were thought to be less likely to understand the ‘deer problem’ [AW1, P1], and more likely to be influenced by the media [AW1].

Three context-themes emerged relating to community engagement - political sensitivity, core values, and political history and culture:

**i) Political sensitivity.** Public attitudes were revealed to affect policy and management due to political sensitivity, which reflects governments’ need for public support and re-election. This can also influence whether, and when, *legislation* may be passed. Community engagement therefore can become necessary in order to gain public support, and to harness political response in favour of management objectives. For example, political sensitivity and lack of fortitude were stated as a reason that the government failed to adopt a licensed volunteer hunter approach in national parks [H1, H4], and aerial culling following severe bush fires in 1994 [CN1]. The influence of public opinion on politics was considered significant, however the ability of the wider community to make environmental decisions was debated, as expressed in the following quotation, and there was argument that the public’s role in decision-making should be limited [C3]:

*“Unfortunately, politics will manage the situation, it won’t be managed on what’s good for the deer or anything else, it will be managed by what’s good for the politicians to be re-elected, and that will be based on their perception of the community view, and the community view doesn’t have to be right. It’s just the way democracy works. If the majority are wrong, that’s where it’s going to go anyway”* [H4]

Government sensitivity to public support was also shown to work in favour of, rather than hindering, management action and achieving ecological objectives. Whereas initially government bodies (such as local councils) exercised caution or doubt in undertaking lethal control of deer, a change in community attitudes towards deer (which can result

from engagement strategies) and subsequent demands for deer control [P1], led to governments fearing backlash if they *failed* to undertake management action. This appeared to be particularly apparent where human safety was of concern, for example increases in vehicle-deer collisions [H1]. One stakeholder even suggested that the deer control occurring in the RNP was ‘window dressing’, in order to appease the community’s demand for action [H5].

**ii) Core values.** Public support for invasive species management primarily gravitated around two core values, human safety and animal welfare [C4]. Realisation of these values may be achieved through appropriate protocols [AW1, P1, C4]. However perceptions of safety and animal welfare appeared mixed despite the protocols in place. For example, licensed volunteer hunting was argued by some stakeholders to meet high safety and animal welfare standards [H1-3, H5], but lack of a selection process was argued to increase safety and welfare risks [AW1, AR1, C4], with the possibility of also damaging the reputation of professional shooters [C4]. Similarly, the potential for using aerial shooting was thought to be considerably limited by lack of public support particularly due to animal welfare concerns [P2, AW1, P1, C2-4, AR2]. Furthermore, some stakeholders perceived any form of shooting as inhumane [AR2]. Perceptions of safety and animal welfare may also have been influenced by social context such as an urban-rural divide in acceptance of control methods, for example in the acceptance of aerial culling [AW1, CN1]. Three approaches emerged for gaining public support. Firstly, ensuring that the outcomes were met to a high-standard, achieved through intensive training and selection, and limitations to the number of shooters to ensure maintenance of skills, as was described for NPSW staff [P1, C4], and the Feral Animal Aerial Shooting Team (FAAST) [C4]. Rigorous training courses and strict protocols were also described for volunteer licensed hunters [H1-3, H5]. Secondly, gaining approval of animal welfare organisations, in particular RSPCA, was considered important for gaining wider public and political support [AW1, P1, C4]. Thirdly, supportive legislation and communication of the protocols to the public was also thought to help gain support [H1, H5, P1, C4], as illustrated below:

*“By the Crimes Act, if you damage personal property, there’s no defence. So even if I did this work and I injured someone or shot a house, I’d go to jail. My department cannot protect me from that. So with those sort of implications you can understand that our staff take the safety very seriously. And that’s one of the things that I always try to emphasise*

*when I'm talking to members of the public that there are all these personal risks involved, if we were to do something stupid..." [C4]*

Support for hunting as a management approach may also have been increased through mitigating poaching activity, which was considered by some stakeholders to be problematic and a safety issue [E2, H3, C1, C4, AR1].

**iii) Political history and culture.** The need to address cultural context and historically imbedded opinions, rather than simply relaying scientific facts, emerged as an important factor in community engagement and for gaining support for deer management approaches. For example, some stakeholders argued that a culturally specific stigma associated with hunting exists in Australia [H1, H3, H5, C5] thus limiting support for the approach. This stigma was said to be so extensive that hunters in NSW have become vilified:

*"Firearm owners and hunters are one of the last groups of people in this country that are openly vilified by other people and get away with it." [H5]*

This may have been shaped by political history, for example the political movements and Port Arthur massacre (described in *legislation*), as illustrated below:

*"The bottom line was that some guy goes mad with a firearm in Hobart and every shooter in Australia has got to wear the stigma forever. I think a lot of the politicians have run scared since then..." [H1]*

The influence of culture was also exemplified by negative attitudes towards aerial shooting, which may be influenced by a cultural association with violence:

*"...it scares people; people in the community think of Rambo, people coming across in choppers shooting at them. So with the community it is not as accepted" [P1]*

Similarly, the historical and cultural context of deer in Australia, and specifically the length of time that deer have been present in the RNP, also added an additional cultural dimension to public attitudes [H1, AW1, AR1], with the term 'pseudo-native' sometimes referred to [AW1]. A culture of trophy hunting (whereby hunters have a preference to shoot stags and not does) was also stated as problematic in Australia, limiting its acceptability as a serious deer control method for reducing ecological impacts. Understanding cultural context can therefore be important for achieving management objectives. For instance, education strategies directed towards hunters helped induce cultural change in the hunting community, as well as altering public attitudes towards hunters [H1, H3-4, C4]. Educating hunters towards a sustainable 'quality deer management' approach, and the need for fewer deer, was stated as one priority [H1, H3, H5], however there was some expectations that hunters should be educated to manage deer

as a pest, not a resource, to make a meaningful contribute to deer population control and ecological regeneration [C3]. Progress in achieving these cultural changes was considered challenging [H1, H3], although education strategies (including the Game Council handbook, workshops, club education programmes, courses and advertising) had shown some success, particularly with the younger generation of hunters who may be less exposed to the trophy hunting culture [H3]. Culture also emerged as a source of support, for example hunting was described as having cultural and historical standing in Australia [H1, H4-H5] related to the introduction of deer for hunting by the acclimatisation societies [H1] but also in broader terms as a historical activity by humans [H4]. Encouraging hunters to take pride and promote the activity, and raising their profile and public respect for hunting [H5], may have elicited cultural changes to help increase public support and acceptance. The re-branding of ‘recreational hunting’ to ‘conservation hunting’ was also described by one stakeholder as a public engagement strategy (as opposed to ecological strategy) aimed at increasing social acceptance of the activity [P1].

## FACILITATING MECHANISMS

### *Funding and resources*

Although funding and resources can act as a facilitating mechanism, a number of issues arose in using this mechanism effectively:

- (i) *Budget allocation*: Budget restrictions were stated as a key factor limiting effectiveness of deer management [E2, H3, P1, CN1, C3-4], compounded by costs associated with bureaucracy [H3, C1], the expansion of national parks estate [H1-2], collaborative arrangements and community engagement [H2-3, C1-2], and other management priorities in addition to deer control [AW1, C1, AR1]. Allocation of more funding to monitoring was considered necessary [E2, AW1, C1], although also recognised as costly [C2-4, AR1], and may be considered as not necessarily the most effective use of limited resources [P1].
- (ii) *Ecological factors*: Ecological factors were also stated as reducing cost-effectiveness and creating a need for increased resources. This included species characteristics and behaviour, such as the cryptic nature of deer in forest habitat [E2, H1, AW1, AR2], their adaptive ability (particularly their ability to regenerate rapidly after bush fires and to migrate) [E1-2, H1-3, H5, P1, C1] and intelligence, for example in avoiding shooting zones [H3, P1].

- (iii) *Management strategy*: Strategy viability was affected by cost, for example fertility control was considered by some stakeholders to be too costly to be viable [E2, P2], although there are arguments to the contrary [AR1, AR2]. A central argument relating to using licensed volunteer hunting was related to the potential for increased cost-effectiveness of this approach [H1-4], through utilising a free resource to reduce deer populations, and through producing economic benefits (such as licence fees) [E2, H1, H3, H5]. Social benefits were also associated with this approach, through utilisation of the end product (such as venison), whilst at the same time supporting a recreational pursuit that had increasing popularity in the country [E2].
- (iv) *Maintenance of funding*: Maintaining continuous, long-term funding was considered important for successful deer control [AW1]. However, this was thought to be at risk if the programme becomes successful [AW1]. Maintaining on-going funding was also thought to be limited by short-term political budgeting [AR2].

### ***Knowledge, research and development***

In addition to being a necessity for informing strategies, decision-making and legislation [H1, H5 AW1, P1-2], several points relating to knowledge, research and development emerged:

- (i) *Reliability*: Some scepticism surrounding research emerged, particularly its reliability [H2, AR1, C3] and its application [E2]. Concerns over reliability of research may result in continued debate.
- (ii) *Justification of management*: Ecological monitoring was stated as being important for justification of control efforts, both ecologically and ethically, and in terms of use of public funds [AW1, H2, C1, AR1]. However, the importance of justification appeared to have, in some circumstances, the unintended and counter-intuitive effect of hindering monitoring efforts. For example, one stakeholder indicated that NPWS did not formally monitor the deer or their impacts in the RNP themselves as they required an independent organisation, in particular an academic institution, to do so [C4], presumably to eliminate any accusations of bias in the studies. Although the intention may then have been to continue monitoring in-house, it had the unintended effect of delaying its implementation [C4].

- (iii) *Knowledge transfer*: The transfer of knowledge, for example between invasive species management programmes, was considered important, and was said to be facilitated by collaborative arrangements such as working groups [CN1, AR1, C4].
- (iv) *Technological limitations*: Technological limitations were described as hindering viability of some management strategies, particularly fertility control [E1-2, P1, C4].

## Discussion

We aimed to determine how management is influenced by social and political context in a value-laden conservation challenge, that of invasive species, and how this may inform management practice. Given the central role of stakeholders in environmental conflicts, and the subsequent need to understand stakeholder values (Webb & Raffaelli 2008), we aimed to do this through analysis of the perspectives of key stakeholders. Although we included a range of stakeholder groups, our analysis was based on a relatively small number of key stakeholder perspectives, so there will inevitably be some social and political factors that did not emerge in our analysis. However, using deer in NSW as a case study, we identified three key mechanisms (*legislation, cooperative arrangements and community engagement*) along with related ‘context-themes’. We also identified two facilitating mechanisms, *funding and resources*, and *knowledge, research and development*. Through our analysis, we highlighted management responses to the social-political context, which may also be applicable to other invasive species management programmes.

Relationships between context-themes were apparent, highlighting the complexity of social and political context. Within *political history*, political movements were a prominent feature, particularly affecting attitudes and legislation towards hunting, but also linking to *political ideologies*. For example, the concept of ‘wilderness’, to which invasive species are one threat, is an ancient term that was promoted as a positive concept in the early conservation movement of the 19<sup>th</sup> century (Mittermeier *et al* 2003), and forming a basis for the national parks system in the US (Colchester 1997). The concept is evident in modern Australia, such as the *NSW Wilderness Act 1987*. The perceived ‘lock-it-and-leave-it’ approach to national park management, a feature of the context-theme *political ideologies*, is likely to be a product of this wilderness concept. This management approach is also echoed by Chapple (2005), who identified farmers’ perceptions of national parks as



areas of wilderness, harbouring invasive species populations which impact on neighbouring land. As highlighted in the *collaborative arrangements* mechanism, migration of invasive species from national parks land often necessitates the use of collaborative management. Additionally in our analysis, the perceived ‘lock-it-and-leave-it’ approach was argued as restricting recreational use of national parks (although this was considered both positively and a negatively) and limiting opportunity to remove deer (for example by hunting). Societal benefits have long been recognised as an important objective of national park management on an international level (e.g. McNeely 1994), and our analysis suggests that this has recently increased in importance in NSW. However these changes also reflect growing financial constraints and the need to generate income to support conservation efforts.

These changes to the role of national parks did not extend as far as permitting hunting in national parks in NSW, even as a potential conservation tool, which is used in other parts of the world (e.g. MacMillan & Leitch 2008). This may be explained by *political history and culture*. For example, as well as political movements, past events seemingly unrelated to invasive species (such as the Port Arthur massacre in Tasmania) can act as a catalyst for changes to attitudes and legislation. Culture (and the social and historical setting) is recognised as having a strong influence on hunting and deer management, for example through limiting the effectiveness of legislation in current deer management contexts (Phillip et al 2009). The effect of culture is also exemplified by contrasting deer hunting in Britain (with a history of over 1000 years) which has typically been a pursuit of the wealthy landed gentry (Phillip et al 2009), with hunting in Australia, which our analysis suggests may be viewed disdainfully by wider society. However, changes may be occurring to this perception through *political action* of the Game Council NSW, and implementation of *community engagement* mechanisms directed at eliciting cultural change. Conflicts surrounding hunting as a conservation tool are well-acknowledged in the academic literature (e.g. Milbourne 2003, MacMillan & Leitch 2008) and was apparent in our case study, within the context-theme *political ideologies*, particularly over their management as a ‘pest’ versus a ‘resource’. This is a recognised conflict with respect to deer (Nugent & Fraser 1993), highlighting the need for compromise if political cooperation is to be achieved.

The two mechanisms *community engagement* and *cooperative arrangements* both exemplify forms of stakeholder participation. This is recognised as an important process

in environmental management, producing a range of benefits (Reed 2008), and is increasingly encouraged for invasive species management (White et al 2008). Participation is often categorised into different levels of involvement (e.g. Arnstein 1969). Jackson (2001) argues that lower levels of participation such as education and informing (a prominent aspect of the *community engagement* mechanism) are important early stages of a participatory process, and a precursor to consultative involvement. Evidence suggests that lack of such engagement can lead to considerable political problems in contentious invasive species management (Chapple 2005, Nimmo & Miller 2007). Our analysis also suggests that education and informing that takes into account cultural context can be an important tool for encouraging social change, for example for the hunting community to move away from a trophy hunting culture and illegal activities such as poaching. Such changes within individuals and the wider hunting community may be considered a form of social learning (Reed *et al* 2010). Collaborative deer management also emerged as one aspect of the *cooperative arrangements* mechanism, exemplifying ‘on-ground’ participation. A common obstacle for effectiveness of this approach is non-participation of some (often strategically positioned) landowners (Phillip *et al* 2009). We identified social context, for example trophy hunting and poaching, as contributing to this barrier, which was also identified as an obstacle by Hall & Gill (2005), along with poor knowledge of deer population dynamics. Additionally, lack of trust emerged as an obstacle to participation, and can also contribute to failure to achieve political cooperation. Trust is widely considered as both an essential requirement for, and a common result of, participation (e.g. McKinney & Field 2008; Reed 2008).

Higher levels of participation such as collaborative decision-making can be important for maintaining positive relationships and cooperation with interest groups and NGOs, as identified in *interest group relationships*. In addition to advocacy and contestation of policy, the role of NGOs includes information dissemination, technology transfer and formation of epistemic networks (Jasanoff 1997), thereby playing an influential role in environmental management, which ideally should be harnessed to benefit conservation objectives. Animal rights and animal welfare NGOs are a particularly common influence on invasive species management programmes (e.g. Chapple 2005; Bertolino & Genovesi 2003; Webb & Rafaelli 2008), and although animal rights represents a minority interest, animal welfare (along with human safety), was identified as a core value to the public and required for public support. Achieving these two outcomes may be facilitated by relevant

legislation (Phillip *et al* 2009), although communication to the public of how these values have been addressed can be equally important.

The two facilitating mechanisms that emerged in our analysis appear frequently in conservation literature in some form. For example, the need for improved funding (including for monitoring), and for more research have both been identified as important requirements for effective invasive species control (Simberloff *et al* 2005). However, policy-makers cannot necessarily rely on science alone to resolve value-laden conflicts (Chapple 2005). Indeed our analysis suggests that some sections of society may perceive science and ecological research as biased or unreliable, thus limiting its influence in the debate, as was also suggested by Chapple (2005). That is not to say that a strong evidence-base is not a critical part of invasive species management, and indeed monitoring is generally considered as important for justification and accountability, and for improving management practice (Braysher & Saunders 2003), as also emerged in our analysis of stakeholder perspectives. However, different perceptions of science validity and its application does pose an additional problem, as exemplified with *legislation* and listing all six deer species as a Key Threatening Process. Shine & Doody (2011) argue that conflicts between researchers and the community in invasive species management (with particular reference to cane toads, *Bufo marinus*) can be attributed in part to poor communication and an 'information vacuum', along with different ways of evaluating the validity of evidence. In this way, the mechanisms *knowledge, research and development* and *community engagement* are linked. Improvement in communication may therefore help increase the understanding of ecological research, both by the public and policy makers (Likens 2010).

Conservation of biodiversity is integral with its context- social, political, economic and ecological - particularly in high-conflict scenarios. Therefore, understanding the social and political context of invasive species management, a typically contentious conservation issue, has the potential to improve management practice and help to achieve conservation objectives. Our analysis of invasive deer management in NSW identified key mechanisms for achieving management outcomes, including legislation, community engagement and collaborative arrangements. We revealed how social and political context may influence management mechanisms in several ways, including through political action, history, ideologies and sensitivity, through culture, core values and alignment of legislation with societal values, and through interest group relationships and the social context of

participation. Our findings reveal the complexity of stakeholder relationships surrounding invasive species management. Social and political factors need to be incorporated into communication and management strategies in order to be appropriate and effective. Effective communication between key stakeholders at all levels – between different government departments and with interest groups, as well as between and within interest groups themselves, and between all stakeholder groups with the broader public - is likely to be essential for long-term success of invasive species management programmes.

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## CHAPTER IV

### PUBLIC ATTITUDES

#### Preface

The previous chapter identified social and political mechanisms for achieving management objectives in invasive species management, and examined how the context of the management of invasive deer relates to these mechanisms. One of the mechanisms identified was community engagement, which is necessary for gaining public support for contentious environmental issues, but requires an understanding of the basis of public attitudes (Larson *et al* 2011; Sharp *et al* 2011). Understanding what shapes public attitudes is useful for foreseeing potential conflict, and for being pre-emptive in responding to the public, through producing appropriate engagement and invasive species management strategies (Larson *et al* 2011). Several studies have explored some of the factors shaping public attitudes in relation to invasive species management, for example, the type of impact (Philip & Macmillan 2003), control methods (Fraser 2006) and taxonomic group (Bremner & Park 2007). A framework for managers to address these and other factors that may shape attitudes of the public may assist in focusing management efforts appropriately and effectively, thereby achieving both positive ecological and social outcomes. This may be particularly applicable where citizens are at the forefront of management activity and invasive species impacts, for example on the boundaries of protected areas.

This paper therefore aims to answer the following research questions: what are the different key factors shaping public attitudes towards invasive species and their management in a protected area and what is their relative importance; and how might these factors be influenced to achieve greater support and thereby minimise conflict and maximise beneficial outcomes. The management of invasive rusa deer in the Royal National Park was used as a case study, and a postal survey was delivered to residents living on the boundary of the park. Analysis of qualitative data helped identify the main dimensions shaping public attitudes and indicated the relative importance of different issues relating to these dimensions. Quantitative analysis provided further evaluation of the attitudes of the local public, and at the same time allowed a degree of cross-validation of the qualitative analysis.

This paper thereby helps to answer the core research question of the thesis through: (a) identifying key dimensions and factors shaping public attitudes towards invasive deer management, which are likely to influence the level of public support or conflict surrounding management; and (b) proposing how these dimensions may be influenced by management strategies, to help minimise conflict and achieve positive social outcomes, thus helping to achieve conservation objectives.

# **Dimensions of local public attitudes towards invasive species management in protected areas**

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**Running title:** Dimensions of attitudes towards invasive species

**Key words:** Australia; community; conceptual framework; deer; invasive species; attitudes; wildlife

## Abstract

Invasive species can be a considerable threat to native biodiversity. However their management is often a source of conflict. Gaining support of the local public, i.e. those living in close proximity to invasive species, can be particularly important for effective management, especially for protected areas. An important first step for gaining support is developing an understanding of, and then responding to, local public attitudes towards invasive species and their management. We aimed to identify the different dimensions of local public attitudes towards invasive species, which may act as a framework for directing management efforts. We used management of invasive rusa deer (*Cervus timorensis*) in the Royal National Park, Australia, as a case study. A combination of both qualitative and quantitative analysis was used, using a predominantly 'bottom-up' approach, based on responses to a survey delivered to residents living on the boundary of the protected area. We identified three main dimensions of local public attitudes - stakeholder, wildlife and management dimensions. Within these dimensions we identified six themes: stakeholder participation and decision-making, stakeholder relationships, invasive species effects, perceptions towards invasive species, effectiveness of management and population management methods. We use the framework to highlight possible implications for the management of invasive species. For example, directing communication and education strategies towards animal welfare and human safety concerns, environmental effects and management activities, maintaining on an on-going consultation process, developing indicators of success in conjunction with the community, and improving the management of protected areas at all levels, rather than just invasive species management. These strategies, and others identified in this analysis, may improve relationships between managers and the local public, thereby helping achieve ecological objectives. Conceptualising attitudes and their implications in this way is likely to be of relevance for other invasive species management programmes that also experience conflict.



## Introduction

Invasive species can be significant threat to native biodiversity, as a result of direct predation and competition, hybridisation with native species, and disruption of ecosystem functioning (Lockwood *et al* 2007; White *et al* 2008). The effective management of invasive species is therefore fundamental for conserving biodiversity and endangered native species. Management often involves attempted eradication programmes (Mack *et al* 2000). However, such programmes are frequently a source of conflict (Stokes 2006; Bremner & Park 2007), particularly where there are social benefits or cultural associations with the species concerned (White *et al* 2011). Yet without public support and socially acceptable methods, achieving biodiversity conservation objectives can become potentially difficult (e.g. Chapple 2005). As a consequence, there is growing recognition of the significance of the social dimension of invasive species management and the need for understanding attitudes towards their management (Larson *et al* 2011; Sharp *et al* 2011).

Consideration of public attitudes towards invasive species management has until recently been somewhat neglected (García-Llorente *et al* 2008; Sharp *et al* 2011). However, recent studies have revealed that attitudes and knowledge differ considerably between stakeholder groups (García-Llorente *et al* 2008) and that there are numerous factors affecting attitudes towards invasive species control. These factors include the taxonomic group (Fraser 2006; Bremner & Park 2007), the severity of impacts (Reiter *et al* 1999), the type of impact (Philip & Macmillan 2003; Fulton *et al* 2004) the methods of control (Fraser 2006; Bremner & Park 2007) and socio-demographics (e.g. age and education) (Sharp *et al.* 2011). This array of potentially important factors creates a challenge for gaining public support for an invasive species management programme, which may limit the ability to achieve ecological objectives. Two questions are of particular significance: i) what is the relative importance of the different factors shaping public attitudes towards an invasive species and the proposed intervention?; and ii) to what extent can these factors be influenced to achieve greater support and thereby minimise conflict and maximise beneficial outcomes?

We aim to answer these questions in the context of invasive species management in national parks and nature reserves, referred to here as protected areas (PAs). Invasive species management in PAs is particularly critical due to typically high levels of native

and endangered species occurring in these areas. The growing number of people living on PA boundaries, which is associated with reduced success in achieving conservation objectives (Wittemyer *et al* 2008; Radeloff *et al* 2010), amplifies the need to attain positive social outcomes to achieve these conservation goals. We focus our research on residents living on a PA boundary, which we termed 'local public'. This contrasts with Garcia- Llorente *et al* (2008) who referred to 'local users', but is more appropriate in our case since although the subjects of our analysis live on a PA boundary, they do not necessarily utilise it. Attitudes of local public can potentially be affected by factors that the wider public may not experience, including human-wildlife conflict, interaction with PA staff, and benefits from the PA (Tessema *et al* 2010). Therefore, understanding attitudes of those living on PA boundaries is likely to be particularly important for achieving conservation objectives in PAs (e.g. Chapple 2005).

We use the management of invasive rusa deer (*Cervus timorensis*) in the Royal National Park (RNP) in New South Wales (NSW), Australia, as a case study. The management of deer, especially where they are invasive, is often a source of contention due to their multiple roles as a hunting resource, a potential ecological and agricultural threat, and as a charismatic species (White & Ward 2010). Deer management in Australia epitomizes these conflicts (Moriarty 2004<sup>a</sup>). The RNP is a high profile PA with a history of conflict over the management of rusa deer. Division in the community over the issue has affected management practice, including temporary suspension of culling activities in the late 1990's (Shephard 2002; English 2005). Deer management in the RNP therefore provides a prime example of the need to understand and respond to local public attitudes if positive ecological outcomes are to be achieved. Therefore, in this study we identify different dimensions of local public attitudes towards deer management in the RNP. We also identify themes and sub-themes within these dimensions, and propose links between these themes with management strategies. The framing of local public attitudes into these dimension and themes, and the related strategies that we propose, is likely to have broader application than that of the case study presented here, particularly for other invasive species management programmes where conflict is prevalent.

## Methods

### CASE STUDY

The Royal National Park is located on the eastern coast of New South Wales in Australia, occupying 15068ha (National Parks and Wildlife Service 2000). It has close urban proximity, situated approximately 32km south of Sydney (population of approx. 4.5 million) and consequently receives a high number of visitors (estimated 3 million visitors per year in 1990, NSW National Parks and Wildlife Service 2000). Declared as a National Park in 1879, the RNP is the second oldest national park in the world and the oldest in Australia. This history, combined with the Park's location, important Aboriginal sites, and high public and political profile led to the RNP's inclusion on Australia's National Heritage List in 2006. The RNP is managed under the legislation of the *National Parks and Wildlife Act 1974*, and is under the jurisdiction of the NSW National Parks and Wildlife Service (NSW NPWS) (of the NSW Office of Environment and Heritage). The Park is important ecologically, with an estimated 43 mammal, 241 bird, 40 reptile, and 20 amphibian species, as well as being rich in native invertebrates. It is also floristically diverse, with over 1000 plant species, and contains important ecosystems, particularly littoral rainforests which are listed as threatened under the *NSW Threatened Species Conservation Act 1995* (NSW National Parks and Wildlife Service 2000).

Rusa deer were introduced into the RNP in 1906 for aesthetic value as part of the acclimatisation movement (Moriarty 2004<sup>a</sup>; NSW National Parks and Wildlife Service 2005). By 1999-2001, the initial population of seven individuals had grown to an estimated population of 2500-2900 in 1999-2001 (Moriarty 2004<sup>b</sup>). In 2005 deer were listed as a Key Threatening Process in NSW under *NSW Threatened Species Conservation Act 1995* due to herbivory and environmental degradation. Specific threats to the RNP vegetation have been identified (Moriarty 2004<sup>b</sup>), along with socio-economic impacts including property damage and deer-vehicle collisions. There have been numerous, unsuccessful attempts to shoot and trap the deer, surrounded by community division on the issue due to the heritage and aesthetic value of deer (Shephard 2002), and animal welfare concerns (NSW National Parks and Wildlife Service 2005). Following large-scale bush fires in 1994/1995 in the RNP which burnt out 90% of the park, organised deer culling was planned to facilitate vegetation rehabilitation and reduce the risk of starvation, however court action led by animal rights groups resulted in a

suspension of culling by the NSW Minister of the Environment until community support could be demonstrated (Shephard 2002). Achieving positive social outcomes, such as public support, was therefore essential for achieving conservation objectives.

A Deer Working Group was established in 2000 to develop a deer management plan (Shephard 2002) using a collaborative approach, which included members of non-government conservation, animal welfare and hunting organisations, NSW NPWS, local government councils, academic experts, and the local Livestock Health and Pest Authority. Further fires in the RNP in 2001 prompted urgent action on the issue and a community strategy was developed which included two community consultation workshops in 2002 (Shephard 2002). Under these plans, a deer management plan was produced in 2002, which incorporated key issues highlighted in the consultation workshops (NSW National Parks and Wildlife Service 2002), followed by a second plan for the period 2005-2008 (NSW National Parks and Wildlife Service 2005). Deer in the RNP are managed through ground shooting by trained NPWS staff and deer occurring on adjacent council land are removed using shooters contracted by Southerland Shire Council in addition to NSW NPWS staff, provided through a Memorandum of Understanding between Southerland Shire Council and NSW NPWS developed in 2007. The contentious history of deer management in the RNP highlights the need for research investigating the social dimensions of the invasive species issue and to determine how management strategies may be best directed.

## POSTAL SURVEY

The study focused on seven main residential areas located on the boundary of the RNP. On the northern boundary, the study included the settlements of Grays Point, Bundeena and Maianbar, the latter two which are completely enclosed between the RNP and the coast. Heathcote, on the northwest boundary, and Waterfall, on the western boundary (both of which are also bordered by Heathcote National Park), were also included, as were Helensburg and Otford on the southern boundary. A total of 1340 surveys were hand delivered in July 2009, representing approximately between 14 and 100% ( $\bar{x} = 51.8 \pm 16.0$ ) of occupied houses within these areas (Australian Bureau of Statistics 2006). The surveys were delivered to those streets closest to the border of the RNP, since large proportions of some of these suburbs were not on the PA border (particularly in Heathcote and Helensburg). Therefore, although not a random sample, a wide cross-section of

residents living on the boundary of the RNP were included, with a focus on those closest to the boundary and therefore most likely to be affected by deer and their management.

The survey consisted of three sections (see Appendix 1): (1) supporting information, related to consultation, interests, and impacts of deer, using predominantly closed questions; (2) attitude agreement, consisting of 32 statements to be rated according to the respondent's agreement or disagreement (from -3, disagree very strongly, to 3, agree very strongly); and (3) open comments question and feedback on the survey. The survey included a pre-paid return envelope, along with the opportunity of winning one of three Aus\$50 retail vouchers on return of a fully completed survey, and a covering letter explaining the purpose of the study and some limited information on the deer management plan.

In Section 1, questions relating to consultation included: length of time living in the area (Q1); whether information had been received on the deer management programme and whether this had been in the last year (Q2); attendance at public meetings regarding deer (Q3); satisfaction with consultation (Q4); and satisfaction with deer management in the area (Q5). Questions relating to interests included: membership of environmental/animal charities (Q6); professional interest in deer (Q7); partaking in feeding of local deer (Q8); and whether the respondents had ever hunted deer, or other animals (Q9). Questions relating to impacts included: experience of property damage from deer (Q10); expenditure of money as a result of deer (Q11); acceptability of any financial costs incurred (Q12); experiences of deer-vehicle collisions or 'near-misses' (Q13); whether the respondent perceived deer to have positive impacts in the area (Q14); preferred change, if any, to deer population numbers in next 10 years (Q15); and types of concern over negative impacts of deer, if any (environment, economic, social, unconcerned) (Q16).

Section 2 was based around statements derived from in-depth interviews with 18 key stakeholders of deer management in the RNP, carried out from February to May 2009. Stakeholders from hunting, animal rights and animal welfare organisations, government and non-government environmental management/conservation organisations, and local council were included, along with two academic experts on deer. The purpose of using statements derived from a range of key stakeholders was to maintain a predominantly bottom-up approach, reducing the amount of imposition of ideas from the researchers onto the respondents. The statements were likely to reflect a range of potential opinions and

issues applicable to the local public. Statements from the interviews were chosen based on a sampling matrix used in q-methodology (Dryzek & Berejikian 1993). Using the matrix involves identifying statements that cover a range of topics from the discourse (i.e. the interviews in our study) that fall into each category of two typologies. The typologies were: (i) *discourse elements*- ontology (entities recognised as existing), agency (degree of agency i.e. ability to act or be acted upon), motivations (e.g. of agents) and natural (relating to relationships), and (ii) *type of claim* – definitive (meanings of terms), designative (questions of fact), evaluation (worth of something that does/could exist) and evocative (concerning something that should or should not exist) (Dryzek & Berejikian 1993). Using this matrix as a guideline, we identified two statements falling approximately into each category of the matrix (e.g. ontology-definitive etc.), resulting in a total of 32 statements.

In section 3, there was an opportunity for respondents to provide “*other comments about deer or their management*” and to expand on previous answers they had given. Providing opportunity to express comments in an open-ended format was important for gaining a more accurate reflection on local public attitudes. Placing this question after sections 1 and 2 allowed the previous questions to act as catalyst for expression of attitudes on a range of issues. Section 3 also provided opportunity to provide feedback on the survey, specifically whether it was easy to complete, and whether it allowed adequate expression of their views. This provides useful information on the reliability of the survey and of ways to improve the design of surveys which focus predominantly on a bottom-up approach.

## ANALYSIS

Dimensions shaping local public attitudes were identified using content analysis of the open comments question of the survey using Atlas-Ti<sup>®</sup>. An approach was used based on the principles of grounded theory, where emergent rather than hypothesised themes were identified (Strauss & Corbin 1990; Bryman 2008). Content analysis was carried out by one person, assisted by a coding frame (i.e. rules for assigning quotations to a particular theme) to ensure consistency in coding (Bryman 2008). Each statement (which consisted of a phrase or sentence) was coded into emerging themes (e.g. *stakeholder participation and decision-making*). These themes were then grouped into families, i.e. the over-arching dimensions (e.g. *stakeholder dimension*). Two themes were identified for each of the three

dimensions. We then analysed each theme by breaking them down into emergent sub-themes (e.g. *'information provision and awareness'*). The 17 sub-themes that emerged reflect specific issues, but not the range of attitudes surrounding each issue. Therefore, each sub-theme was characterised by different attitude categories (e.g. *'education and informing is important'*). These attitudes categories aimed to capture the range of opinions, experiences and perceptions relating to that sub-theme. The number of respondents conveying a particular attitude category within each sub-theme was calculated to provide an indication of the relative importance of each attitude.

Analysis of the open comments therefore provided the framework for assessing the dimensions of local public attitudes. For validation of this 'bottom-up' qualitative analysis, quantitative data was used for comparison, where possible. This consisted of responses to section 1, including information on consultation and impacts, and the responses to the statements of Section 2. Analysis of Section 1 consisted of percentages of different options for each answer. Analysis of Section 2 consisted of means, standard errors and medians of agreement/disagreement to the statements. The questions and statements of Section 1 and 2 were grouped according to the sub-themes of the qualitative analysis, based on similarity of topic. Since the dimensions, themes and sub-themes that were identified through qualitative analysis were emergent rather than hypothesised, not all of the sub-themes had comparable supporting quantitative data. Furthermore, they only provided related information, rather than direct comparison. Nevertheless, using both qualitative and quantitative data in this way acted as a method of validating the results and providing considerable information regarding local public attitudes.

## **Results**

The results are presented in terms of demographic information (e.g. response rate and feedback) followed by the three over-arching dimensions and related themes. Each sub-theme is addressed individually, with reference to the attitude categories and related quantitative data. The dimensions and themes are summarised in Table 1 (stakeholder dimension), Table 2 (wildlife dimension) and Table 3 (management dimension). The response to statements from Section 2 are summarised in Table 4, grouped according to comparable dimension and sub-theme from the qualitative analysis. For each sub-theme, possible implications for management are proposed, summarised in Table 5. In the results,

reference to responses from Section 2 reflects mean response ( $\bar{x}$ ), along with the median response (m). For interpretation of the mean values, the following scale of mean agreement of respondents is referred to:  $0.0 \leq \bar{x} < 0.5$  (negligible agreement),  $0.5 \leq \bar{x} < 1.0$  (limited agreement),  $1.0 \leq \bar{x} < 1.5$  (moderate agreement),  $1.5 \leq \bar{x} < 2.0$  (considerable agreement) and  $\bar{x} \geq 2.0$  (strong agreement), with an equivalent scale used for disagreement. However the majority (71%) of responses had a mean within negligible or limited agreement/disagreement. Therefore the median response provides further indication of attitudes and whether the responses are skewed towards agreement or disagreement. The results do not provide a clear indication of whether there were equally strong but opposing views, instead they provide an indication of whether there was an *overall* strong agreement or disagreement to the statements among the respondents.

## RESPONDENT INFORMATION

A response rate of 30.3% was achieved from the postal survey (406 completed or partially complete surveys). The highest response rates were from Maianbar, Bundeena and Heathcote (35.6%, 35.3% and 34.9% respectively), and the lowest response rates from Helensburg and Otford (22.2%) and Waterfall (21.9%). Of the respondents, 13.8% were a member of at least one environmental charity, 1.2% had a professional interest in deer, 9.1% had fed local deer at some point, 2.2% had hunted deer at some point and 14% had hunted other animals at some point. Of those who responded to the feedback question, 84% found the survey easy to complete (n=374) and 91% stated that the survey was adequate for expressing their attitudes towards deer and their management (n=370). Main concerns over completing the survey related to Section 2, with some respondents stating that some statements were confusing or ambiguous, or that there were too many question. Main concerns over the adequacy of the survey to express attitudes related to the aforementioned complexity/ambiguity, and that the respondent felt insufficiently informed on the issue to answer some questions. Comments were made in the open question by 63% of respondents (n=257).

## STAKEHOLDER DIMENSION

### ***Theme 1: Stakeholder participation and decision-making***

i) *Information and awareness.* Concern over lack of information and awareness appeared in several attitude categories. Moderate agreement with statement 12 (information



reaching the community is low,  $\bar{x}=1.35$ ,  $m=2$ ) supports this concern over information provision (Table 4). Response to Q2 (Section 1), which also relates to this sub-theme, revealed that some information on deer management had been received by 59% of the respondents, suggesting a considerable proportion of those surveyed lacked any information provision. Implications for management therefore relates to the need for regular communication regarding both programme operations and justification for deer culling (e.g. ecological effects of deer).

ii) *Participation in consultation and decision-making.* Lack of consultation was the dominant attitude category, with residents ‘told’ and not consulted. Response to Q4 (Section 1) supports this result, revealing that 49% of respondents were not satisfied with the consultation they had received. However, limited agreement with statement 31 (NPWS agenda is set and community concerns are not acknowledged,  $\bar{x}=0.69$ ,  $m=0$ ), does not reveal an overall strong concern over the level of consultation. Even so, having an on-going strategy of consultation and discourse with the local public, rather than solely information provision at the start of the programme, may help improve public understanding of the issues and support. Related to consultation, dissatisfaction with public meetings emerged in the qualitative analysis, for example due to intimidating behaviour by vocal minorities. However this was raised by only a very small number of respondents, perhaps reflecting the low number of respondents who had attended a public evening on deer management- Q3 (Section 1) revealed this to be 6% of respondents. Contrary to these concerns and arguably low attendance, moderate agreement with statement 10 (public evenings are valuable,  $\bar{x}=1.27$ ,  $m=1$ ) indicates that public evenings were generally considered to have some potential benefit. Public meetings may therefore be valuable as a consultative tool, but may require using experienced facilitators to ensure a positive environment for all participants, and encouraging greater attendance.

Attitudes towards the role of the community in decision-making were divided. Inability to reach an agreement was stated as a problem concerning community involvement in decision-making. Negligible agreement with Statement 24 (community needs to unite on the problem for progress to be made,  $\bar{x}=0.40$ ,  $m=1$ ) suggests there was not strong expectation of the community uniting on the deer management issue. Aiming for community agreement may therefore be considered unnecessary or unlikely, and perhaps not the most efficient use of resources. While consensus may be improbable, moderate agreement with statement 11 (government manages the park on behalf of the community,

$\bar{x}=1.65$ ,  $m=2$ ) suggests that values and preferences of the local public should be acknowledged in management decisions, which can be considered as part of a democratic process. Community groups may have some role in this process, although response to statement 22 (community groups are the conscience of the government,  $\bar{x}=0.58$ ,  $m=1$ ), suggests that there was not an overall strong agreement regarding the importance of community groups.

iii) *Effectiveness in decision-making and action.* The dominant attitudes were that effective leadership and decision-making are both necessary and lacking. The influence of politics and interest groups on decision-making and action also emerged as a concern. Limited agreement with statement 23 (an independent person is needed to assess the deer management programme,  $\bar{x}=0.50$ ,  $m=1$ ) and with statement 32 (government may not be relied upon to see the programme through,  $\bar{x}=0.72$ ,  $m=1$ ) indicates that credibility of decision-making and leadership surrounding deer management was of some concern, but again there was not an overall strong agreement regarding this. In terms of management, a potentially difficult balance may be required between showing strong leadership while at the same time having extensive engagement with stakeholder groups and the public, to ensure the programme is politically and publicly acceptable. Decision-making using a collaborative management approach may facilitate this process, particularly if adopted from the onset.

## ***Theme 2: Stakeholder relationships***

i) *Relationships within communities.* Conflicts were apparent within communities, related to different perceptions towards deer (e.g. sentimentality), actions towards the deer (e.g. cruel/inhumane behaviour), and lack of willingness to adapt to deer presence, although this sub-theme does not have comparable quantitative data for validation. Where there are tangible solutions, managers may be able to reduce conflict within communities, for example through providing assistance in adapting to deer presence (e.g. deer-proofing gardens) or enforcing regulations (e.g. illegal behaviour in terms of animal welfare). However conflicts surrounding perceptions towards invasive species are less tangible and are likely to be more difficult to influence through management strategies.

ii) *Relationships between communities and wildlife authorities:* Dissatisfaction with attitudes of government wildlife authorities towards the management of the RNP, or

national parks in general, was the dominant cause of conflict. This mostly related to restriction of people's freedom, access and recreation in the park, as well as poor maintenance (for example bush fire management and aboriginal heritage). Strong agreement with statement 8 (RNP is for conservation, public enjoyment and recreation,  $\bar{x} = 2.43$ ,  $m=3$ ), indicates that the park is highly valued for both conservation and social benefits, although the statement does not address the relative importance of these two benefits. Implications for management relate to improving management at a broader level to improve relationships with the local public, with acknowledgement of other values of PAs in addition to conservation. Improving broader management may reflect positively upon invasive species management and thereby help gain public support.

**Table 1.** Themes and sub-themes within the *stakeholder dimension* of local public attitudes in relation to deer management, and the frequency of occurrence of related attitudes.

Theme	Sub-theme	Attitude category	Number of respondents
Stakeholder participation & decision-making	Information provision and awareness	There is lack of information/not aware of deer management programme	18
		There is lack of information generally [ <i>type unspecified</i> ]	10
		There needs to be more information to make informed decisions	8
		There is lack of information on ecological impacts/not aware of ecological impacts or the deer population	6
		Education and informing is important	6
		The only information has been from newspapers or local residents	5
		There is lack of information on culling activity	4
	Participation in consultation and decision-making	Notification may have been received, but there has been a lack of consultation	28
		Higher level participation of community is not useful for decision-making	6
		Higher level participation of community is important for decision-making	4
		Publics meetings have not been satisfactory	3
	Effectiveness in decision-making and taking action	The issue requires strong leadership/decision-making/action	13
		Politics and interest groups affect decision-making and action	12
		There is no strong leadership/decision-making/action	11
Have been involved in lobbying for change		2	
Confident in leadership/decision-making and/or action		2	
Stakeholder relationships	Relationships within communities	Other people are over-sentimental about the deer	11
		Other people are cruel to deer/create animal welfare issue	6
		Other people should accept/adapt to the deer	4
		The community is polarised on the deer issue	3
	Relationships between communities and wildlife authorities	Concerned over wildlife authority/government attitude or approach to national park management	19
		Government bodies are not taking responsibility	6

### *Theme 3: Invasive species effects*

i) *Environmental effects.* The dominant attitude demonstrated an awareness of the environmental effects of deer. Quantitative analysis supports this, with response to Q15 revealing 74% of respondents considered deer to have a negative environmental impact. This suggests that education strategies in the RNP have been effective. However some scepticism regarding environmental effect was also apparent in the qualitative analysis. The negligible (as opposed to strong) disagreement with statement 26 (environmental damage in the RNP is not that evident,  $\bar{x} = -0.43$ ,  $m = -1$ ) also reflects a level of scepticism. Both direct observation of environmental effects (e.g. browsing damage or reduction in native species) and knowledge gained from ecological research and public engagement may influence attitudes of the local public towards environmental effects of deer. Limited agreement with statement 15 (an independent scientific committee have highlighted deer as an ecological threat, so there is no debate over impact,  $\bar{x} = 0.87$ ,  $m = 1$ ) suggests that the scientific assessment helps to reduce, but not eliminate, scepticism over environmental effects. Continuation of education strategies may be necessary to maintain awareness of environmental effects, however ecological monitoring data to support claims of environmental effects would also be useful for reducing scepticism.

ii) *Human safety from wildlife interaction.* Considerable concerns over deer-vehicle collisions emerged in the qualitative analysis. Response to Q13 (Section 1) reiterate these concerns, revealing that 14% respondents had experienced a deer-vehicle collision, 55% had experienced a 'near-miss', and 59% knew someone who had had a deer-vehicle collision or near miss. However, limited agreement with statement 2 (deer can be very dangerous,  $\bar{x} = 0.61$ ,  $m = 1$ ) suggests that although deer may not be seen as benign, there was not an overall strong agreement regarding their level of threat to human safety. Implications for management relate to minimising any human safety risk, particularly those that are potentially fatal (e.g. wildlife-vehicle collisions). Understanding and responding to perceived (rather than actual) risk to human safety may also be important for maintaining public support.

iii) *Socio-economic effects.* Both positive and negative social-economic effects relating to deer emerged from the qualitative analysis. The dominant attitude category related to

negative effects from property damage. Quantitative data supports this result, as Q10 and Q11 (Section 1) revealed that 63% of respondents had experienced property damage and 41% had spent money due property damage. Of those who had incurred cost and answered whether it was acceptable (Q11) just under half (49%) considered the incurred cost to be unacceptable. Negative experiences from illegal hunting also emerged, with concerns over human safety. However, limited disagreement with Statement 30 (people do not like deer because they attract illegal activity,  $\bar{x} = -0.55$ ,  $m=0$ ) suggests that illegal activity may not be a significant factor influencing attitudes toward deer. Management implications relate to reducing negative socio-economic effects through financial and educational support, and enforcement of regulations if necessary. The dominant positive socio-economic effect was enjoyment of seeing deer. Q14 (Section 1) revealed that 21% of respondents considered deer to have positive impacts, which included enjoyment from and interaction with deer, cultural associations (e.g. with the religious festival of Christmas) and heritage value, tourism, and their role in reducing weeds and maintaining clear tracks and firebreaks. Although positive effects were not a majority viewpoint, recognising positive effects in management objectives may help mitigate conflict, if this can be achieved without being detrimental to ecological objectives. For example, managing an invasive species at a measurable low level of impact may achieve both positive social and ecological outcomes.

#### ***Theme 4: Perception towards invasive species***

i) *Invasive species characteristics.* Attitudes relating to deer characteristics included both positive and negative perceptions. The dominant attitude category related to positive aesthetic characteristics (e.g. 'beautiful'), followed by negative behavioural characteristics (e.g. 'pest'). Aesthetic attractiveness was also the most common positive association emerging from the open-ended part of Q14 (Section 1), with 29% ( $n=85$ ) of those who perceived deer to have a positive impact stating aesthetic benefits. Perceptions towards species characteristics may be difficult to influence through management, as these perceptions may stem from values and cultural associations.

ii) *Position in the environment.* A negative connotation towards the non-native status of deer (e.g. 'feral' and 'out-of-place') was the dominant theme. However, negligible agreement with statement 21 (any non-native species should be killed regardless of beauty,  $\bar{x} = 0.35$ ,  $m=0$ ) indicates lack of strong overall agreement regarding generic

removal of invasive species. Therefore non-native status may not be considered sufficient reason itself to carry out lethal control, particularly if the species has aesthetic value. Providing justification for culling invasive species is therefore necessary. Attitude categories also reflected sympathetic attitudes towards deer (e.g. animal rights). Limited disagreement with statement 13 (deer in the RNP may be considered pseudo-native,  $\bar{x} = -0.67$ ,  $m = -1$ ) suggests length of presence was not of strong factor influencing attitudes towards deer management, however lack of a strong overall disagreement suggests it may have some influence. Understanding sympathetic attitudes towards invasive species (animal rights, heritage value etc.) may be important for managing conflicts, although such values may be difficult to influence through management, other than on-going education and awareness strategies on invasive species effects.

**Table 2.** Themes and sub-themes within the *wildlife dimension* of local public attitudes in relation to deer management, and the frequency of occurrence of related attitudes.

Theme	Sub-theme	Attitude category	Number of respondents
Invasive species effects	Environmental effects	Deer cause significant impact on the environment	65
		Environmental damage by deer is not that evident/significant	22
	Human-safety from wildlife interaction	Deer are a hazard on the roads	50
		There are solutions to potential deer-vehicles collisions/ do not consider deer a significant traffic hazard	13
		There is risk of injury from direct contact with deer	7
		Deer are dangerous [ <i>generally</i> ]	7
		Deer are not dangerous	6
		There is risk of disease transmission from deer	5
	Social and economic effects	There is significant damage to property caused by deer	52
		There are social benefits from the deer (e.g. enjoyment/attraction to tourists/historical value)	27
		There are social problems relating to illegal hunters	16
		Any impact on property is negligible and/or easily preventable, or is beneficial	13
		There are social problems associated with the deer management programme	8
		There are negative social impacts of deer (e.g. disturbance)	8
		There are potential benefit from venison production	6
Deer in the RNP provide no benefit to society		5	
Concerned over economic cost of the deer management programme	3		
Perception towards invasive species	Invasive species characteristics	Deer have positive characteristics (e.g. beautiful/charismatic)	32
		Deer have negative characteristics (e.g. pest/vermin)	18
		Deer have neutral characteristics [ <i>general, non-polarised descriptions</i> ]	8
	Position in the environment	Deer are feral /introduced and are out of place in the RNP	36
		Other non-natives also need managing in the RNP	23
		Sympathetic towards the deer despite being non-native; non-natives still have rights/ are no different	12
	Deer are 'pseudo-native'/ have a right to be in the RNP	8	

## MANAGEMENT DIMENSION

### *Theme 5: Effectiveness of management*

*i) Observed invasive species populations.* A high variability between respondents emerged in observed deer populations, although there was no corresponding quantitative data. The local public may therefore need to be considered as distinct communities in the context of invasive species interactions. Public involvement in wildlife reporting (e.g. utilising a citizen science approach) may help achieve ecological outcomes, particularly with respect to targeting culling efforts to observed areas of high density.

*ii) Satisfaction with implementation and outcomes.* Although dissatisfaction with implementation and outcomes (for example due to lack of a continuous culling effort) emerged with a higher frequency than satisfaction, there was not a pronounced difference. Similarly, negligible agreement with statement 17 (NPWS doing the best they can with available resources,  $\bar{x} = 0.03$ ,  $m=0$ ) does not indicate strong agreement or disagreement towards effectiveness of management. However response to Q5 revealed 44% of respondents were not satisfied with management and only 16% satisfied, with 35% unsure. Identification of, and response to, public concerns over management implementation may improve satisfaction levels within the local public. Developing indicators of success with community input may help facilitate this process.

*iii) Research.* Both satisfaction and dissatisfaction with the quantity and/or quality of research relating to deer and their impacts emerged. Limited agreement with statement 29 (information is required for justification of culling,  $\bar{x} = 0.61$ ,  $m=1$ ) indicates some recognition of the value of basing management on scientific foundation, although there is not an overall strong agreement regarding this. This may be considered surprising given the conflict surrounding deer management. Negligible agreement with statement 20 (too much can be spent on research rather than taking action,  $\bar{x} = 0.46$ ,  $m=1$ ) does not indicate a strong overall attitude towards expenditure on research versus taking direction action. Although there does not appear to be a dominant attitude towards the role of research, a sound knowledgebase may typically be considered good practice in invasive species management and important for justifying lethal control and expenditure. Improved communication of science and research to the public may improve the awareness of the scientific basis of invasive species management.

## ***Theme 6: Population management methods***

*i) Current management methods and objectives.* The dominant attitude category was support for eradication of deer from the RNP. Support for culling and/or maintaining the population at a manageable number (rather than eradication necessarily) was also apparent, but there was also some objection to culling. Qualitative results suggest reducing deer numbers to be the dominant management preference, but with some polarisation of attitudes. Q15 (Section 1) also supports these results, revealing that 67% of respondents wanted to see a decrease in the deer population, 18% preferring no change and 3% wanted an increase. The quantitative data from the responses to Section 2 also show an overall preference towards decreasing numbers, although without strong agreement. For example, limited agreement with statement 3 (deer are a pest and need to be removed,  $\bar{x} = 0.83$ ,  $m=2$ ) and limited disagreement with statement 1 (like to see the deer remain,  $\bar{x} = -0.79$ ,  $m=-2$ ), show some preference towards reducing the deer population, with median values that indicate a skew towards this preference. Negligible disagreement with statement 25 (small numbers of deer would be tolerated  $\bar{x} = -0.32$ ,  $m=0$ ) suggests no strong overall attitude towards maintaining low population levels. These results suggest the majority preference appears to be for a reduction of the deer population. Some objection to culling may always be expected, and gaining majority support is a realistic goal which is politically and publicly feasible.

*ii) Alternative/complementary methods.* Fertility control was the most supported alternative method raised, followed by relocation. Recreational hunting was the least supported alternative method, followed by aerial shooting. Quantitative data supports the qualitative data with respect to recreational hunting, for example there was considerable disagreement with statement 19 (can't understand why hunting is not allowed in national parks  $\bar{x} = -1.87$ ,  $m=-3$ ) and considerable agreement with statement 9 (national parks are sacred and are not hunting grounds,  $\bar{x} = 1.44$ ,  $m=2$ ). However, there was only negligible disagreement with statement 27 (sustainable utilisation is the only approach  $\bar{x} = -0.24$ ,  $m=0$ ) although this may reflect lack of awareness of the association between sustainable utilisation and recreational hunting. Limited disagreement with statement 28 (aerial shooting would be a potential modification,  $\bar{x} = -0.73$ ,  $m=-1$ ) suggests that aerial shooting is not widely considered a desirable option, although it may be more acceptable than recreational hunting. In terms of management implications, when complementary or alternative methods of management are under deliberation, consideration of local public



attitudes may be necessary in order to avoid potential conflict, particularly regarding options that have high objection, such as recreational hunting or and to a lesser extent aerial shooting. Communication regarding low viability of some options e.g. fertility control, may also need to be improved.

*iii) Humaneness and animal welfare.* The dominant attitude category was support for culling if carried out humanely. This was supported by moderate agreement with statement 6 (humane euthanasia is acceptable,  $\bar{x}=1.36$ ,  $m=1$ ) suggesting lethal control of deer may be acceptable if animal welfare standards are met. However perception of humaneness varied between respondents and some considered current management to be inhumane. Humaneness of alternative methods was also raised, including concern that aerial shooting and recreational hunting would be inhumane. Implications for management relate to ensuring animal welfare protocols are in place and implemented in order to maintain support for lethal control, and communication to the public about these protocols.

*iv) Human-safety relating to management.* Concerns emerged over safety of the management programme, particularly surrounding shooting in close proximity to residential areas. This was supported by quantitative data, with only negligible agreement with statement 16 (deer programme is safe with necessary precautions,  $\bar{x}=0.33$ ,  $m=0$ ). However, negligible agreement with statement 18 (people could die with people shooting in the park,  $\bar{x}=0.48$ ,  $m=1$ ) suggests that use of firearms per se may not be of major concern. Even so, both qualitative and quantitative data indicate some concerns over safety. Management implications therefore relate to minimising risk and communicating safety precautions effectively to the local public.

**Table 3.** Themes and sub-themes within the *management dimension* of local public attitudes in relation to deer management, and the frequency of occurrence of related attitudes.

<b>Theme</b>	<b>Sub-theme</b>	<b>Attitude category</b>	<b>Number of respondents</b>
Effectiveness of management	Observed population of invasive species	Deer population has decreased and/or deer exist in negligible numbers	19
		Deer population has increased and/or deer exist in large numbers	15
		There are additional factors which lead to a population increase	11
		Deer are spreading out of the RNP	5
	Satisfaction with implementation and outcomes	Dissatisfied with implementation/ outcomes of the programme	15
		Satisfied with implementation/ outcomes of the programme	10
	Research	There is sufficient research/no need for more research	6
		Not convinced by the research/more research is needed	5
Population management methods	Current management methods and objectives	Support eradication of deer from the RNP	51
		Support culling and/or maintaining deer at a manageable number in the RNP (but not necessarily eradication)	39
		Do not support culling of deer/shooting	21
		Alternative/complementary methods	19
	Alternative/complementary methods	Support fertility control	15
		Against recreational hunting	13
		Support relocation	11
		Support other methods [ <i>not otherwise listed</i> ]	9
		Against aerial shooting	7
		Recognize problems in implementing other methods	5
		Support natural regulation	5
		Support recreational hunting	2
	Humaneness and animal welfare	Support humane culling	12
		Current management methods are not humane	12
		Some alternative methods would be more humane	5
		Some alternative methods would not be humane	3
Human safety relating to management	Concerned over human safety relating to the deer management programme	20	

**Table 4.** Level of agreement/disagreement with the statements of Section 2 of the postal survey to residents boarding the Royal National Park on a scale of -3 (strongly disagree) to 3 (strongly agree).

Statement ID	Statement	n	Mean ±SE	Median	Related sub-theme from Section 3
a) Stakeholder dimension					
12	The actual amount of information that is coming out to the community is very low, it's all hidden away in papers.	399	1.35 ± 0.08	2	Information and awareness
11	It's not just a government issue, it is the community's issue, and the National Parks & Wildlife Service is managing the Royal National Park on behalf of the community.	399	1.65 ± 0.08	2	Stakeholder participation and decision making
10	Public information evenings and feedback forums are a valuable opportunity to discuss other options for deer management.	401	1.27 ± 0.07	1	
31	The feeling now is that National Parks & Wildlife Service has their agenda and that agenda is set. So if you don't agree with it, you can raise your concerns, but I don't think anyone is listening.	393	0.69 ± 0.09	0	
22	Community groups are the conscience of the government and the bureaucrats as to the ways of approaching deer problems and pest problems.	396	0.58 ± 0.08	1	
32	I don't put my faith in any government to be able to see this sort of thing [the deer management programme] through.	400	0.72 ± 0.09	1	Effectiveness in decision-making and action
23	There really needs an independent person to assess the [deer management] programme.	396	0.50 ± 0.09	1	
24	Until the whole community sees deer as a problem, we won't go forward.	395	0.40 ± 0.10	1	Relationships within communities
8	The Royal National Park is there for conservation, public enjoyment and education.	395	2.43 ± 0.06	3	Relationships between communities and wildlife authorities
b) Wildlife dimension					
15	An independent scientific committee says that deer are a key threatening process [to the environment], so there's really no debate [about their impact] any more.	395	0.87 ± 0.10	1	Environmental effects
26	I don't think environmental damage in most of the Royal National Park is that evident.	397	-0.43 ± 0.10	-1	
2	Deer can be very dangerous.	395	0.61 ± 0.10	1	Human safety from wildlife interactions
30	People don't necessarily not like the deer per se, they don't like the deer because they attract illegal activities.	395	-0.55 ± 0.09	0	Socio-economic effects
21	Any feral animal in a nature reserve should be killed, no matter how beautiful it is.	399	0.35 ± 0.11	0	Position in the environment
13	The deer have been there [in the Royal National Park] for so long they are almost pseudo-native animals in the park.	400	-0.67 ± 0.11	-1	

**Table 4 continued**

## c) Management dimension

17	At the moment they [National Parks & Wildlife Service] are doing the best as they possibly can with what they've got and what they have available to them.	395	0.03 ± 0.09	0	Satisfaction with implementation and outcomes
29	National Parks & Wildlife Service can't make an argument [to cull deer] without good information to push the case.	396	0.61 ± 0.09	1	Research
20	You can spend too much on research, it is better if you just deal with the problem.	395	0.46 ± 0.10	1	
3	I recognise that the deer are a pest; they've got to be removed.	397	0.83 ± 0.11	2	Current management methods and objectives
5	I think the deer need a lot more pressure put on them.	385	0.57 ± 0.11	1	
25	There's nobody that's so strongly against deer that they wouldn't tolerate small background numbers.	391	-0.32 ± 0.10	0	
14	We're facing a huge environmental crisis at the moment, which makes any deer issues pale in comparison.	396	-0.38 ± 0.10	0	
1	I'd like to see the deer remain.	398	-0.79 ± 0.12	-2	
9	National parks are something sacred, something a bit different, and we need to preserve them. They are not recreation grounds or hunting grounds.	393	1.44 ± 0.10	2	Alternative / complementary methods
4	I've always thought that a non-violent approach [to deer management] is the only course to take.	396	0.27 ± 0.11	0	
27	I think sustainable utilisation of deer is the only approach that will ultimately succeed.	385	-0.24 ± 0.10	0	
28	There are a few modifications to the [deer management] strategy that could make it more effective, and one of those strategies would be aerial shooting.	398	-0.73 ± 0.10	-1	
19	I can't understand why you can't hunt deer in a national park.	394	-1.87 ± 0.09	-3	
6	There's no issue with the deer being euthanized, providing it's done quickly, humanely and without causing additional stress to the animal.	392	1.36 ± 0.10	1	Humaneness and animal welfare
18	You could die with people shooting [deer] in the national parks.	393	0.48 ± 0.10	1	Human-safety relating to management
16	It [the deer management programme] is totally safe; precautions are all in place, there is no risk taken	392	0.33 ± 0.09	0	
7	It [the deer management programme] encourages illegal shooters to come in.	390	0.09 ± 0.10	0	

**Table 5.** Implication of dimensions of local public attitudes for management

<b>Theme</b>	<b>Sub-Theme</b>	<b>Implications for management strategies</b>
<b>(a) Stakeholder dimension</b>		
1. Stakeholder participation and decision-making	Information and awareness	Provision of information on programme operations and justification of management (e.g. ecological effects) to maintain public support.
	Participation in consultation and decision-making.	On-going, regular discourse with the local public, but without expectation of reaching consensus (unlikely in value-laden conflicts); utilisation of experienced facilitators in the consultation processes, for example in public meetings, to improve quality of participation process.
	Effectiveness in decision-making and action	Maintenance of a balance between management action and politics/engagement - may be facilitated through decision-making using a collaborative management approach from the onset.
2. Stakeholder relationships	Relationships within communities	Assistance with conflict mitigation where there are tangible solutions. May require providing information, assistance or enforcing regulations.
	Relationships between communities and wildlife authorities	Improvement to broader protected area management processes (including issues unrelated to invasive species) and acknowledgement of social values of protected areas to improve credibility and relationships between local public and wildlife managers – this may reflect positively upon invasive species management programmes.
<b>(b) Wildlife dimension</b>		
3. Invasive species effects	Environmental effects	Information provision on environmental impacts - may necessitate investment into ongoing monitoring of invasive species population/effects to provide ecological data to support such claims.
	Human safety from wildlife interaction	Identification and response to human safety risks experienced or perceived by the local public.
	Socio-economic effects	Minimisation of socio-economic impacts e.g. through financial support and information provision. Incorporation of positive social impacts into management objectives e.g. maintaining a low population of invasive species, at a level of ecological impact that is measurably low.
4. Perception towards invasive species	Invasive species characteristics	Likely to be value-led and difficult to influence through management-possibly influenced through education and awareness strategies.
	Position in the environment	Awareness of other (e.g. sympathetic) attitudes towards non-native species may assist in conflict management-likely to be difficult to influence through management other than through on-going education and awareness campaigns on invasive species effects.
<b>(c) Management dimension</b>		
5. Effectiveness of management	Observed invasive species populations	Improvement to management and engagement strategies by approaching the local public as distinct communities in context of invasive species interaction. Public involvement in wildlife reporting, for example, utilising a citizen science approach, to facilitate targeted management efforts to help achieve ecological objectives.
	Satisfaction with implementation and outcomes	Identification and response to local public concerns over management to increase satisfaction levels amongst local public - may be facilitated through development of indicators of success with community input.
	Research	Effective communication of science and research to the public to increase public awareness of the scientific basis of invasive species management and help gain support.

**Table 5 continued**

6. Population management methods	Current management methods and objectives	Aim for majority public support as a realistic and politically feasible goal – levels of support may need to be measured.
	Alternative/complementary methods	Consideration of local public attitudes regarding alternative methods, to avoid potential conflict. Communication regarding viability of options may also need to be improved.
	Humaneness and animal welfare	Implementation of animal welfare and shooting protocols to ensure humaneness of management, and communication of protocols to the public to maintain public support.
	Human safety relating to management	Effective communication of safety precautions to the public to maintain public support and credibility.

## Discussion

In this paper we aimed to identify the different dimensions of local public attitudes towards invasive species management in a protected area. We also addressed whether, and how, management may influence attitudes within these different dimensions. This can be considered an important initial step towards developing an adaptive management approach which responds to community concerns and attitudes (Fraser 2006), which may be necessary for achieving ecological objectives. Other research into attitudes towards invasive species has focused on the influence of stakeholder characteristics (e.g. García-Llorente *et al* 2008; Sharp *et al* 2011). In our study, rather than focusing on stakeholder characteristics, we aimed to identify the different dimensions of attitudes towards invasive species management based on a combination of situational factors (e.g. experiences) and perceptions. The purpose of this was to identify issues that managers may need to address when managing invasive species, even in the absence of knowledge of the specific characteristics of the stakeholders involved. We identified three main dimensions to local public attitudes- stakeholder, wildlife and management dimensions. Within these dimensions, we identified specific themes and sub-themes and analysed related attitudes, thus forming a conceptual framework for understanding, and subsequently responding to, local public attitudes. Conceptualising local public attitudes in this way, and identifying potential management strategies with regards to these dimensions, may help to improve both ecological and social outcomes in invasive species management.

We used a predominantly bottom-up approach, using both qualitative and quantitative analysis. Identification of emerging themes, based on qualitative data, reflects community attitudes more realistically than using pre-defined themes (Strauss & Corbin 1990). The

quantitative data mostly supported the qualitative data, without notably conflicting cases, although responses to the statements typically showed less overall agreement (or disagreement) than may have been expected based on the qualitative data alone. This highlights the potential risk of basing conclusions solely on qualitative responses (which may be based on the most opinionated respondents), as factors may appear more important than they are to the local public as a whole. The combination of both qualitative and quantitative analysis therefore provides an indication of the most important issues, but also the strength of agreement with respect to the whole sample. However some limitations existed in our approach. Using statements based on key stakeholder attitudes (Section 2) is likely to only partially reflect factors that may be important to the local public, as the key stakeholders who were interviewed may not experience situational factors related to living on the PA boundary, and are likely to have a different level of knowledge and interest. The closed questions of the survey (Sections 1 and 2) will have also influenced the responses to the open comments questions (for example in providing additional information on previous answers), which is a limitation in terms of gaining truly bottom-up data. Nevertheless, respondents are likely to have only made further comments on issues that they considered important. The majority of feedback on the survey was positive, although some ambiguity or complexity of the statements of Section 2 was noted by some respondents. In our survey design, we used the original statements derived from the interviews, with only slight changes for clarification, in order to minimise bias. However, to improve clarity further, it may be beneficial to adapt statements such as these to a simpler format to reduce ambiguity. Despite the limitations, our analysis has produced a potentially useful approach for framing local public attitudes towards invasive species, and could be used a basis to assess and respond to attitudes of the local public to help achieve management goals. The relative importance of the themes we identified will most likely vary depending on the case in question, and is also likely to vary in time. Additional factors may also apply to other cases. Therefore, to develop upon our analysis, further research, for example using a meta-analysis approach, could be conducted to test the applicability of these dimensions and related themes to other case studies, and to formulate clearer objectives for incorporating them into management strategies.

The emergence of a stakeholder dimension reflects the significance of human interactions in invasive species management. Stakeholder participation and decision-making emerged as a key theme within this dimension. Stakeholder participation is recognised as an important process in environmental management (e.g. Reed 2008). Our analysis highlights

three main areas to address within this theme. The first of these, *information provision and awareness*, is a recognised factor influencing attitudes towards invasive species in several studies (Bremner & Park 2007; García-Llorente *et al* 2008). For example, prior knowledge of invasive species management programmes can lead to increased support (Bremner & Park 2007). Informing and education can be used as an on-going process in conjunction with higher levels of participation as an iterative process (Jackson 2001). The second sub-theme, *participation in consultation and decision-making*, highlighted that lack of continuation of consultation risks a deterioration in support and trust in local decisions (Hudson *et al* 2007). Our analysis also suggests some value in consultative participatory methods such as public meetings, although absence of effective facilitation may undermine such participation processes (Reed 2008). The third sub-theme, *effectiveness in decision-making and taking action*, reflects the difficulties faced in contentious wildlife management. A potential dilemma emerged in our analysis between demonstrating strong leadership and decision-making, and taking action to reduce ecological impacts, while at the same time maintaining political and public acceptability. In high conflict and high profile scenarios, extensive stakeholder engagement is likely to be a necessity, and the influence of politics and interest groups on decision-making can be critical (e.g. Bertolino & Genovesi 2003; Nimmo & Miller 2007). To address this, adopting a collaborative management strategy from the onset, incorporating key interest groups into decision-making, may facilitate the process (e.g. Shephard 2002; Nesbitt 2006). This should be used in conjunction with, rather than instead of, public consultation (Margerum 1999).

The second key theme that emerged within the stakeholder dimensions was stakeholder relationships. Conflicts related to wildlife management are increasingly recognised to be between people, rather than between humans and wildlife (Madden 2004; Peterson *et al* 2010). Such ‘human-human conflicts’ are a result of often incompatible values and demands of different stakeholders groups (White & Ward 2010). Management strategies which are directed at conflicts between people, rather than solely human-wildlife conflict, may lead to improved social outcomes. Two types of conflicts were identified- *conflicts within communities*, and *conflicts between communities and wildlife authorities* (e.g. managers and government staff). Conflicts between communities and wildlife authorities may lead to a break-down of relationships and public support. However, such conflicts may be the more easily addressed than those occurring within the communities. We found the main source of conflicts between communities and wildlife authorities were related to broader issues of PA management, including the need for managers to appreciate social



benefits of PAs as well as conservation benefits. Indeed social benefits, such as recreation, are a recognised a function of PAs (McNeely 1994). Although this issue is not directly related to invasive species management, breakdown in confidence on one issue of management can diminish credibility and trust in another (Fraser 2006). This suggests that improving management on a broader level may influence attitudes towards invasive species management.

Within the wildlife dimension, invasive species effects was identified as a key theme, reflecting the importance of interactions between humans and wildlife, whether positive or negative, on attitudes (White & Ward 2010). Within this theme, three types of effects were identified. The first, *environmental effects*, may not only be important for wildlife managers with conservation objectives, but also to the local public who may also share conservation-related values. Environmental effects may also be the main justification for undertaking control efforts. Although in our case study there appeared to be considerable awareness of environment effects (a probable result of education strategies), having reliable ecological data to support claims of environmental effects is likely to be important. The second type of effect was *human-safety from wildlife interactions*. Reducing human safety risks should be a management priority (for example through risk avoidance behaviour), however communicating the potential risks may also increase support for a reduction in invasive species population (Stout *et al* 1993). The third sub-theme revealed the importance of both positive and negative *social and economic effects*. The intangible nature of many of the positive social benefits (such as connectedness with nature) can mean that they are often considered unconvincing by wildlife managers compared to negative ecological impacts (White *et al* 2011). These positive social effects, and the fact that eradication may not be seen as a desirable goal by all members of the local public, needs to be recognised by wildlife managers. This may be achieved through formulating objectives that allow for positive benefits to be maintained at some level. For example, eradication of established invasive species is often difficult (Mack *et al* 2000). In such cases, formulating an objective of maintaining a population of invasive species at a level of environmental impact that is measurably low may help maintain continued support and improve relations (Larson *et al* 2011), particularly with those against eradication, while in practice having negligible effect on management strategies and still meeting conservation objectives. The second key-theme of the wildlife dimension, *perception towards invasive species*, is perhaps the least easily affected through management strategies. Perceptions are likely to be considerably influenced by underlying

wildlife value orientations, which change more gradually than attitudes (Teel & Manfredi 2010). Sharp *et al* (2011) found that environmental orientations were a stronger indicator of support for invasive species management than other factors such as knowledge. Heterogeneity of value orientations can also result in increased conflict (Teel & Manfredi 2010). Therefore, although values and perceptions may not be easily influenced by management, they play an important role in the level of support. Awareness and understanding of these perceptions and values may therefore be useful for conflict mitigation, although may be difficult to influence.

The third dimension was the management dimension. By its nature, management strategies should be able to influence attitudes within this dimension. A key theme that emerged related to *population management methods*. Several alternative/complementary methods were raised by respondents. Fertility control was the most preferred, consistent with the findings of Bremner & Park (2007), however there was a lack of support for recreational licensed hunters or aerial shooting, the latter which was also highly contentious in the management of feral horses in Australia (Chapple 2005). The preferred method of control, and the method which is practical and effective for a particular species, can differ considerably, highlighting the need for effective community education (Bremner & Park 2007). Human-safety relating to selected control methods emerged as a concern. Fraser (2006) ascertained that the perception of risks associated with certain control methods (for example the use of the bait 1080 and biological control) can make public acceptability improbable. Reducing perception of risk associated with control methods is important for gaining support, but may require community engagement beyond that of simply providing information (Fraser 2006). Similarly, the humaneness of control methods was also an important factor, therefore ensuring that animal welfare procedures (e.g. Sharp & Saunders 2004) are in place and implemented is vital. Involving animal welfare organisations (such as RSPCA) in decision-making, and educating communities regarding humaneness may also increase support. Our results indicated considerable support for culling and a reduction in the deer population, if carried out humanely. This may be considered surprising giving the target of control is a large, charismatic species, with associated positive social effects (as emerged in the wildlife dimension). The relative importance of the different dimensions and themes is therefore of interest. Each dimension plays a role in the level of support towards invasive species control, but some themes may be more influential than others. In our case study, a combination of awareness of environmental effects, experience of human safety risks and property damage, and the use

of professional ground shooting as a method, appear to have contributed (amongst other factors) to a majority support for decreasing deer numbers, despite positive species characteristics. However, changes in any one of these (or other) factors, including levels of consultation or the method of control use, has the potential to change the balance to minority support and higher levels of opposition. For example, a study by Finch & Baxter (2007) revealed that over 50% of landowners that they surveyed in Queensland preferred deer levels to remain the same or increase. A meta-analysis approach, examining a range of case studies, may provide greater understanding of the interactions between the dimensions.

Our research highlights how social research can assist in biodiversity conservation through identifying ways of improving social outcomes, which in turn can help achieve conservation objectives. This process can be vital in contentious issues such as invasive species management. To make such improvements, wildlife managers need to develop an understanding of local public attitudes towards invasive species management, and direct management strategies accordingly. This paper conceptualises local public attitudes under three main dimensions - stakeholder, wildlife and management dimensions, comprised of several themes and sub-themes. We identified several management strategies based upon this framework to help achieve more effective management. The framework may provide a valuable guidance for setting management objectives and directing community engagement strategies. Responding reactively to social challenges can result in delays to invasive species control, resulting in greater damage to the environment, and a break down of stakeholder relationships which can take considerable time to form. The framework developed here may facilitate in pre-empting social problems, thereby helping to achieve social and ecological outcomes in invasive species management.

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## CHAPTER V

### CONCLUDING DISCUSSION

#### 5.1 Summary

The aim of this thesis was to identify key factors shaping the relationship between society, invasive species and conservation and examine how these factors inform the management of invasive species in terms of achieving ecological and social objectives. This was approached through focusing on three dimensions of this relationship - stakeholder participation, social and political context and mechanisms, and public attitudes. These dimensions were addressed through three distinct but related studies in the context of invasive species management in Australia.

Chapter II analysed stakeholder participation. The aim was to identify what features of participatory invasive species programmes influence success from both a social and ecological perspective, for example through improving stakeholder relationships and protecting native species. This was achieved using interview-based questionnaires administered to wildlife managers across Australia. Several relationships between participation features were identified. Invasive species effects were related to programme origin, stakeholder composition, and to the drivers for using a participatory approach. Programme origin was also related to participation methods, level of governance, change in stakeholder interaction and change in invasive species population. Change in invasive species population, an ecological outcome, was negatively correlated with stakeholder satisfaction, a social outcome. Furthermore, change in participation numbers, stakeholder satisfaction and occurrence of conflict were also related.

Chapter III examined social and political context. The aim was to identify social mechanisms used in invasive species management, i.e. management approaches based predominantly around people and society (as opposed to ecology), and explore how context shapes these mechanisms. This was achieved using invasive Rusa deer (*Cervus timorensis*) in New South Wales (NSW) as a case study, using in-depth interviews with key stakeholders. Social mechanisms that emerged from the analysis were legislation, collaborative arrangements and community engagement, along with two facilitating mechanisms, funding and resources, and knowledge, research and development. The analysis revealed how ‘context-themes’ relate to these mechanisms. For example political

history and culture were shown to affect legislation (particularly surrounding hunting) and community engagement (for example trophy hunting culture). Legislation was identified as needing, in some cases, to align more closely with society, and core values were identified as being important factors to address in community engagement. Political ideologies and interest group relationships were also found to affect collaborative arrangements. A need for effective communication that incorporates social and political factors at all stakeholder levels was identified.

Chapter IV investigated public attitudes in relation to invasive species management. The aim was to identify different dimensions, for example the types of issues or factors that shape local public attitudes towards invasive species management in a protected area, and to use this to develop a framework for understanding, and then responding to, these attitudes. This was achieved using deer management in the Royal National Park (RNP) as a case study, using a postal survey delivered to local residents. Three main dimensions to local attitudes were identified- stakeholder, wildlife and management dimensions. These dimensions consisted of six themes: stakeholder participation and decision-making; stakeholder relationships; invasive species effects; perceptions towards invasive species; effectiveness of management; and population management methods. The analysis provides a framework for identifying potential conflicts and directing management strategies towards improved social outcomes and public support.

This chapter (Chapter V) aims to consolidate these three studies. This is approached by identifying common themes that emerged within the studies, and considering the implications for achieving positive ecological and social outcomes. The chapter discusses the two main themes that emerged in the analyses - social factors affecting invasive species management (5.2) and the role of stakeholder participation in achieving ecological and social outcomes (5.3). Within these two themes, key findings from the three studies are discussed. Links to the behavioural and social theoretical approaches identified in 1.1 and 1.2 are also discussed. Finally, this chapter considers the thesis in terms of broader implications for understanding the relationship between conservation, society and invasive species, including the challenges facing the management of human relationships with wildlife, and the necessity of participation in this process (5.4).

## **5.2 Social factors affecting invasive species management**

Social factors play a significant role, alongside environmental and economic factors, in invasive species management (Larson *et al* 2011). Social factors are related to how people interact with and perceive invasive species, and how people interact with each other with regards to the management of invasive species. For example, social factors may be related to stakeholder attitudes and preferences (García-Llorente *et al* 2008; Sharp *et al* 2011) and social benefits or losses relating to invasive species (Pejchar & Mooney 2009). This section addresses three main social factors that emerged in the three studies – (i) social associations with species (5.2.1), (ii) conflict over wildlife-related values (5.2.2), and (iii) conflicts between humans and invasive species (5.2.3). An understanding of the relevance of these social factors in invasive species management, and the development of appropriate strategies in response to these factors, may help improve stakeholder relationships and ensure that management and policy will be supported by the public, which is a necessity for sustainability of invasive species management programmes (Larson *et al* 2011).

### **5.2.1 Social associations with species**

Social associations are important in human-wildlife conflict (Dickman 2010) and in invasive species management (White *et al* 2011). This thesis reveals that:

- (a) Social associations with invasive species relate predominantly to two factors - species characteristics and their position in the environment (Chapter IV).
- (b) Social associations can result in the need to align legislation with societal views and preferences for it to be accepted, but may be overcome through management strategies (Chapter III).
- (c) Although a native-alien dichotomy exists, and can affect the approach to management, the perceptions of native-alien boundaries are not necessarily fixed (Chapter IV).

This section also discusses the potential importance of other social associations such as cultural or religious connections.

Within the wildlife dimension described in Chapter IV, *perceptions towards invasive species* emerged as a theme shaping public attitudes. This included the sub-themes

*invasive species characteristics*, and *position in the environment*, reflecting types of social associations related to invasive species. In *invasive species characteristics*, both positive and negative social associations relating to invasive deer were evident. For example, in Chapter IV, the dominant attitude was that deer are ‘beautiful’ and ‘charismatic’. These positive associations and aesthetic value of deer also emerged in Chapter III as a social benefit. In Chapter II, ‘pro-pest attitudes’, which included social influences such as aesthetic value (amongst other motives such as economic benefit), were also identified as a motive for non-participation in invasive species management programmes (Chapter II, Table S4). Similarly, Bremner and Park (2007) revealed that there was less public support for control of invasive birds compared to other taxa. These attitudes link to *invasive species characteristics*, particularly the tendency of society, including the research community, to show a bias towards particular taxonomic groups, especially mammals and birds (Clark & May 2002). Taxonomic bias therefore transcends the boundary of native-alien species.

*Invasive species characteristics* may affect preferences in control methods in invasive species management, as some control methods are considered more or less acceptable depending on the species (Perry & Perry 2008). For example, in Chapter IV, there was overall disagreement with the use of aerial culling as a method of controlling invasive deer in the RNP, which is likely to relate at least in part to the positive social associations with deer, although it is also related to concerns over human safety and animal welfare (Chapter III). Chapple (2005) also identified a strong opposition to aerial culling of feral horses (*Equus caballus*), leading to a ban on aerial culling of horses in NSW. This opposition is despite the fact that aerial shooting is used frequently for the culling of feral goats (*Capra hircus*) and feral pigs (*Sus scrofa*) in Australia (Reddiex *et al* 2005) with apparently minimal opposition by the general public. In Chapter III there was suggestion that an urban-rural divide in acceptance to aerial culling may exist, indicating that the strength of social associations may be affected by other social influences. *Invasive species characteristics* can also influence policy and legislation (Chapter III). For example, the decision to incorporate deer management into a combined ‘feral animal’ policy was based on the lack of acceptance of deer culling at the time due to positive social associations with deer. This illustrates that social associations, such as *invasive species characteristics*, can have a considerable affect on management, and may require changes to policy to create a better *alignment with society* (identified as a context theme in Chapter III). However, it also illustrates that social associations may be overcome through appropriate

management strategies, as Chapter IV revealed deer culling in the RNP to be generally supported (Chapter IV), a clear shift away from opposition that had been first experienced (Chapter III) (Shephard 2002).

The sub-theme *position in the environment* relates to the native-alien dichotomy and the value given by humans to native over non-native species (Davis *et al* 2011). In addition to *invasive species characteristics*, *position in the environment* may also influence preferences towards control methods. For example, strong public opposition to culling overabundant koalas (*Phascolarctos cinereus*) on Kangaroo Island in South Australia, which are a native species and national symbol, led to an alternative option of fertility control being explored; however wheat-baits used to poison non-native mice in South Australia were used extensively during the same period without such opposition, despite both species having the ability to feel pain and suffer (Oogjes 1997). However, *position in the environment* and the native-alien dichotomy may not always be clear-cut. For example in Chapter IV, although the dominant attitude was that deer were ‘out-of-place’ or ‘feral’ in the RNP, there was some perception that deer should not be treated differently to native species, and could be considered ‘pseudo-native’ (a term that emerged in Chapter III) due to the length of time they had been present in the park, although there was greater disagreement than agreement with this attitude. There was also lack of strong support for killing non-native species based solely on their alien status, regardless of aesthetic value (Chapter IV). This may represent a form of double-loop learning, as assumptions and governing variables (such as alien status and aesthetic value) underlying the actions (culling of animals) may be reflected upon (Reed 2010). Other examples of a ‘pseudo-native’, or a ‘naturalised’ status of invasive species also exist, for example the brown hare (*Lepus europaeus*) is non-native to Britain yet is a protected species and their expansion is encouraged, being the subject of a UK Biodiversity Action Plan (White *et al* 2011). While the native-alien dichotomy is evident in this thesis, the results also suggest that, at least from the perspective of some sections of society, such a distinction between native and non-native species may be inappropriate. This is also argued by several authors, such as Peretti (1998), Slobodkin (2001), and more recently Davis *et al* (2011). The native-alien dichotomy may present a dilemma from which triple-loop learning could develop, as it challenges values and norms, which is characteristic of this learning level (Reed *et al* 2010; Tosey *et al* 2011).



These findings support previous research which highlights the importance of social associations in biodiversity conservation. For example Dickman (2010) identified social influences to be an important factor in human-wildlife conflicts with native endangered or threatened species. Dickman (2010) refers to negative social associations which may be problematic in the protection of native species, such as the threatened aye-aye (*Daubentonia madagascariensis*), persecuted for its association with bad luck and disaster (Simons & Myers 2001). However, positive associations may assist conservationists in the protection of endangered species, for example, the Sclater's guenon (*Cercopithecus sclateri*), a rare monkey in Nigeria at risk from deforestation and hunting, is considered sacred by the Igbo tribe and is protected in their local villages (Oates et al 1992). For invasive species, the converse is true, as positive social associations may hinder control efforts of invasive species, exemplified with deer in the RNP, and also by Chapple (2005) with respect to non-native horses in Australia, whereas negative associations may assist invasive species control efforts. Some studies into human-wildlife conflicts have also identified religious associations with native species, for example some primates are beheld as gods and evil spirits (Hill & Webber 2010). Religious beliefs can be an important part of a person's social identity, which was identified by Van Vugt (2009) as a key focus for management intervention. Religious associations with invasive species only emerged as a minor factor in this thesis, with less than 1% of respondents in Chapter IV mentioning a link between deer and Christmas (although this link may be more cultural than religious). Religious associations with non-native species may be expected with the major religions of the world which are not confined within particular biogeographical boundaries. However, positive indigenous religious associations with non-native invasive species have been identified, for example that of feral pigs (*Sus scrofa*) in Hawaii (Pejchar & Mooney 2009). Invasive species can also have negative effects on religious practices, such as cane toads (*Bufo marinus*) plagues decreasing the populations of native species that are religiously important to indigenous tribes in Australia (Pfeiffer & Voek 2008). Therefore, although cultural or religious associations of the case study used in this thesis was minimal, the effect of non-native species on cultural services (for example through impoverishing, enriching or facilitating culture) (Pfeiffer & Voek 2008), may be an additional factor to be considered in the relationship between society, conservation and invasive species.

### 5.2.2 Conflicts over wildlife-related values

The prevalence of human-human conflicts surrounding invasive species (Maguire 2004; Bremner & Park 2007) makes understanding the nature and causes of these conflicts highly relevant for their effective management. In this thesis, wildlife-related values were identified as an important cause of conflict. In particular, the analyses revealed that:

- (a) Wildlife-related values contribute to human-human conflicts at different stakeholder levels, related to three main themes- management of ‘game’ species as a pest or a resource (Chapter III), the role and management of protected areas (Chapters II-IV) and animal rights (Chapter III).
- (b) Animal welfare is a prominent wildlife-related value, therefore humaneness of control methods needs to be both achieved and communicated to the public (Chapters III & IV).
- (c) Political history, through affecting wildlife-related values, influences attitudes towards, and conflict surrounding, invasive species management methods (Chapter III).

Understanding the nature of the conflicts, and identifying where there is potential for conflict is essential for increasing the effectiveness of conflict mitigation strategies. Approaches to conflict mitigation are addressed in 5.3.

Valuing deer as a resource, rather than as a pest, has contributed to conflict surrounding deer management (Chapter III), which has also been identified as a source of conflict by Nugent & Fraser (1993). In the case study of this thesis, these opposing wildlife-values have contributed to contention between government departments, occurring predominantly between the Game Council NSW and the Office for Environment and Heritage NSW (OEH) (Chapter III) exemplifying what Grimble & Wellard (1997) term ‘macro-macro’ conflicts. This, combined with distrust and ineffective communication, has hindered political cooperation between the departments regarding deer management. Although Van Vugt (2009) identifies stakeholder trust in institutions as of key importance, it is apparent that trust *between* institutions is also relevant. Some successful cooperation had been achieved, however, this was stated as being aided by an agreement to use a ‘pest’ management approach (Chapter III). Different values also emerged even within the hunting community. In particular, a culture of trophy hunting was apparent in NSW but was not supported by the governing body, the Game Council (Chapter III). The trophy hunting culture may relate in part to social identity, a factor identified as an important

motive affecting environmental attitudes and behaviour (Van Vugt 2009). This trophy hunting culture relates to valuing wildlife based only on retrieving a trophy i.e. head, of an animal, rather than sustainable population management or undertaking a skilled pursuit with a meaningful connection with wildlife (e.g. as predator and prey), as might be argued with recreational 'sport' hunting (Gunn 2001). Therefore, the Game Council employed strategies for changing this trophy hunting culture (see 5.3), by facilitating a process of social learning, thereby attempting to change wildlife-related values in this section of society (Chapter III).

Wildlife-related values relating to the role and management of protected areas in Australia were also identified as a cause of conflict (Chapter III & IV). In particular, the approach to national park management was perceived as 'lock-it-and-leave-it' by some stakeholders (Chapter III). As discussed in Chapter III, this approach is likely to be related to the concept of 'wilderness', which transformed from having negative associations, through to positive connotations in the 19<sup>th</sup> century, in concordance with conservation movements of the time (Mittermeier *et al* 2003). The value of wilderness therefore changed from being a place of hostility and savagery, to a place of refuge to fulfil emotional and spiritual needs (Colchester 1997). The wilderness concept, and associated management approaches to national parks, may have a role in macro-micro conflict regarding whether licensed volunteer hunting should be allowed in national parks as a recreational pursuit (Chapter III). 'Macro-micro' conflicts relating to the management of protected areas, occurring between national institutions and local people (Grimble & Wellard 1997), were also exemplified in both Chapters II and IV. For example, conflict resulted from perceived lack of government action and responsibility over invasive species management in protected areas, resulting in migration of invasive species onto adjacent land, thus contributing to human-wildlife conflict (Chapter II), and consequently the need for collaborative management efforts (Chapter III). This was also illustrated in Chapple (2005) with respect to managing non-native horses in protected areas. In Chapter IV, an apparent lack of government appreciation of the social benefits that can be provided from protected areas also contributed to macro-micro conflicts, identified in the theme *stakeholder relationships* (Chapter IV). Social benefits are a recognised function of protected areas (McNeely 1994) and there was some indication in Chapter III that there may be move towards increasing societal value of national parks in NSW. As identified in Chapter IV, making these changes, and improving national park management on a broad level, may strengthen relationships between the local public and wildlife managers (e.g. trust in the

environmental institutions, Van Vugt 2009) and may result in increased support for invasive species management programmes being conducted in protected areas.

Animal rights values, while not emerging as a prominent element of these analyses, are an important example of differing wildlife-related values that can affect invasive species management. Chapter IV indicated considerable support for culling deer using professional ground shooting. However, the use of lethal control often elicits opposition from some stakeholders, particularly, but certainly not limited to, animal rights groups. For example, animal rights activists were identified as opposing the culling of deer in the RNP, and forming a counter-intuitive alliance with hunting groups, in an attempt to prevent deer culling (Chapter III). The different philosophical stances and values of animal rights protagonists on the one hand, concerned primarily with the life and rights of individual animals, and conservationists on the other, concerned primarily with species and communities (Perry & Perry 2008), can jeopardize invasive species management programmes due to opposition of animals rights activists (e.g. Bertolino & Genovesi 2003; Nimmo & Miller 2007; Webb & Raffaelli 2008). Where eradication may have been possible, but the window-of-opportunity lost, such opposition has resulted in a decline of native species and more invasive animals being killed in the long-term (Perry & Perry 2008). Stakeholder identity, in terms of philosophical stances and values, can therefore be highly relevant to invasive species management. However, Perry & Perry (2008) argue that despite the differences and reservations, animal rights groups and conservationists share some common ground, in having concern for the environment and animal welfare. Greater emphasis on a proactive approach for reducing new biological invasions, and greater financial support from animal rights groups for alternative approaches to lethal control, such as fertility control, may provide scope for cooperation between these stakeholder groups (Perry & Perry 2008).

Animal welfare emerged as a key wildlife-related value affecting public support for control methods. In Chapter III, *core values* were identified as a context theme, gravitating predominantly around animal welfare and human safety. Both of these values were also identified as themes within the *population management methods* theme of Chapter IV, specifically *humaneness and animal welfare*, and *human safety relating to management*. Humaneness was also identified by Fraser (2006) as a factor affecting public support for different control methods. The importance of animal welfare as an issue has developed progressively over recent decades (or even centuries) from concerns of

animal cruelty, relating specifically to deliberate intention to cause pain when there is no reasonable human need to do so, to concern over pain and suffering regardless of the human necessity for the action (Rollin 1990). Therefore, despite necessity for controlling invasive species, legislation typically requires a humane approach and minimal suffering. In a similar way that perceptions of risk of wildlife impacts and actual risk may differ (Dickman 2010), actual humaneness of control techniques and perception of humaneness by the public may not necessarily coincide. Different attitudes regarding the humaneness of ground shooting of deer in the RNP (Chapter IV) illustrate that perception of humaneness also varies between stakeholders. Therefore, in addition to ensuring that control methods are actually humane, the humaneness of the control method needs to be conveyed to the public if support is to be gained, in much the same way as human safety protocols need to be effectively communicated to the public (Chapters III and IV). This supports Van Vugt's (2009) identification of information as a key management intervention focus, although Brown (2009) notes that the public may not necessarily accept scientific assessments of risk (such as safety or environmental risk), even with effective information communication.

Wildlife-related values relating to invasive species control methods were also found to be affected by political history, and can change over time, in a similar way to the changing value of wilderness areas (Mittermeier *et al* 2003). For example, in Chapter III within the *political history* context theme, environment and peace movements of the 1960s were stated as contributing to lack of public and political support for hunting, and a stigma towards hunters in NSW, leading to legislative changes limiting the use of firearms. These socio-political movements represent a change in relationships between humans and wildlife in the western world, away from a utilitarian or domination orientation, based around hunting and use of wildlife, towards a more mutualism orientation, relating to caring and social affiliation with wildlife (Teel & Manferdo 2010), resulting in some sections of society viewing hunting as unethical or uncivilised (Gunn 2001). These changing values may also be related to increased urbanisation, income and education (Manfredo *et al* 2003). Invasive species management may therefore be affected by global changes in societal values and by demographic changes. The opposition to recreational hunting identified in the RNP (Chapter IV) is a likely consequence of these changing values and associated stigma towards hunters (Chapter III). As well as participatory strategies (discussed in 5.3), political strategies were identified as being used to influence social attitudes towards hunting, and to attempt to return social wildlife-related values to a

more utilitarian or domination orientation (Manfredo *et al* 2003; Teel & Manfredo 2010) (Chapter III). For example, in Chapter III, *political action* was identified as a context theme, which included using a pro-active political approach to achieve changes to wildlife-related values, as well as changes in legislation. The approach appeared to have some success in changing legislation surrounding using licensed volunteer hunters on public land; whether the approach will lead to broad changes in wildlife-values across society in NSW remains to be seen. The role of social learning in such changes in wildlife-values is an area that could be further explored.

### **5.2.3 Conflicts between humans and invasive species**

Conflicts between humans and invasive species represent a form of ‘human-wildlife conflict’. Such conflicts involve the impact of wildlife on humans, and human on wildlife, usually in retaliation to damage (e.g. to agriculture or property) or other risks (e.g. to human safety or other species’ survival) (Treves *et al* 2009; White & Ward 2010). Human-wildlife conflicts are fundamental in invasive species management, as the term ‘invasive’ typically implies damage is being caused by the species. This section examines the types of human-wildlife conflicts in invasive species management, and relationships relating to these different conflicts. The analyses in this thesis reveal that:

- (a) The type of human-wildlife conflict influences the management approach, and is also related to wildlife-related values (Chapters II & IV).
- (b) The type of human-wildlife conflict has different importance to different stakeholders, which may be related to human-human conflict and programme implementation. (Chapters II & IV).

In Chapter II, conflicts between humans and invasive species, described as *invasive species effects*, were categorised as *economic* (e.g. impacts on agriculture), *social* (e.g. impacts on property, health and related stress) and *environmental* (e.g. impact on native or endangered species or habitats) effects, based on a ‘triple bottom line’ approach (McLeod 2004). *Stakeholder conflicts* (human-human conflict) were also included as an additional category, discussed further in 5.3. *Environmental effects* were found to be the dominant driver for implementing invasive species management programmes in Australia (Chapter II). This is likely to have a considerable influence on the approach to invasive species management. Specifically, the importance of *environmental effects* is likely to be responsible for the preference of wildlife managers to remove invasive species from the

environment (Zavaleta *et al* 2001) rather than increasing human tolerance (e.g. Treves *et al* 2009), as removal (whether eradication, control or containment) of invasive species is typically seen as a necessity for native species conservation. The alternative approach of increasing human tolerance towards invasive species, as opposed to removal, would require conservationists to also show a shift towards tolerance, and perhaps even a realignment of the perceived position of invasive species in the environment, away from the ‘native-alien dichotomy’ (Davis *et al* 2011). Changes in values, including environmental values such as these, are typically gradual processes occurring over generations (Teel & Manfredo 2010). This is illustrated with the brown hare (*Lepus europaeus*) in Britain, which although has become naturalised or ‘pseudo-native’, and is subject of a UK Biodiversity Species Action Plan, has been present in Britain for a considerable length of time, being introduced in the Roman era (White *et al* 2011). However, Chapter IV indicates that these alternative value systems may persist continuously in society as a minority viewpoint. Without such shifts in values in conservationists, which may require elements of triple-loop learning, removal rather than tolerance of invasive species is likely to remain the dominant approach to management.

Human-wildlife conflicts also emerged as an important factor in Chapter IV, through shaping public attitudes towards invasive species management in protected areas. Human-wildlife conflicts that emerged included *environmental effects*, *human safety from wildlife interactions*, and *socio-economic effects*. A range of attitudes were associated with each of these effects. For example, some respondents considered the impact of deer on the environment and human safety to be serious, and others considered these impacts to be negligible. Such disparity in attitudes and experiences are typical in human-wildlife conflicts, and are likely to exacerbate human-human conflict, because they can result in conflicting preferences over how the species should be managed, if at all (White & Ward 2010). This was exemplified in Chapter II (see Tables S3 and S4), where one of the factors influencing non-participation of landowners in invasive species management programmes was related to the different levels of impact experienced. This was a cause of contention between landowners, due to the necessity of participation across all major land tenures for the programme to be successful (Chapter II). Thus incentives, in terms of impacts experienced and the resulting personal need to manage invasive species, has implications for participatory uptake in management programmes and levels of conflict experienced – corresponding to Van Vugt’s (2009) identification of incentives as an important management focus.

In Chapter II, the different types of human-wildlife conflicts were also found to be relatively more important to some stakeholders than others, however in this analysis these differences were also revealed to be linked to the origin of invasive species programmes. In particular, *economic effects* were reported as more important as a driver in *citizen-initiated* compared to *authority-initiated* programmes. This is likely to be related to legislation requiring landowners to manage invasive species on their land (as discussed in Chapter II). The type of conflict, and where it is occurring, may therefore have a considerable effect on whether a control programme is even implemented. Furthermore, the type of human-wildlife conflict was found to lead to differences in stakeholder composition, in terms of diversity of interests represented, with *social effects* related to heterogeneity in *stakeholder composition* (Chapter II) (discussed further in 5.3). Bremner & Park (2007) also found that some conflicts or invasive species effects were more important to some stakeholders than others, however this was based on socio-demographics. For example economic impacts and environmental impacts as drivers for invasive species control were more likely to be supported by older people (Bremner & Park 2007). Understanding when invasive species programmes may be implemented and whether they may be supported, and by whom, may therefore be related to both the type of human-wildlife conflict and the type of stakeholder.

### **5.3 Towards ecological and social outcomes through stakeholder participation**

In this thesis, stakeholder participation was identified as an essential and widely-used approach to achieving economic and social outcomes in invasive species management. The potential benefits of stakeholder participation in environmental management are well recognised, including increasing citizen empowerment, building trust between stakeholders, and promoting fairness, equity and social learning (Reed 2008). While these may be viewed as principally social outcomes, participation also has an important role in achieving ecological objectives. Several of the approaches to participation identified in Chapter II can help achieve this. For example, ecological objectives may be achieved through on-the-ground participation (as a *community resource* and through using *activity-based methods*), identification of the most appropriate solutions to human-wildlife conflicts and the most effective management options (i.e. *decision-making*) and increasing support for conservation objectives (e.g. through *education & informing*) (Treves *et al* 2009). Furthermore, although distinct, social and ecological outcomes are also interlinked



and are likely to be mutually dependent in several ways. For example achieving ecological objectives, such as a reduction in invasive species population, is related to increased stakeholder satisfaction, a social outcome (Chapter II).

There are undoubtedly some limitations associated with participation, as the process can be costly, putting pressure on an already restricted budget for invasive species management and limited resources of participants (Chapters II & III). It may be time consuming or perceived to be difficult, particularly in involving marginalised social groups such as indigenous communities (Chapter II, Table S3). It can potentially increase conflict and debate (Chapter III), and may be dominated by particular interest groups which can result in an ineffective process (Chapter IV) (Irvine & Stansbury 2004). In Chapter III, there was also some concern that the preferences of the participants may not necessarily achieve the optimal ecological, or even social, outcomes, yet may be politically difficult to disregard (Irvine & Stansbury 2004), while in Chapter IV there was some concern regarding the ability of communities that are polarised on an issue to make decisions. However, despite these limitations and challenges, participation has become increasingly viewed as fundamental to successful conservation, and was identified as such in this thesis.

In this section, the role of participation in achieving ecological and social outcomes in invasive species management is explored. Three main themes emerged in the analyses that may contribute to achieving these objectives – (i) conflict resolution and representation (5.3.1), (ii) responsiveness to social associations, wildlife-related values and conflicts between humans and invasive species (5.3.2), and (iii) justifying invasive species management programmes and building trust (5.3.3). Finally, improvements to the participatory process are briefly considered (5.3.4).

### ***5.3.1 Conflict resolution and representation***

Conflicts between stakeholders were identified as a prominent factor affecting invasive species management, relating to both social associations (5.2.1), and wildlife-related values (5.2.2). Resolving such human-human conflicts is an important part of achieving social outcomes, which in turn can also assist in achieving ecological outcomes. The dimensions and themes identified in Chapter IV may be useful for identifying the potential for conflict, through providing a framework for understanding the issues that shape public

attitudes towards invasive species management. Causes of conflict were also identified in Chapter II, relating to participatory invasive species management programmes (Chapter II, Table S4), and conflicts also arose in Chapter III, particularly surrounding the approach to deer management.

In Chapter II, *stakeholder conflicts* were found to be significantly related to *consultation*. Higher levels of participation, such as collaborative partnerships, and medium level participation, such as consultation (Arnstein 1969), are typical approaches used for conflict mitigation and decision-making surrounding wildlife management (Raik *et al* 2005; Treves *et al* 2009). Consultation may be used as a means of conflict resolution in human-wildlife conflicts (Redpath *et al* 2004), including in invasive species management (e.g. Chapple 2005), through providing a means of synthesising, contesting and sharing information (Catt & Murphy 2003). This type of knowledge exchange and interaction therefore provides benefits that simple provision of information, as suggested by the information deficit model, may not (Brown 2009). Collaborative partnerships were identified in Chapter III, within the *collaborative arrangements* mechanism, as an approach to decision-making and conflict mitigation surrounding deer management, and similarly in Chapter IV, *participation in consultation and decision-making* was identified as a theme within the stakeholder dimension. There are various factors which may help achieve more effective consultation and decision-making processes. For example, in Chapter IV, the importance of having on-going (rather than one-off) consultation, and for having experienced facilitators to improve the quality of the process, as recommended by Reed (2008), were proposed as methods for improving consultation. In Chapter III, the need for regular feedback to participants on programme progress was also raised, which Larson *et al* (2011) propose requires communicating measurable progress to stakeholders, necessitating managers to establish and monitor progress indicators.

As highlighted in Chapter II with the typology *participation methods*, there are many different techniques that may be used (e.g. New Economics Foundation 1998), some of which can contribute to conflict resolution. In Chapter II, *innovative methods* of participation were used significantly more by *citizen-governed* than *agency-governed* programmes, suggesting that government could play a stronger role in implementing non-traditional participation methods for resolving conflicts. The nil tenure approach was identified as a successful approach to conflict resolution in invasive species management by removing the land tenure boundaries during the decision-making process (Chapter II)

(Saunders & McLeod 2007). The need for using this nil tenure approach relates to the issues identified in Chapter III, where macro-micro conflicts had emerged over national park management and the movement of invasive species from protected areas onto private land. Other methods include multi-criteria decision analysis, which has been used in human-wildlife conflict scenarios to help determine the most suitable management option (Redpath *et al* 2004). Increasing the use of innovative methods such as these may be achieved through improved training in community engagement for wildlife management personnel (as identified in Chapter II).

In Chapter II, *change in stakeholder interaction* (assessed on a scale from increased conflict to improved cooperation) was related to *program origin* and *stakeholder composition*. There was a greater improvement in stakeholder interaction in *citizen-initiated* compared to *agency-initiated* programmes, and programmes *heterogeneous* in composition. The origin of, and representation in, a participatory invasive species programme may therefore influence relationships between stakeholders, thereby affecting social outcomes. A heterogeneous composition, i.e. having a range of stakeholder interests represented, was also suggested to have improved the effectiveness of collaborative partnerships in Chapter III, and is considered as best practice in participation (Jackson 2001) and necessary for sustainability of invasive species management programmes (Larson *et al* 2011). Fernandez-Gimenez *et al* (2008) also found that more diverse and heterogeneous collaborative groups tend to result in more social learning, community-building and trust-building. The incorporation of interest groups and non-government organisations (NGOs) is an important element of this inclusivity approach to participation, particularly because NGOs can play important roles in environmental management (Jasanoff 1997), such as knowledge transfer and continuity of involvement and interest, and maintaining public support (Chapter III). Participation of interest groups and NGOs may come from stakeholder demands, as interest groups are increasingly exerting what is being considered as their democratic right (Reed 2008). However, this can also be detrimental to conservation programmes, for example action taken by animal rights groups to prevent lethal control of invasive species (e.g. Bertolino & Genovesi 2003), as discussed in 5.2.2. The importance of including animal welfare groups in participatory processes appeared to be well recognised, and can be linked to the identification of animal welfare as a core value affecting public attitudes towards invasive species management (Chapter III) and increasing emphasis of animal welfare for the choice and delivery of control methods (Oogjes 1997). However, although animal rights groups have often

played a role in conflicts surrounding invasive species they did not appear, at least from the studies in this thesis, to have had a role in planned participatory processes such as working groups or partnerships, presumably due to the what may be considered as irreconcilably different philosophies (Perry & Perry 2008). This highlights the opposing approaches that can be taken towards participation, which may involve either inclusion or exclusion of stakeholders that are considered to be problematic (Chapter II).

Although wildlife managers may be able to decide who they *prefer* to include and exclude from participation processes, there are often obstacles in achieving participation, which can result in under-representation of some stakeholder groups or individuals (Chapter II). When strategically placed landowners refuse to participate, particularly in on-the-ground participation, effectiveness of wildlife management efforts may be compromised (e.g. Phillip et al 2009). This may be particularly important in broad-scale invasive species management efforts, as non-participating land tenures may act as a place of refuge for species population regeneration. Similarly, in protection of endangered native species in human-wildlife conflict scenarios, non-participation of stakeholders may seriously undermine conservation efforts, as illustrated in human-wildlife conflict associated with protected areas in India (Ogra & Badola 2008). Non-participation can contribute to conflict between landowners, a form of ‘micro-micro’ conflict (Grimble & Wellard 1997), as exemplified in Chapter II (Table S3), however as well as being a result of non-participation, conflict can also be a cause of non-participation (Chapter II). Several other factors affecting decisions not to participate were identified in Chapter II. This includes ‘pro-pest’ attitudes, such as social associations (see 5.3.1), economic benefits (such as recreational hunting or hunting for income) and ecological arguments, such as mesopredator release (Zavaleta *et al* 2001). Different experience or importance of human-wildlife conflict to different stakeholders (as discussed in 5.2.3) may also result in non-participation, along with lack of awareness of environmental effects of invasive species (requiring education strategies) and limitations in resources (Chapter II). Chapter III also revealed the influence of social and political context on participation in collaborative management, in particular negative associations of hunters with illegal activities, and the culture of trophy hunting. Causes of non-participation in wildlife management and conservation initiatives therefore vary considerably, based on the context of the programme. For example, participation in human-wildlife conflicts in developing countries may be influenced by poverty, position in society, gender and information provision (Ogra & Badola 2008). To achieve ecological and social outcomes in

conservation programmes, identifying causes of non-participation and determining ways to break down these barriers, is likely to be essential.

### ***5.3.2 Responsiveness to social associations, wildlife-related values and human-wildlife conflicts***

Education and informing stakeholders emerged as important for achieving social and ecological outcomes, relating to each of the social factors identified in 5.2. Lower levels of participation such as this are recognised as playing an important role either alongside, or prior, to higher levels of participation (Dorcey 1994; Jackson 2001). Information is also recognised as one of the four key foci for management intervention for environmental protection by Van Vugt (2009). In Chapter II, *education & informing* was rated as an important driver for using a participatory approach, particularly for programmes dealing mainly with *environmental effects* of invasive species. Education strategies were also likely to be responsible for the high public awareness of environmental effects of deer that was apparent in Chapter IV. In the case of Chapter II, increasing awareness over environmental issues may be viewed as more appropriate than higher levels of participation such as *decision-making*, which are more suitable when stakeholders are already aware of the issues (Jackson 2001). This is likely to be the case for *economic effects*, with which *decision-making* was found to be significantly related (Chapter II). This supports the recommendation that the level of participation needs to be appropriate to the circumstances and objectives, as well as to the participants involved (Reed 2008).

Wildlife-related values may also be influenced by education strategies. For example, education strategies were identified as being used to encourage social and cultural changes, in particular hunting culture and societal acceptance towards hunting (Chapter III). Rather than attempting to change wildlife-related values, a more typical approach is to respond to wildlife-related values to maintain public support. *Political sensitivity*, as identified as a context theme in Chapter III, illustrates how responding to these wildlife-related values, and social association, can influence management decisions. However, education strategies may also be used to communicate management alignment with wildlife-related values to the public. For example, animal welfare is an important wildlife-related value (Chapters III & IV) (Fraser 2006), and may be responded to by ensuring that high animal welfare standards are met, and using education and informing strategies to ensure the public are aware of these standards and protocols (5.2.2).

### ***5.3.3 Justifying invasive species management programmes and building trust***

Justification of invasive species management, both in terms of lethally removing species but also in terms of financial cost (Field *et al* 2005), may be particularly important given the social factors surrounding their management and the associated conflicts identified in this thesis (5.2). Justifying the control of invasive species relates to the level of impact (or human-wildlife conflict) that the species is having. As highlighted in Chapter IV, this is perceived differently by different stakeholders. The level of impact may be ascertained, and quantified, using on-going monitoring programmes, the need for which is highlighted in each of the three studies (Chapters II-IV). Chapter II in particular highlights the lack of empirical data on the ecological outcomes of invasive species management programmes. The importance of monitoring also relates to ensuring a proportional response to the invasive species impacts. Dickman (2010) identifies ‘disproportionate responses’ as an important social influence on human-wildlife conflict, referring to responses to human-wildlife conflict that are not in proportion to the impact or damage (Dickman 2010). With respect to the native-alien dichotomy, it has been argued that responses of conservationists may be, in some cases, disproportionate to their impact on the environment (Davis *et al* 2011). However, there is a legitimate counter-argument that a precautionary approach is necessary even if environmental impact is not certain (Simberloff 2011). Research into specific risks and threats of invasive species, including monitoring of ecological impacts and risk of native species extinction, is important for ensuring effective and appropriate management intervention (Gurevitch & Padilla 2004) and thus ensuring a proportionate response.

However, limited funding and resources provide an obstacle for achieving on-going monitoring programmes (Chapter III) (Simberloff *et al* 2005), along with other factors such as climatic changes, seasonal fluctuations and logistical problems (Chapter II). Issues of trust in research and science may also limit the value of monitoring, where stakeholders may not believe in the legitimacy of the data (Chapters III & IV) (Philip & Macmillan 2003; Fraser 2006). As discussed in Chapter II, citizen science, which involves voluntary participation in collection of scientific data, can act as a solution to deficits in monitoring data (Silvertown 2009), thereby helping to achieve ecological outcomes, whilst at the same time it can help improve public understanding of and trust in science in the context of wildlife management (Bonney *et al* 2009). Ecological data may also be obtained

through using innovative participatory techniques such as participatory Geographic Information System. For example, local knowledge from land managers on species distributions and behaviour can help ecological modelling of species populations, while simultaneously improving stakeholder understanding of the scientific process and improving communication (Irvine *et al* 2009).

Trust in science may also rely upon effective communication of information and knowledge, as well as active participation. In Chapter IV, *information provision and awareness* emerged as a theme shaping public attitudes, and lack of on-going information provision was raised as a concern within this theme. This corresponds to both Van Vugt's (2009) identification of information as key management focus for management intervention for environmental protection, and to the information deficit model (Stugis & Allum 2004). However, despite assertions of the deficit model, obtaining and transferral of scientific facts and information alone may not be sufficient to gain public support (Brown 2009), as there are many other factors that affect attitudes and trust in scientific expertise and institutions (Sturgis & Allum 2004). Nevertheless, without sufficient, reliable information and effective communication of science, the public are likely to be more susceptible to media interpretation of the issues, particularly those not experiencing direct impacts (Chapter III). Media is well recognised as a factor influencing public awareness in environmental issues (Likens 2010), including surrounding invasive species management, where language can play an important role in shaping public attitudes (Webb & Raffaelli 2008). Media has the potential to reduce public trust in science and research, or contribute to debate, as exemplified with anthropogenic climate change (Oreskes 2004), although it can also be used as a beneficial tool for gaining public support if used astutely (Chapters II & III). Trust in institutions is identified as a core motive and focus for management intervention in Van Vugt's (2009) four Is theoretical approach. Trust in institutions and scientists can be of concern not only in invasive species management (Chapters III & IV), for example over uncertainty of the effects of biocontrol methods (Fraser 2006), but in broader societal terms in a range of scientific issues (Haerlin & Parr 1999). The organisation to which the scientist is affiliated may also affect the level of trust by the public in invasive species management programmes (Philip & Macmillan 2003). Improving communication and transparency, and responding to public values and opinions, rather than discounting them if they are not convenient, may be important steps for building trust in science and research (Haerlin & Parr 1999), thereby increasing support for invasive species management.

### ***5.3.4 Improving participation in invasive species management***

This thesis highlights key factors for improving participation in invasive species management. These factors add to, or are consistent with, other guidelines for effective participation, such as Buchy and Hoverman (2000), Reed (2008) and Larson *et al* (2011) (see section 1.1.3). Factors that were identified in this thesis which may facilitate participation in invasive species management include (but are not limited to) the role of governments in facilitating participatory programmes (Chapter II), the use of appropriate levels of participation (Chapter II), effective and on-going consultation and provision of information over invasive species effects and management activities (Chapter IV), communication of animal welfare and human safety protocols (Chapters III & IV), development of positive relationships with interest groups (Chapter II) and using participation to encourage social and legislative changes (Chapter III) and to increase trust in science (Chapter II). These factors, and the others discussed in this thesis, can help ensure that participatory processes are effective and help to achieve both ecological and outcomes in conservation initiatives.

### **5.4 Conclusion**

The relationship between society and conservation is complex, even when focused on the specific context of invasives species management. This thesis is limited to just three features of this relationship – participation, social and political mechanisms and context, and public attitudes, and consequently there are many additional aspects of the relationship to be explored. Furthermore, relationships involving humans are dynamic, changing over time as well as being affected by specific circumstances and context. Humans and their relationships with the environment and wildlife are a result of both internal factors, such as values, beliefs and psychology, and a vast range of external factors, including the political and economic environment, societal and cultural influences, and situational factors and personal experiences. Wildlife itself affects the relationships, including population dynamics, species behaviour and characteristics, and effects on the environment and on people. The diversity of factors involved in the relationship between society and conservation creates a significant challenge for conservationists.



Despite the complexity, research has been successful in breaking down some of the problems and identifying specific factors that may help achieve ecological and social outcomes in the management of wildlife. Recognition that both of these outcomes are important has also been a critical development in conservation science. This thesis explored different dimensions of human-wildlife relationships and revealed how social factors, including social associations, conflicts over wildlife-related values and conflict between humans and invasive species, can affect invasive species management. The analyses also highlight the importance of stakeholder participation in achieving ecological and social objectives, in particular its necessity in conflict resolution, responding to social factors, and building trust and justifying invasive species management.

The thesis draws upon theoretical approaches and concepts from behavioural and social sciences, such as social learning, the four Is of intervention in environmental protection, and the information deficit model. However, there is much room for further research in this area, particularly in using behaviour and social sciences approaches as comprehensive frameworks for analysing ecological challenges, whilst still drawing out conclusions that are relevant for environmental managers. Drawing upon multiple disciplines effectively is a challenging task, requiring continued recognition that ecological, social, economic and political systems are all interlinked. Yet doing so may result in more effective and sustainable environmental management, meeting both social and ecological objectives.

This thesis aimed to contribute towards this goal, through analysis of the social dimension of invasive species management. The relevance of the social factors identified in this thesis and stakeholder participation in wildlife-related conflicts may apply not only to invasive alien species, but also overabundant, and indeed endangered, native species. Responding to these findings can lead to improved outcomes for both wildlife and society, both in the context of invasive species management and other wildlife challenges.

## APPENDICES

### *Supporting information Chapter II*

#### **Appendix S1.** Interview-based questionnaire used to assess relations among participation features and management outcomes of participatory conservation programs targeting invasive vertebrates in Australia

Stakeholder participation in invasive vertebrate species management:  
Interview-based Questionnaire

Interview:  
Date:  
Interviewee:  
Project Name  
Project Address:  
Phone Number:  
E-mail:

##### Section 1: Drivers and Methods

1. This question aims to identify the impacts that the project is addressing.  
*On a scale of 1-5, where 5 is the most important how would you rate each of the following issues in your project? Please also give details.*

- a) Environmental impact (*including biodiversity loss and environmental degradation*)
- b) Economic impact (*e.g. loss of agricultural productivity*)
- c) Social impact - i.e. the impact of pest species on the welfare of the people living in the area (*e.g. risk to health, stress, and damage to personal property*)
- d) Stakeholder conflict (*e.g. alternative views on management methods or other disagreements*)
- e) Other

2. This questions aims to identify the reasons that the community and stakeholders have been involved in the project.  
*For each category, please answer on a scale of 1-5, where 1 is 'not an objective', and 5 is a 'high-priority objective'.*

- a) Community resource: *e.g. participants provide input of labour, time or resources to help carry out objectives - for example on-ground management*
- b) Education and informing: *e.g. increasing public awareness*
- c) Gathering information: *e.g. on public views and opinions, and extracting expertise*
- d) Consultation: *where participants present and contest information over a management plan, but final decisions are made by the organisation running the participatory process*
- e) Decision-making: *participants deliberate on an issue to reach an agreement, which will be implemented/incorporated into policy or management*
- f) Political-social pressure: *e.g. animal welfare concerns, equal rights for indigenous people*
- g) Obligation: *e.g. legislation, or the participants provided funding for the project*
- h) Other objectives or comments (please give details):

3. What methods and techniques of participation are used? *Please answer yes or no for each method. For each method I will provide a brief definition.*

- a) Wildlife surveying/ reporting  
*Members of the public report on particular events, for example sightings of a particular species, or vehicle-wildlife collisions.*
- b) Active participation in deterring or encouraging species  
*Participants actively follow advice on wildlife management activities. For example, setting up fencing to deter pest species, or planting tree/plant species to encourage threatened species.*

## Appendix S1 continued

c) Active participation in culling

*Participants are involved in the culling of a particular pest species, for example by following a hunting management plan or setting traps or poison.*

d) Attitude surveys/ Opinion polls

*A survey of public opinion on an issue, using a sample of people.*

e) Satisfaction surveys

*A survey of public or service-user satisfaction regarding a particular service, using a sample of people*

f) Complaint schemes

*A scheme which allows members of the public to make complaints over a particular issue or service.*

g) Public meetings

*Formal meetings open to the public (usually from within a particular geographic area), in which participants are informed of a policy or plan.*

h) Question & Answer sessions

*Meetings open to the public providing the opportunity for people to ask questions and receive responses over a particular issue.*

i) Consultation documents

*Official documents made available to the public that detail a particular policy or plan.*

j) Appraisals

*Participants identify their perception of an issue and the problems, and propose solutions, often through innovative and visual techniques*

k) Visioning exercises

*Creative methods to imagine the future, and thereby identifying aims and goals.*

l) Community indicators

*A participatory technique for simplifying, measuring and drawing attention to important issues. Local people decide what is important to them and agree how best to measure whether things are getting better or worse, by deciding on formal measures of change.*

m) Focus groups

*A research technique that collects data through group interaction on a topic determined by the researcher.*

n) Workshops

*Group meetings where an issue is discussed extensively e.g. Round Table workshops.*

o) Field days or Forums

*Activities which bring together users of a particular service, or those with a shared interest, usually on a regular basis.*

p) Citizen panels

*A randomly selected group of citizens are asked their opinions on a particular issue.*

q) Referendums

*A vote by the people in which every voter has the right to vote on a given issue.*

r) Citizen juries

*A group of randomly selected people, go through a process of informed deliberation and make public their conclusions on the issue.*

Other(s). Please describe:

4. How often does participant engagement occur?

## Appendix S1 continued

### Section 2: Representation

5. a) Which stakeholder groups or individuals participate in the project? *Please list all, and try to be specific. For example, if farmers are involved, please indicate which type of farmers, e.g. wool sheep farmers etc. But for individuals, please provide their role (eg. cattle farmer, or general public), and not their name.*

5. b) How many people participate from each of the stakeholder groups?

6. How are participants selected? *Please describe*

7. a) Are there any stakeholders which need to be better represented, and if so, who? *\* If no, skip to question 7c.*

7. b) Why were these stakeholders under-represented?  
*(Prompt: for example, were they not affected by the pest, or not have enough money or time to be involved? Or were they not invited to participate?)*

7. c) What overall change has there been in the number of participants involved?

High drop-out:

Small but noticeable drop-out:

No or little change:

Small but noticeable increase:

Large increase:

### Section 3. Monitoring and Evaluation

8. a) Has there been monitoring of the population size of the project's pest species since the implementation of the project? *Please answer yes or no.\*If no, skip to question 8c).*

8. b) Please rate the population change for each pest species on a scale of -2 to 2, where -2 is significant decrease, 0 is no change, 2 is large increase, or answer 'don't know'.

8 c) Was the pest impact quantified prior to the commencement of the project? *Please answer yes/no*

9. a) Has there been monitoring of the condition of biodiversity or environment since the implementation of the project? *Please answer yes or no or not applicable*

9. b) Has there been monitoring of agricultural production since the implementation of the project? *Please answer yes or no or not applicable\*If no to both, skip to question 10*

9. c) Please rate these changes on a scale of -2 to 2, where -2 is large deterioration, 0 is no change, and 2 is large improvement, or answer 'don't know' or 'not applicable'. *Please give details if required (e.g. specific endangered species).*

Biodiversity:

Environmental condition:

Agricultural production:

10. a) This question aims to assess the change in the intensity of stakeholder interactions since the implementation of the project. *Please rate change on a scale of -2 to 2 where -2 is increased conflict, 0 is no change and 2 is improved interaction, or answer 'don't know'.*

Stakeholder interaction:

10. b) Has there been conflict over land tenure issues?

10. c) Has there been conflict over pest control methods?

10. d) Over what other issues have stakeholders conflicted?

11. a) Have participants been provided with feedback following their involvement in the project?

*Please answer yes/no*

11. b) How was done and how often? *(Prompt: for example, did the participants receive newsletters, or have follow-up meetings etc)?*

## Appendix S1 continued

12. a) Has there been assessment of participant satisfaction, either formally or informally?  
*Please answer yes/no \*If no, skip to question 13*

12. b) How was this done?

12. c) Please rate the overall participant satisfaction on a scale of -2 to 2, where -2 is very dissatisfied, and 2 is very satisfied, or answer 'don't know'

### Section 4: Background

13. a) What is your position within the project, and what are your responsibilities?

13. b) How did you get involved in the project? (*prompt: For example, were you involved in the project set up, or was the task passed on to you?*)

14. a) What is the location and size of the area covered by the project?

14. b) What land-use occurs in the project area? *There are six categories\*- please firstly answer yes or no for each. I will then ask you for an approximate percentage coverage for each category and brief details.*

- 1. Conservation and 'Natural Environments'

*Includes nature conservation areas (such as Nature Reserves and Parks and protected landscape), as well as Managed Resource Protection (such as ground water supply and indigenous uses) or other minimal use landscape.*

- 2. Production from relatively natural environments.

*Includes grazing in natural environments and production forestry*

- 3. Production from Dryland Agriculture and Plantations

*Includes plantation forestry, grazing modified pastures, cropping, perennial and seasonal horticulture and land in transition.*

-4. Production from Irrigated Agriculture and Plantations

*Includes plantation forestry, irrigated modified pastures, cropping, irrigated perennial and seasonal horticulture and irrigated land in transition*

-5. 5. Intensive Uses

*Includes land for intensive horticulture (such as glass houses), intensive animal production, Industrial, Residential, Services, Utilities, Transport, Mining and Waste Treatment/Disposal.*

-6. Water

*Includes lakes, reservoirs/dams, rivers, channels, marsh/wetland and estuary/coastal waters*

15. a) When did the project commence?

15. b) What is the duration, or expected duration, of the project?

16. a) Did the project originate from concerns raised by the community, or through issues identified by relevant authorities?

16. b) Is the project run by the government, a non-government agency or a community group?

## Appendix S1 continued

17. a) Does the project receive external funding?  
*Please answer yes or no.\* If no, skip to question 18*

17. b) What proportion of your overall funding comes from external sources (*in monetary terms, rather than 'in kind' support*)?

17. c) Approximately what proportion of your external funding comes from each of these external sources?

Local Government Authorities:

Catchment Management Authority:

State:

Commonwealth (National):

Other e.g. *business*:

18. a) Was there a management plan prior to commencement of the project? *Please answer yes/no*  
*\* If no, skip to question 19.*

18. b) Please briefly describe how this was developed. (*Prompt: was it developed by stakeholders, and did it include milestones and key objectives?*)

19 a). Is there a core committee to oversee the project?  
*(yes/no)\* If no, skip to question 20*

19. b) Which stakeholders are in the committee?

19. c) What is their role?

20. For community meetings, was a qualified facilitator used? *Please answer yes/no*

21. Are there any other comments you wish to make?

22. Are there any other projects that you can recommend that I contact? *Please give details.*

23. Would you like to receive a copy of any reports/publications from this research?

\* categories based on Australian Land Use and Management (ALUM) Classification.

**Appendix S2.** Basis of classification of features that may affect the outcomes of participatory conservation programs, with specific reference to management of invasive vertebrates.

Variable	Basis of classification
Effects of invasive species	Relates to the ‘triple bottom line approach’ consisting of <i>environmental</i> , <i>economic</i> and <i>social</i> impacts, for assessing invasive species impacts in Australia (e.g. McLeod 2004) <sup>j</sup> , referred to in this study as ‘effects’. <i>Stakeholder conflict effects</i> also included in our study, due to relevance for invasive species management (Webb & Raffaelli 2008) <sup>n</sup> .
Program initiator	Adapted from Moore & Koontz’s (2003) <sup>k</sup> typology of partnership composition, which includes the categories ‘agency’, ‘citizen’, and ‘mixed-based’ composition, reflecting relative representation in a collaborative partnership. Moore & Koontz (2003) <sup>k</sup> identified relationships between these features and group accomplishments. We applied the typology to initiation of a program ( <i>agency</i> , <i>citizen</i> and <i>joint initiated</i> ), as a distinction can be made between how a program is initiated and its composition or governance.
Level of governance	Adapted from Moore & Koontz’s (2003) <sup>k</sup> typology of partnership composition (agency, citizen, and mixed-based) of collaborative partnerships. We adapted the typology to determine responsibility for administering and running the program (rather than member composition).
Geographical extent	Geographic scale is related to other participation features in environmental management programs, e.g., qualities displayed in representatives (Rockloff & Moore 2006 <sup>m</sup> ), stakeholder relationships (Cheng & Daniels 2005 <sup>e</sup> ), and collaborative levels (Margerum 2008 <sup>i</sup> ). We categorised scale into four categories (local, district, regional and broad scale) based on estimated operational area ( $\leq 1000 \text{ km}^2$ to $>50,000 \text{ km}^2$ ).
Motivations for using a participatory approach	Based on the levels proposed by Dorsey et al. (1994) <sup>f</sup> . We included <i>education and informing</i> (combined as one feature), <i>gathering information</i> , ‘ <i>consultation</i> ’ (adapted from ‘consult on reactions’, consistent with Arnstein 1969 <sup>a</sup> and Catt & Murphy 2003 <sup>d</sup> ), and the top of the ladder described by Dorsey et al. (1994) <sup>f</sup> we simplified to ‘ <i>decision-making</i> ’. We added ‘ <i>obligation</i> ’ and ‘ <i>socio-political pressure</i> ’ to account for using participation out of necessity (e.g. legal or policy requirements), and ‘ <i>community resource</i> ’ to account for on-the-ground participation (field work).
Stakeholder composition	Based on Bidwell and Ryan’s (2006) <sup>b</sup> typology of partnership composition in collaborative watershed management, who identified relationships between composition and program activities and conflict. We used the same categorisation ( <i>homogenous</i> and <i>heterogeneous</i> ) based on number of stakeholder interest groups represented, although our categories apply to different levels of participation (rather than just collaborative partnerships). Bidwell and Ryan (2006) <sup>b</sup> identified three interest groups as a natural cut off point for the two categories. We applied this method to our study, where four interest groups emerged as the natural cut off.
Representative voice	Based on Catt & Murphy’s (2002) <sup>c</sup> typology of representative voice, which categorises the relative presence of a stakeholder group in a consultation process into <i>controlling</i> , <i>proportional</i> and <i>symbolic</i> . We used the typology to reflect general approach of program managers towards participant selection. We also included an additional category, <i>under-represented</i> , to account for interest groups that would ideally be participants but currently are not.
Participation methods	Adapted from participation methods described by Lowndes et al. (2001) <sup>h</sup> (consumerist methods, traditional methods, forums, consultative innovations and deliberative innovations). We adapted some methods for clarity (e.g., re-classed ‘deliberative innovations’ as <i>deliberative methods</i> , ‘consultative innovations’ as <i>democratic methods</i> , and added the categories <i>innovative methods</i> , and <i>activity-based methods</i> , to account for on-the-ground methods). We characterised each method by three participation techniques, based on predominately on Lowndes et al. (2001) <sup>h</sup> and New Economics Foundation (1998) <sup>l</sup> . In <i>innovative methods</i> we included appraisals, exercises in visualising environmental problems, and community indicators; in <i>democratic methods</i> we included citizen panels, citizen juries and referendums; in <i>deliberative methods</i> we included focus groups, workshops, and forums; in <i>traditional methods</i> , public meetings, question and answer sessions and consultation documents; in <i>consumerist methods</i> , satisfaction surveys, attitude surveys and complaints and suggestion schemes; and in <i>activity-based methods</i> we included participation in wildlife monitoring and reporting, active participation in culling invasive species, and active participation in deterring or increase presence of species.

## Appendix S2 continued

Management outcomes      Based on the two principle outcomes of collaborative watershed partnerships described by Koontz et al. (2004)<sup>g</sup> - environmental outcomes (e.g., restoration projects and pollution reduction, and tools such as education and planning documents) and social outcomes (e.g. trust, relationships between stakeholders, and capacity to solve problems and self-govern). We used the categories ecological outcomes, focusing on direct ecological changes (e.g. changes in invasive species abundance, environmental and agricultural conditions) and social outcomes, focusing on stakeholder relationships, satisfaction and changes in participation numbers.

- <sup>a</sup>Arnstein, S. R. 1969. A Ladder Of Citizen Participation. *Journal of the American Planning Association* **35**:216-224.
- <sup>b</sup>Bidwell, R.D., and C.M. Ryan. 2006. Collaborative partnership design: the implications of organizational affiliation for watershed partnerships. *Society and Natural Resources* **19**:827-843.
- <sup>c</sup>Catt, H., and M. Murphy. 2002. *Sub-state nationalism: a comparative analysis of institutional design*. Routledge, London.
- <sup>d</sup>Catt, H., and M. Murphy. 2003. What voice for the people? Categorising methods of public consultation. *Australian Journal of Political Science* **38**:407-421.
- <sup>e</sup>Cheng, A.S., and S.E. Daniels. 2005. Getting to 'we': examining the relationship between geographic scale and ingroup emergence in collaborative watershed planning. *Human Ecology Review* **12**:30-43.
- <sup>f</sup>Dorcey, A., L Doney, and H. Rueggeberg. 1994. *Public Involvement in Government Decision-making: choosing the right model*. British Columbia Round Table on the Environment and the Economy, Victoria, British Columbia.
- <sup>g</sup>Koontz, T.M., T.A. Steelman, J. Carmin, K. Smith Korfmacher, C. Moseley, and C.W. Thomas. 2004. *Collaborative environmental management: what roles for government*. Resources for the Future, Washington DC.
- <sup>h</sup>Lowndes, V., L. Pratchett, and G. Stoker. 2001. Trends in public participation: Part 1- local government perspectives. *Public Administration* **79**:205-222.
- <sup>i</sup>Margerum, R.D. 2008. A typology of collaboration efforts in environmental management. *Environmental Management* **41**:487-500.
- <sup>j</sup>McLeod, R. 2004. *Counting the cost: impact of invasive animals in Australia, 2004*. Cooperative Research Centre for Pest Animal Control, Canberra.
- <sup>k</sup>Moore, E.A., and T.M. Koontz. 2003. A typology of collaborative watershed groups: citizen-based, agency-based, and mixed partnerships. *Society & Natural Resources* **16**:451-460
- <sup>l</sup>New Economics Foundation 1998. *Participation Works! 21 techniques of community participation for the 21st century*. New Economics Foundation, London.
- <sup>m</sup>Rockloff, S. F., and A.S. Moore. 2006. Assessing representation at different scales of decision making: rethinking local is better. *The Policy Studies Journal* **34**:649-670
- <sup>n</sup>Webb, T.J., and D. Raffaelli. 2008. Conversations in conservation: revealing and dealing with language differences in environmental conflict. *Journal of Applied Ecology* **45**:1198-1204



**Appendix S3.** Stakeholder groups participating in conservation programs targeting invasive vertebrates in Australia

<b>Stakeholder category</b>	<b>Number of programs in which stakeholder category is represented</b>
State government departments (e.g., Department of Environment and Conservation, Livestock Health and Pest Authorities)	34
Rural landholders-farmers (pastoral and arable)	25
Local government (e.g., shire councils)	17
Environmental or conservation nongovernmental organizations or professionals	15
Other industry or business (e.g., mining companies and pine plantations)	14
Agricultural nongovernmental organizations or representatives (e.g., Landcare community groups)	11
General public and urban communities	10
Indigenous communities (including local indigenous community members and Central Land Council)	7
Education interests (universities and schools)	6
Hunting nongovernmental organizations or professionals (e.g., Sporting Shooters Association of Australia)	5
Animal welfare organizations and veterinarians	5

**Appendix S4.** Causes of under-representation of stakeholders participating in conservation programs targeting invasive vertebrates in Australia.

<b>Causes of under-representation</b>	<b>Comments</b>	<b>Examples*</b>
Limitations in resources for the program (such as time, money and staff)	participation often costly, particularly when dealing with marginalized groups	engaging indigenous communities: <i>"I believe that in some cases they may have been put in the 'hard basket'- it is perceived to be difficult to deal with them and the time that is expended would not yield the results."</i> <sup>[18]</sup>
Limitations in resources for participants	participants may lack motivation to participate, as participation is typically un-paid and voluntary (risk of participants 'burning out') external forces, such as climatic stress, can limit resources available for stakeholder participation	limitations in resources: <i>"I just can't see how we could have a RSPCA rep in every one of our wild dog plans across the state; I don't know how that would work."</i> <sup>[28]</sup>  external influences limiting resources: <i>"We are in the middle of drought, and people aren't necessarily willing to put up their hand."</i> <sup>[27]</sup>
Lack of interest	perception by some stakeholders that there is no personal benefit of participating- can generate conflict between stakeholder groups	lack of interest in conservation programs on farmland: <i>"I don't think they [the farmers] are terribly interested in these kinds of projects- it's for the preservation of biodiversity and we're not aiming to preserve agricultural values. [They are] simply not interested."</i> <sup>[18]</sup>  conflict resulting from different perceptions of invasive species problem: <i>"Well they don't see it has having a problem whilst others see them as the problem. So they feel...like the surroundings are a bit hostile for them."</i> <sup>[20]</sup>
Actively disagreeing with program objectives	financial, social and/or ecological arguments to maintain presence of invasive species	economic benefit of invasive species: <i>"They might be driven away for instance when the price of goats are high, and even though they are deemed feral animal they produce an income, so there's a bit of negativity with regards to putting their hand up and saying 'I'll be involved'."</i> <sup>[27]</sup>  ecological benefit of invasive species: <i>"Some state that they believe foxes are needed to keep the Tamar wallaby numbers down, since they can cause damage."</i> <sup>[1]</sup>
Conflict between the government bodies and communities	conflict surrounding responsibility for invasive species control and government contribution to management programs	responsibility: <i>"I think it's because there is a perception by the community that this is a government problem and the government sees it as an individual landholder problem."</i> <sup>[26]</sup>  contribution by the government: <i>"The Department of Environment and Conservation should be much better represented, because they... control ... an absolute bagful of land in the area. In other words they should be getting off their backsides and doing something."</i> <sup>[23]</sup>
Problems/conflict in the past	skepticism surrounding management programs due to breakdown in trust and credibility in previous programs	past conflicts: <i>"[There is] reservation or resentment about National Parks [and Wildlife Service] due to past issues over fencing, kangaroos and emu damage."</i> <sup>[1]</sup>
Not previously considered a stakeholder	oversight of key stakeholders, or the evolution of the program (new stakeholder become important)	identification of additional stakeholder groups: <i>"We didn't consider law enforcement to be as big an issue as it has become."</i> <sup>[29]</sup>
Fear of conflict	risk that participation in invasive species control programs will create conflict	risk to non-target species: <i>"Blockies are not so reliant on the land and are concerned with controversy over occasional domestic dog poisoning."</i> <sup>[34]</sup>

## Appendix S4 continued

Lack of awareness	lack awareness of the program, or the alternative ways to become participate	awareness of invasive species control methods: “ <i>For small landholders and townspeople, it’s more a school of thought that baiting is the major control method, so it is trying to get across to them that there are other control methods like trapping.</i> ” <sup>[33]</sup>
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\*Numbers in brackets after quotations (e.g., <sup>[18]</sup>) refer to identification numbers assigned to the respondent in the study.

## Appendix S5. Conflicts and social challenges in participatory conservation programs targeting invasive vertebrates in Australia.

Conflicts and social challenges	Comments	Examples*
Land tenure	often between government bodies and private land owners, over responsibility and commitment	government commitment: "... <i>state government commitment to managing that [wild dogs in certain areas] isn't good and there's also reluctance from private landholders adjacent to that land to put funding into control programs if the state government is not matching it.</i> " <sup>[11]</sup>
Land access	refusal by stakeholders to participate or allow access on their land conflict between those stakeholders who do participate and those who do not (e.g., absentee landholders or unaffected by invasive species) lack of participation also a tactic to avoid conflict, particularly near urban areas	refusal to participate: "... <i>those that don't bait are seen as the source of their problems and viewed with a fair bit of disgruntlement by those who do bait. So that's a big problem right around the country.</i> " <sup>[20]</sup>  access refusal to avoid conflict: " <i>Some land managers are less happy than others to have control done on their properties- because it is too public really for some of them</i> ". <sup>[5]</sup>
Attitudes in favor of invasive species presence	invasive species presence favored due to intrinsic, aesthetic, recreational or economic value (particularly large vertebrates and game animals)	aesthetic and intrinsic value: "... <i>they are completely horrified when they find that their neighbors are shooting them [rainbow lorikeet] in large numbers.</i> " <sup>[5]</sup>  economic and social value: " <i>A lot of people like seeing them [deer] and hunting them too... they are very popular and important economically among some communities because of the hunting aspect.</i> " <sup>[3]</sup>
Control methods	conflicts arising from attitudes against shooting or use of firearms conflicts arising from use of poison baits (especially 1080), particularly risk to non-target species (e.g. pets, native species) different legislation in different states within Australia (e.g. use of carbon monoxide to kill birds)	baiting and non-target species: " <i>[There are] concerns about the use of poisons to kill foxes and possible impacts on non-target species.</i> " <sup>[15]</sup>  "... <i>I think we've killed a few pet dogs with our 1080 baits too over the years.</i> " <sup>[13]</sup>
Access and rights to resources	stakeholder perception that access to government resources is not evenly distributed (e.g., funding of one volunteer organization and not another) access restriction at local level (e.g. restrictions in land access due to conservation programs)	access to government resources: " <i>There have been a lot of neighborhood issues. There's been a lot of perception around people having more access to [government] services. There have been some issues about bias or favoritism to some landholders. Most of these issues come from people who haven't been doing their work. They're trying to relay blame for their inactivity.</i> " <sup>[31]</sup>
Limitation in resources and training	participation an additional pressure on resources which may already be limited lack of expertise in community engagement (seen as increasingly necessary) problem of maintaining funding when the program is successful	community engagement skills: " <i>[The survey] didn't have any input from anyone who knows anything about writing survey questions.... It would have been helpful if people like me had been a bit better trained prior to being involved in the group.</i> " <sup>[5]</sup>

## Appendix S5 continued

		maintaining funding: <i>“I have concerns about some of these programs, even if they are successful, and at times because of their success, then whoever the funders are start to say ‘you don’t have a wild dog problem, or a pig problem, or a rabbit problem any more, you don’t need that money any more so we’re going to take it off you’ ...”</i> <sup>[28]</sup>
Public relations	negative portrayal of the programs in the media lack of public education and awareness of invasive species and management programs	media: <i>“There are two particular media outlets in our area which have taken an aggressive stance against our wild dog management group.”</i> <sup>[29]</sup>  education: <i>“This particular [wild dog] program has lived upon myths... There is a lot of community myth out there as to the size of the population, the type of animal, where it lives, where it goes etc, and Australia really hasn’t come to grips with this.”</i> <sup>[29]</sup>

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\*Numbers in brackets after quotations (e.g., <sup>[11]</sup>) refer to identification numbers assigned to the respondent in the study.

## Appendix S6. Solutions to conflicts and social challenges in participatory conservation programs targeting invasive vertebrates in Australia.

Solutions	Comments	Examples*
Community coordinators and representatives	can lead to increased trust and motivation of other participants	community representatives: <i>“Having stakeholder representation at particular sites, when it comes to carrying out on-ground activities, it breaks down the big-brother problem.”</i> <sup>[6]</sup>
Motivation	motivation increased through improvements in working conditions (e.g., career and program structure, wages) motivation increased through more effective enforcement of legislation surrounding invasive species control	program work structure: <i>“Having a life of three years for the group keeps it as a structured group, it keeps it from falling apart, and it also keeps up the interest, because it’s a term. If you’ve had enough, you get out, and someone with some more passion and interest comes up.”</i> <sup>[29]</sup> more effective enforcement: <i>“15 years ago people didn’t believe that when DPI come out and ask you to get rid of rabbits that we would actually go out and check it out whereas now they are convinced that if we send them a letter saying we’ve got a rabbit project in your area, they know we are coming back. So it’s a huge attitudinal and behavioral change.”</i> <sup>[31]</sup>
General compliance and consideration	understanding of participants’ needs (e.g. only baiting at certain times of year to minimize disruption to farming practices) minimize conflict through ensuring fairness in accessibility to funds and resources	equality in program implementation: <i>“This program, by treating everyone fairly and equally, everyone is getting the same level of service and access to the same amount of money.”</i> <sup>[33]</sup>
Specific management methods	nil tenure approach (ownership boundaries disregarded in the decision-making process) minimizes arguments over responsibility	nil tenure approach: <i>“There was [conflict] at the start, but then we went through nil tenure process which was fantastic, people were able to look beyond the boundary fence, they were able to focus on the pest...”</i> <sup>[28]</sup>
Community engagement and social science training and expertise	improvements to community engagement skills (often deficient in management staff, predominantly ecologists)	social science expertise: <i>“Because that’s potentially a contentious issue we will incorporate a facilitator with a social science background. We will bring those people in now and then but ideally if you had somebody like that who you could tap into fairly easily that would be a good thing.”</i> <sup>[14]</sup>
Education and public relations	important for increasing support for programs, and changing attitudes and behavior media and public support can be critical for program success	media support: <i>“I guess we are very lucky in having a lot of media support which I think goes a really long way for the success of the program.”</i> <sup>[32]</sup>
Handling problematic stakeholders	integration of problematic stakeholders into the program to utilize their knowledge and consider their values exclusion of problematic stakeholders from the program	inclusion of ‘problematic’ stakeholders: <i>“We’ve overcome that by giving these people who like to hunt onboard the group and using their expertise to reduce the problem.”</i> <sup>[23]</sup> <i>“Groups are approached so that they feel they had the opportunity to be involved, so do not cause problems later.”</i> <sup>[5]</sup> exclusion of ‘problematic’ stakeholders: <i>“...Several people who don’t like things being shot .... So we basically wait until they go on holiday.”</i> <sup>[10]</sup>
Scientific justification	important for mitigating conflict, particularly for contentious issues justification of resource use	scientific justification: <i>“It certainly taught us that we need to make sure that we have good science and good rigor behind our decision making process. So we are not killing pests for the sake of killing pests.”</i> <sup>[31]</sup>

\*Numbers in brackets after quotations (e.g., <sup>[6]</sup>) refer to identification numbers assigned to the respondent in the study.

**Appendix 1** Postal survey on invasive deer and their management delivered to residents bordering the Royal National Park.

**Deer management in the Royal National Park and surrounding areas:  
Local Community Survey**

**SECTION 1** Please circle and give details as appropriate (there is room for further details and comments on the last page)

CONSULTATION					
<b>1</b>	How long have you lived in this area?				
<b>2 (a)</b>	Have you ever received information about deer and/or their management from the National Parks & Wildlife Service or Sutherland Shire Council?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes, have you had such information in the last year?	<b>Yes</b>	<b>No</b>		
<b>3 (a)</b>	Have you ever been to a public meeting about deer?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes who was it held by:				
	National Parks & Wildlife Service?	<b>Yes</b>	<b>No</b>		
	Other (please give details)?	<b>Yes</b>	<b>No</b>		
<b>4</b>	Are you satisfied with the consultation that you have received (if any)? (e.g. opportunity for discussion and community input?) <i>If no, please give details on the last page.</i>	<b>Yes</b>	<b>No</b>		
<b>5</b>	Are you satisfied with the way deer are managed in the area? <i>If no, please give details on the last page.</i>	<b>Yes</b>	<b>No</b>	<b>Not sure</b>	
INTERESTS					
<b>6 (a)</b>	Are you a member of any environmental or animal charity or non-government organisation (e.g. National Parks Association, RSPCA, Australian Deer Association, WIRES, Animal Liberation, Landcare groups etc.)?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes, please state which groups:				
<b>7 (a)</b>	Have you a professional interest in deer?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes, please state what profession:				
<b>8</b>	Have you ever actively fed local deer?	<b>Yes</b>	<b>No</b>		
<b>9</b>	Have you ever hunted:				
<b>(a)</b>	deer?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	other animals?	<b>Yes</b>	<b>No</b>		
IMPACTS					
<b>10 (a)</b>	Have you ever incurred property damage caused by deer?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes, please give details:				
<b>11 (a)</b>	Have you spent money to deter deer or fix damage?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes, please give details and estimated cost per year:				
<b>12</b>	How acceptable do you consider these costs (if any) to be?	<b>Acceptable</b>	<b>Unacceptable</b>		
<b>13 (a)</b>	Have you ever had a deer-vehicle collision in the Royal NP area?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes, please give details of cost and location:				
<b>(c)</b>	Have you ever had a 'near-miss' deer-vehicle collision in the area?	<b>Yes</b>	<b>No</b>		
<b>(d)</b>	Do you know anyone who has had a deer-vehicle collision/'near-miss' in the area?	<b>Yes</b>	<b>No</b>		
<b>14 (a)</b>	Do you think deer have a positive impact in the area?	<b>Yes</b>	<b>No</b>		
<b>(b)</b>	If yes, please give details:				
<b>15</b>	How would you like to see the deer population change in the next 10 years?	<b>Decrease</b>	<b>No change</b>	<b>Increase</b>	<b>Not sure</b>
<b>16</b>	Which of the following <i>potential negative</i> impacts of deer concern you? (you can circle more than one if you wish, or 'unconcerned')	<b>Environmental impacts</b> (e.g. biodiversity loss, habitat degradation etc.)	<b>Social impacts</b> (e.g. risk to health, stress, nuisance etc.)	<b>Economic impacts</b> (e.g. damage to property etc.)	<b>Unconcerned</b>

## Appendix 1 continued

**SECTION 2. Please read over all of the statements first.** Then for *each* statement *please tick* how much you agree and disagree with that statement compared to all the others, using the scale below.

-3	-2	-1	0	+1	+2	+3
<b>Disagree very strongly</b>	<b>Disagree quite strongly</b>	<b>Disagree a little</b>	<b>Neither agree nor disagree</b>	<b>Agree a little</b>	<b>Agree quite strongly</b>	<b>Agree very strongly</b>

The statements below were derived from consultations with key persons from a range of interest groups concerned with deer management. Minor modifications, and some additions [in brackets], were made to some of the statements to improve clarity.

How much do you agree and disagree with each statement compared to all the others? <i>Please rate EVERY statement.</i>		-3	-2	-1	0	+1	+2	+3
1	I'd like to see the deer remain.							
2	Deer can be very dangerous.							
3	I recognise that the deer are a pest; they've got to be removed.							
4	I've always thought that a non-violent approach [to deer management] is the only course to take.							
5	I think the deer need a lot more pressure put on them.							
6	There's no issue with the deer being euthanized, providing it's done quickly, humanely and without causing additional stress to the animal.							
7	It [the deer management programme] encourages illegal shooters to come in.							
8	The Royal National Park is there for conservation, public enjoyment and education.							
9	National parks are something sacred, something a bit different, and we need to preserve them. They are not recreation grounds or hunting grounds.							
10	Public information evenings and feedback forums are a valuable opportunity to discuss other options for deer management.							
11	It's not just a government issue, it is the community's issue, and the National Parks & Wildlife Service is managing the Royal National Park on behalf of the community.							
12	The actual amount of information that is coming out to the community [about the deer and their management] is very low, it's all hidden away in papers.							
13	The deer have been there [in the Royal National Park] for so long they are almost pseudo-native animals in the park.							
14	We're facing a huge environmental crisis at the moment, which makes any deer issues pale in comparison.							
15	An independent scientific committee says that deer are a <i>key threatening process</i> [to the environment], so there's really no debate [about their impact] any more.							
16	It [the deer management programme] is totally safe; precautions are all in place, there is no risk taken.							
17	At the moment they [National Parks & Wildlife Service] are doing the best as they possibly can with what they've got and what they have available to them.							
18	You could die with people shooting [deer] in the national parks.							
19	I can't understand why you can't hunt deer in a national park.							
20	You can spend too much on research, it is better if you just deal with the problem.							
21	Any feral animal in a nature reserve should be killed, no matter how beautiful it is.							
22	Community groups are the conscience of the government and the bureaucrats as to the ways of approaching deer problems and pest problems.							
23	There really needs an independent person to assess the [deer management] programme							
24	Until the whole community sees deer as a problem, we won't go forward.							
25	There's nobody that's so strongly against deer that they wouldn't tolerate small background numbers.							
26	I don't think environmental damage in most of the Royal National Park is that evident.							
27	I think sustainable utilisation of deer is the only approach that will ultimately succeed.							
28	There are a few modifications to the [deer management] strategy that could make it more effective, and one of those strategies would be aerial shooting.							
29	National Parks & Wildlife Service can't make an argument [to cull deer] without good information to push the case.							





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