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Ecological and human dimensions of management of feral horses in Australia: a review

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Abstract. In Australia, the management of feral horse populations is a contentious issue, owing to their pluralistic status as an introduced pest and a national icon. In this review, we synthesise current knowledge of the ecological effects of feral horses and the human dimensions of feral horse management, using case studies from around the world to illustrate contentious and successful management practices. We highlight gaps in the literature and suggest that more peer-reviewed research would be beneficial in reducing the current public controversy surrounding management of feral horses.

Introduction

Although human values towards wildlife have been important since the inception of wildlife management in the early 20th century, it wasn't until the mid–late 1960s that the need for a field of study based solely on human–wildlife interactions was realised (see Decker *et al*. 2001). This field, now known as 'human dimensions of wildlife management' seeks to reduce the controversy surrounding wildlife management, while having the broader aim of producing a greater understanding of the complex interactions between people and wildlife. Since the field's inception, researchers have undertaken broad-scale collection of qualitative and quantitative data, revealing a plethora of information about how people value and interact with wildlife (see Kellert and Berry 1987; Kellert 1993; Fulton *et al*. 1996; Enck and Decker 1997; Decker *et al*. 2001; Manfredo *et al*. 2003).

Australia has progressed more gradually than North America in its human dimensions enquiry (see Jones *et al*. 1998). However, in the past two decades Australian studies have provided us with information on: the way in which people value wildlife (Aslin 1996; Aslin and Bennett 2000; Miller 2000, 2003); how those values differ between genders (Miller and McGee 2000; Miller and Jones 2006); how people view pest species and pest management (Johnston and Marks 1997; Finch and Baxter 2007); indigenous views of wild animals (Nugent 1988); attitudes towards endangered species (Reading *et al*. 1994); attitudes and perceptions of wildlife managers (Miller and Jones 2005); and examples of human–wildlife conflicts in suburban areas (Thomas and Jones 1997; Miller *et al*. 1999). Despite the slow start, interest in human dimensions of wildlife management is now growing at a similar rate in Australia as in other nations (Baxter *et al*. 1999).

In Australia, as in many post-industrial nations, there are few wildlife management issues that receive as much public attention as feral horse (*Equus caballus*) management (see Symanski 1994, Symanski 1996; Linklater *et al*. 2002; Rikoon 2006). It is in precisely such circumstances that ecological and human-dimensions studies are pertinent to the formulation of appropriate government policy. The primary aims of this review are to synthesise current knowledge on the ecological effects of feral horses, summarise human-dimensions research on feral horses, and present several case studies that differ (1) in their approach to feral-horse management and (2) in the controversy that has subsequently ensued. We will highlight gaps in the relevant ecological and human-dimensions literature, and suggest ways to reduce the contentiousness of managing feral horses in Australia and elsewhere.

History and current status of the feral horse in Australia

Introduced to Australia in 1778 with the First Fleet (Dobbie *et al*. 1993) and released from human captivity by 1804 (Rolls 1969), feral horses became relatively common in areas of southern Australia by the 1830s (Sidney 1854; cited in McKnight 1976). Feral horses dispersed erratically through the mainland, but inferential references suggest that they reached every mainland state by the 1840s (Letts 1962; McKnight 1976; Appleton 1983; Dobbie *et al*. 1993). By the 1860s feral horses were considered 'pests' by some (Rolls 1969), while reports of their ecological impact date back to the 1870s (Low 1999).

The range expansion of feral horses in Australia was aided by the spread of human settlement and pastoralism (Dobbie *et al*. 1993). When pastoral holdings were abandoned (owing to factors such as farming unfamiliar land, drought, etc.), horses were often left behind, while others were released when their market value (based on supplying remounts to the British Army) plummeted after World War I (McKnight 1976; Burke 1996). Mechanisation also contributed greatly to horse 'feralisation', as machines increasingly made animal labour obsolete (Burke 1996; Walter 2002). Today, Australia has the largest population of feral horses in the world, estimated at more than 400 000 individuals (Dawson *et al*. 2006).

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The ecological dimension

Documented environmental effects of feral horses include:

- soil loss, compaction and erosion (Dyring 1990; Andreoni 1998; Beever and Herrick 2006);
- trampling of vegetation (Turner 1987; Dyring 1990; Rogers 1991; Beever and Brussard 2000*b*)
- reducing plant species richness (Beever and Brussard 2000*b*)
- inducing mortality of native trees through bark chewing (Schott 2002; Ashton 2005)
- damage to bog habitat (Dyring 1990; Rogers 1991)
- damage to water bodies (Dyring 1990; Rogers 1991, 1994*b*)
- facilitation of weed invasion (Rogers 1991; Taylor 1995; Weaver and Adams 1996)
- altering community composition of birds (Levin *et al*. 2002; Zalba and Cozzani 2004), fish, crabs (Levin *et al*. 2002), small mammals, reptiles (Beever and Brussard 2004) and ants (Beever and Herrick 2006).

Trampling and grazing

Beever and Herrick (2006) observed soil penetration resistance to be 15.4 times higher in horse-occupied sites than in sites from which horses had been removed. Dyring (1990) noted that trampling of sandy, granitic soils by feral horses increases soil compaction, which reduces the aeration, water infiltration, pore space, and water content of soils. Soil loss was also observed (Dyring 1990), a finding consistent with several studies on recreational horse use (see DCE 1991; Whinam *et al*. 1994; Whinam and Comfort 1996).

Plant species richness declines on tracks utilised by horses (Dyring 1990). Substrate disturbances caused by trampling and grazing (in combination with subsequent removal of vegetation) have the propensity to increase levels of exposure of soils to rainfall, alter slope angles, modify drainage conditions, and add nutrients to soils via animal dung (Dyring 1990). These changes, like many disturbances, are generally recognised to favour weed species (see Cole 1978; Rogers 1991; Tyser and Worley 1992; Whinam *et al*. 1994).

Introduced plant species such as white clover (*Trifolium repens*), and cat's ear (*Hypochoeris radicata*) are most successful at colonising sites affected by trampling in the Australian Alps (Dyring 1990). *T. repens* has been observed colonising sites disturbed by trampling and grazing in other studies within Australia (Weaver and Adams 1996), as well as Britain (Bates 1935), New Zealand (Rogers 1991) and North America (Dale and Weaver 1974; Cole 1978).

Continued trampling has the tendency to create extensive track networks (Dyring 1990), which can aid the dispersal of weed species through the habitat matrix (Campbell and Gibson 2001). In some areas of the Australian Alps, these tracks are quite extensive, ranging from 3.4 to 5.8 km km^{-2} (Dyring 1990).

Grazing also leads to changes in the species composition and structure of plant communities (Berman and Jarman 1988; Rogers 1994*a*; Beever and Brussard 2000*b*; Hobbs 2001). Rogers (1994*a*) observed retrogressive successional-shifts in vegetation communities grazed by feral horses. Mack and Thompson (1982) have suggested that, owing to the longer evolutionary association of Eurasian grasses with ungulates, they are more resistant to ungulate grazing and, consequently, possess a competitive advantage over plant species that have not evolved with ungulates.

Dyring (1990) noted that feral horses preferentially graze heathlands and grasslands, which may exacerbate effects on those habitat types. In addition, feral horses have the potential to alter tree composition by bark chewing, which induces tree mortality (Ashton 2005). Ashton (2005; p. 79) states that bark chewing caused 'widespread and in some areas, intense, damage to eucalypt species'. This is significant, as increased mortality resulting from bark chewing can potentially alter vegetation composition and structure, especially as feral horses seem preferentially to chew certain species (Ashton 2005).

Grazing and trampling by feral horses also have the capacity to damage waterways (Berman and Jarman 1988; Rogers 1991, 1994*b*) and bog habitat (Dyring 1990; Rogers 1991; Clemann 2002). Trampling near streams can increase run-off (Dyring 1990; Rogers 1994*b*), and hence reduce water quality. Rogers (1991) observed that flush zones, probably owing to their high nutrient content, are particularly favoured by feral horses, resulting in trampling of vegetation as well as alterations in water flow and downstream siltation. In addition, several weedy sedges, herbs and rushes have been seen to benefit from trampled substrates in conjunction with dung heaps in flush zones (Rogers 1991).

Berman and Jarman (1988; p. 54) state that feral horses 'foul water holes with carcasses and cause accelerated gully erosion' in central Australia (Berman and Jarman 1988). Additionally, in the Australian Alps, Dyring (1991; p. 6) noted that stream banks were 'extensively churned up and broken down' owing to horses' hooves sinking into peaty soils, while Rogers (1994*b*) observed fracturing of saturated soils and water ponding as a result of trampling by feral horses in New Zealand.

Weed dispersal

Feral horses directly disperse weeds via (1) epizoochory (attachment of seeds to the body of the animal), and (2) faeces (Campbell and Gibson 2001). Taylor (1995) found that a single feral horse can pass 19412 seeds per day, with a viability of 6.7%. Most seeds pass through a horse's digestive tract within two days of consumption (Vander Noot *et al*. 1967), but some can remain viable for much longer (Janzen 1981). This means that feral horses have the potential to disperse plant species both long and short distances (Janzen 1981; Campbell and Gibson 2001) and hence contribute to the establishment of weed species across several spatial scales.

Effects on wildlife

Levin *et al*. (2002) found that feral-horse-induced changes in vegetation structure can alter bird assemblages in marsh environments – shifting communities dominated by nesting gulls and terns to communities dominated by foraging shorebirds. Zalba and Cozzani (2004) found that intense grazing by feral horses resulted in increased predation on bird eggs in grasslands, leading to reduced avian richness and diversity. However, avian richness and diversity were higher in areas subject to moderate levels of grazing than areas in which horses had been excluded (Zalba and Cozzani 2004).

Beever and Brussard (2004) found lower abundances of several reptile species, and lower total squamate reptile diversity

in areas subject to horse grazing in the Great Basin, USA. In the same area, Beever and Herrick (2006) observed lower abundance of ant mounds and lower ant species richness in horse-occupied sites than in sites from which horses had been removed. Similarly, grazing by feral horses has been linked (although not quantitatively) to the decline of reptiles (Coventry and Robertson 1980; Mansergh 1982) and amphibians (Gillespie *et al*. 1995; cited in Clemann 2002) in the Australian Alps.

Changes have also been observed in mammal communities following horse-related disturbances: Beever and Brussard (2004) found that areas in which horses had been absent for over 10 years contained a greater proportion of species that would be expected to inhabit sample areas than did horse-occupied sites. Also, horse-occupied sites had greater abundances of deer mice (*Peromyscus maniculatus*), which are known to fare well in 'conditions of environmental or disturbance-imposed harshness' (Beever and Brussard 2004; p. 288).

Berman and Jarman (1988) found fewer signs of macropods in areas heavily grazed by feral horses and cattle, while Nano *et al*. (2003) cited the control of feral horse populations in the MacDonnell Ranges, Northern Territory, as a possible explanation for the recovery of central rock rats (*Zyzomys pedunculatus*). Similarly, Matthews *et al*. (2001) found more signs of black-footed rock wallabies (*Petrogale lateralis*) in a series of surveys conducted after the removal of feral horses from Finke George National Park, Northern Territory.

Grazing and trampling by feral horses can also influence aquatic fauna (Levin *et al*. 2002). For example, the removal of *Spartina* salt marshes by feral horses can result in increased predation of mummingchog fish by xanthid crabs (Levin *et al*. 2002). Furthermore, horse grazing in marsh environments can significantly reduce the species richness of fish communities and the abundance of individual fish species (Levin *et al*. 2002).

A cautionary note

From the above review, it may seem as if the ecological effects of feral horses are well established. We contend that this is not strictly the case, particularly for Australian ecosystems.

Like all species, horses use and respond to their environment in a heterogeneous fashion (Turner 1987) over several spatial scales (Bailey *et al*. 1996; Beever *et al*. 2003; also see Wiens 1989; Mackey and Lindenmayer 2001; Kelly 2006). Hence they modify the spatial patterns of landscape elements variably across spatial hierarchies (Hobbs 1996; Beever *et al*. 2003). For example, horse distribution on more local scales is influenced by factors such as nutrient content of soils, whereas on a landscape scale, aspect and slope play an important role (Bailey *et al*. 1996; Cameron *et al*. 2001). This results in differential utilisation of landscape elements across different spatial scales, which are themselves disparately susceptible to disturbance (for example, the ramifications of trampling disturbance is influenced by local slope: Whinam *et al*. 1994). Consequently, results on the effects of grazing disturbance (for example) can differ according to the scale at which the investigation is being undertaken (see Beever *et al*. 2003). For instance, plant diversity, when investigated at a small scale, has been seen to increase in the presence of grazing, but when the spatial domain is increased the outcome is reversed (Olff and Ritchie 1998).

Despite this, most research on the ecological effects of feral horses has occurred at single, small, spatial scales (Beever *et al*. 2003) (notable exceptions include work undertaken recently by Erik Beever and associates in the Great Basin, USA; see Beever 2003; Beever *et al*. 2003; Beever and Brussard 2004; Beever and Herrick 2006). Although these studies are of value in that they characterise disturbance at scales relevant to some species, it is dubious to treat such findings as illustrative of the conditions prevalent on a landscape or regional scale (Beever and Brussard 2004). Sites investigated may not be representative of the system in general, which means that broad management regimes derived from such research may be erroneous (Bestelmeyer and Wiens 2001; Beever and Brussard 2004).

This problem is best exemplified by the critique of Rogers (1991), offered by Linklater *et al*. (2000), demonstrating that positioning of horse exclosures can result in impact measurements unrepresentative of the broader system. Similarly, Beever (1999) and Beever and Herrick (2006) highlighted that effects of feral horse grazing on plant and animal taxa depends on elevation (also see Beever and Brussard 2000*a*).

Further confounding results is the fact that past research into the effects of feral horses have typically included only a small number of response variables (Beever *et al*. 2003), *usually* measuring direct effects of disturbance on a few plant characteristics, ignoring both direct effects on other taxa (Beever and Brussard 2004) and indirect effects occurring concurrently and subsequently from the formation of feedback loops (Beever and Herrick 2006).

The small number of feral horse studies that have paid credence to the importance of factors such as scale (see Beever and Brussard 2004), feedback loops and indirect effects (see Levin *et al*. 2002; Beever and Herrick 2006) have been undertaken in semiarid and marshland environments, and hence their applicability to similar disturbances in other ecological systems may be limited. Furthermore, we are not aware of any peer-reviewed research that analyses the effects of feral horses on native environments in Australia.

In conclusion, there remain several critical gaps in our understanding of the ecological effects of feral horses on native environments, particularly with regard to Australian ecosystems.

Management options

Owing to the perceived threat of feral horses to native environments, management authorities (sometimes in conjunction with private landowners, see for example Watkins 2006) are at times required to reduce population numbers (Edwards *et al*. 2006; Jennings 2006; Nesbitt 2006; Wilke and Paroz 2006). Currently, legislation that defines the responsibilities of public agencies differs between Australian states (Dawson *et al*. 2006). For example, in South Australia, horses are a declared pest species under the *Natural Resources Management Act 2004* (Dawson *et al*. 2006), whereas in Queensland feral horses do not have pest status (Wilke and Paroz 2006). As such, the obligations of management authorities to control populations differ between states (although recently there have been calls from several stakeholders for a unified, national approach to management: see Dawson *et al*. 2006).

Options for population control of feral horses are quite limited but include ground shooting, mustering and trapping,

helicopter shooting, immobilisation, and fertility control (for a brief review of these see English 2000; McLeod 2004).

Fertility control is generally viewed favourably by those concerned with animal welfare (Burke 1996; Singer 1997; Chapple 2005). Empirical evidence gathered from research on the acceptance of control methods for large herbivores supports this (see Stout *et al*. 1997; Lauber *et al*. 2001). However, although research on fertility control of feral horses has been underway for over 25 years (Turner *et al*. 2001), and despite promising results from recent trials (see Kirkpatrick *et al*. 1997; Turner *et al*. 2001; Killian *et al*. 2004), there still exists no proven cost-effective method for long-term fertility control of feral horses at a population level (English 2000; Killian *et al*. 2004; Hinds 2006).

Shooting from helicopters by trained marksmen is regarded by many wildlife managers as the most practical and humane control method because: (1) shooters can get close to the target animal, and (2) wounded animals can be followed up and killed quickly (English 2000). Whether the latter actually occurs in the field is a source of contention among stakeholders (see New South Wales Legislative Assembly Hansard 2002; Crossley 2006).

Other non-lethal methods for feral horse control have also been trialled recently, most notably the New South Wales National Parks and Wildlife Service's (NSW NPWS) feed-luring trial. This involves placing hay bales in trap yards in an attempt to attract feral horses, which are then captured and relocated to private estates (at which point the responsibility of the management authority ceases, although horse-related stakeholders have assisted in finding adequate homes for a large proportion of horses removed during the trial) (Ashton 2005; Nesbitt 2006). However this method, like the others, has shortcomings in that it is labour intensive (NSW NPWS 2003), trap yards are cumbersome and expensive to set up (Foster 2004), and finding new homes for large numbers of horses is an extremely difficult and costly undertaking.

Control methods for feral horses, however, also vary in their social acceptability (Ballard 2005; Nimmo 2005), which must be weighed against the logistic and economic constraints outlined above. Some methods, while economically and ecologically viable, may be politically tenuous, and *vice versa*.

The human dimensions of management

The management of feral horses is one of the most contentious issues facing wildlife managers in Australia (see Symanski 1994; English 2000). Horses are seen by many Australians as a culturally significant, iconic species (see Walter 2002) and, as such, play more than a passing role in Australian folklore. *The Man from Snowy River*, a famous poem by Banjo Patterson (within which feral horses are the central theme), is a culturally significant story to Anglo-Australians. Horses are also a popular domestic pet in Australia, estimated to number 1.2 million (Long 2003). The importance of the horse to Australian folklore is perhaps best exemplified by its appearance on the Australian $10 note, and its conspicuous presence during Sydney's 2000 Olympic Games opening ceremony.

Feral horse management has provided an impetus for a diverse discourse concerning matters such as: the proper appropriation of funding and research effort during politically sensitive management regimes (Linklater *et al*. 2002); the virtues and vices of post-modernism in the environmental sciences (Symanski 1994; Dear 1994); the morality of non-human population control (Lynn 1998); and the problem of differential access to power in marginalised communities (Rikoon 2006).

Despite such an obvious presence in the peer-reviewed literature as a discussion topic, this commentary has spawned surprisingly little *applied* social research. In particular, we note that no studies focusing on the human dimensions of feral horse management have appeared in the peer-reviewed literature to date. However, horses have figured in a small number of 'grey literature' social studies, and parenthetically in at least one peer-reviewed article (Finch and Baxter 2007). Below is a brief summary of this research.

- Johnston and Marks (1997) found that 13.6% of respondents considered feral horses to be a pest species in Victoria, Australia.
- Fraser (2001) found that ~10% of respondents regarded feral horses as a pest in New Zealand. Additionally, 80% of respondents said that they would enjoy seeing feral horses in the New Zealand bush or high country.
- Nimmo (2005) found that 21% of respondents considered feral horses a pest in Victoria. Preferred management techniques included immobilisation and mustering and trapping, while aerial culling was deemed 'never acceptable' by ~50% of respondents.
- Ballard (2005) revealed that ~40% of respondents preferred retaining some feral horse populations in national parks in New England, New South Wales. Preferences for management techniques were similar to Nimmo (2005), with removal for private consumption favoured, and aerial culling being deemed unacceptable by ~50% of respondents.
- Finch and Baxter (2007) found that ~25% of respondents did not consider feral horses to be a pest species in Queensland, while a further 26.1% regarded them as a 'slight pest'.
- Kellert and Berry (1980) found that horses were the second favourite animal among respondents in surveys of the American public.

These attitudes and perceptions are manifested in the controversy surrounding feral horse management internationally.

Case studies

The literature highlights how contentious feral horse management can be (Wagner 1983; Symanski 1994, 1996; Linklater *et al*. 2002; Rutberg 2003; Chapple 2005; Rikoon 2006), particularly when lethal methods are employed. Below are four brief synopses to illustrate this.

Case study #1 – feral horses in the United States

In 1971 the US congress passed the *Wild Free-Roaming Horses and Burro Act* (Wagner 1983; Rutberg 2003). This Act stipulated that feral horses were a 'national treasure' that symbolises 'the historic and pioneer spirit of the west' (Wagner 1983) and should be managed in a manner that reflected such a status. As such, feral horses were considered a public resource and offered legal protection (Wagner 1983). Rutberg (2003; p. 217) describes the passage of this Act as 'the clearest possible statement that the American people would not and will not tolerate any kind of cruelty or abuse of wild horses'.

Subsequent population analyses showed an increase in feral horse numbers (Boyles 1986), despite the Bureau of Land Management's (BLM) removal of horses via non-lethal means (Wagner 1983). In 1978, action was taken with the *Public Rangelands Improvement Act* allowing 'the removal and disposal' of feral horses owing to their perceived threat to rangeland ecosystems (Wagner 1983; Boyles 1986). This move was met with a public outcry and ignited a fierce battle between pro-horse stakeholders including Michael Blake (author of *Dances with Wolves*), and the BLM (Symanski 1996).

Blake and his colleagues argued that the BLM was removing excessive numbers of horses to appease local ranchers. To investigate this, Blake funded an aerial census of the region under the aegis of the Public Lands Resource Council (PLRC) in an attempt to assess the BLM's alleged dishonesty. The census revealed great disparities between BLM figures and PLRC figures, with the former being some four times the latter (Symanski 1996). The methods employed for the PLRC's count, however, were later shown to be inadequate, leading to erroneous results (Symanski 1996). Despite this, Blake and The Animal Rights Law Clinic at Rutgers University, New Jersey, filed civil actions against members of the United States government related to the issue. Blake also funded billboards that depicted the BLM engaging in cruel behaviour towards horses, while referring to the BLM's management regime as a campaign of 'genocide against America's wild horses' (Blake *et al*. 1992, quoted in Symanski 1996).

Symanski (1996), in reference to environmental damage caused by feral horses, states 'the delays caused by these spurious data are serious considering the rapid losses of species and habitats in an environment always scarce in resources' (Symanski 1996; p. 712).

Case study #2 – feral horses in central Australia

In the mid to late 1980s, the Conservation Commission of the Northern Territory (CCNT) undertook aerial surveys of feral horses. The findings showed that feral horse numbers were far higher than originally thought, with a population of ~200 000 (Dobbie *et al*. 1993; also see Bowman 1985). As a result, the CCNT offered financial assistance to pastoralists who wished to remove feral horses from their land in conjunction with other population-control programs (Symanski 1994). The culling of feral horses received international attention, with numerous animal rights groups voicing outrage (Symanski 1994). For example, prominent animal rights activist Linda McCartney stated:

> 'Men who go around shooting animals should be castrated. They're no different from rapists and murderers who should share the same fate. It's like watching white hunters in Africa; they say they're 'culling'. I say 'killing'. It's pathetic that there is no place for horses to run. Surely, the Australian government can find a bit of land in that vast country where the horses can live in peace' (quoted in Symanski 1994, p. 251).

Legal action ensued and the International Court of Justice for Animal Rights tried and convicted members of the Australian government for massacring horses (see International Court of Justice for Animal Rights 1987; Symanski 1994).

Symanski (1994) claims that these objections were met with subservience by the CCNT who, according to Symanski, used reduced population estimates to claim that further management was no longer required. These estimates were the result of aerial surveys (see Low and Hewett 1990), which found horse numbers to be 23% of what they were four years earlier (Dobbie *et al*. 1993). Some researchers have attributed this population plummet to unseasonably dry conditions (Dobbie *et al*. 1993) and lethal management (Edwards *et al*. 2006); however, Symanski (1994) challenged these figures stating:

> 'There is simply no credible way to maintain that a 'drought' resulted in a population decline from either 200 000 or 238 000 to 70 000' (Symanski 1994, p. 261).

It is impossible to know whether the population estimates were accurate, or whether, as Symanski (1994) claims, they were accepted uncritically for purely political reasons, although there is no doubt that drought can exert a significant effect on feral horse populations (see Berger 1983; Dawson 2005). (Indeed, mass mortality for wild equids from natural events has been cited frequently: see Penzhorn 1984; Walker *et al*. 1987; Scorolli *et al*. 2006.) Regardless, the Northern Territory cull illustrated a growing trend that the public was emerging as a central and vocal stakeholder in the management of feral horses, internationally.

Case study #3 – feral horses in New Zealand

In 1981, following concerns about reductions in feral horse numbers in the southern Kaimanawa Mountains (New Zealand), a population of feral horses known as the 'Kaimanawa wild horses' were afforded the same legislative protection offered to native species (Rogers 1991; Fleury 2006) under New Zealand's *Wildlife Act 1953* (Cameron *et al*. 2001; English 2001). Subsequently, the Kaimanawa horse population was reported to increase markedly, from 174 in 1979 (Aitken *et al*. 1979) to an estimated 1102 in 1990 (Rogers 1991), although there is uncertainty as to the accuracy of these population estimates (see Veltman 2001; Linklater *et al*. 2004).

In response to concerns about the growing population's environmental impact, a management plan was developed and made available to the public in 1991. A high degree of public interest ensued, resulting in the development of a working party composed of key stakeholders. The working party assisted in the development of a draft management plan that was approved by the Minister of Conservation in 1996 (Fleury 2006).

The management plan included aerial culling as a control technique, which attracted further public interest (New Zealand Department of Conservation 1995; Fleury 2006). The government recognised the heavy opposition to this method (Mack *et al*. 2000), and instead opted to implement a large muster and adoption program, which took place in 1997 (English 2001). This followed the removal of legal protection for most Kaimanawa wild horses in 1996 (Linklater *et al*. 2000). A total of 1069 feral horses were removed during the muster and adoption program, resulting in a significantly reduced population size and range, which has been maintained since that time by annual musters (Fleury 2006).

Case study #4 – feral horses in Guy Fawkes River National Park, eastern Australia

The above three case studies illustrate how sensitive the issue of feral horse management is, both in Australia and elsewhere. This information was published in well known, peer-reviewed jour-

nals. Nonetheless in October 2000, at Guy Fawkes River National Park, in north-east New South Wales, history repeated itself when ~600 feral horses were shot dead by trained marksmen from helicopters.

The justification for the cull was that drought and bushfires had imposed severe conditions on the park and horse populations alike (English 2000, 2001; NSW NPWS 2006; Chapple 2005). What followed the cull was a predictable sequence of events, so congruent with past experiences that it could have been foreseen from past literature alone. Once again, public outcry occurred (Chapple 2005) and legal action was taken against the management body responsible for the cull: the Royal Society for the Prevention of Cruelty to Animals (RSPCA) charged the NSW NPWS with several counts of cruelty to animals (Chapple 2005) (although all charges were eventually dropped).

Political repercussions were also evident, with a ban placed on aerial shooting of feral horses in New South Wales (English 2001; Nesbitt 2006), and an independent inquiry into the cull initiated (see English 2000). Members of major political parties referred to the cull in emotive terms. For example, National Party member Andrew Fraser described the cull as 'barbaric slaughter' (New South Wales Legislative Assembly Hansard 2002). Chapple (2005; p. 234–235) notes 'the absence of community consultation during the decision making process about whether or not to do aerial culling proved to be a significant oversight of NPWS'.

Since the cull, management authorities in New South Wales have more actively sought community involvement by making horse-management plans available to the public before their implementation, by commissioning a study into the heritage value of feral horses (and creating a working party for that purpose), and by setting up the Guy Fawkes River National Park Horse Sterring Committee composed of central stakeholders (Nesbitt 2006). The steering committee aided in the development of a feral horse management plan, which focused on the use of feed lures to attract horses into trap yards (mentioned above). The current plan's objective is the complete removal of horses within 5 years (Nesbitt 2006) although, as Nesbitt (2006; p. 53) states, there remains 'a need to raise public awareness on the significant environmental impacts of feral horses'.

Another call for research?

> 'Scientists often have a naïve faith that if only they could discover enough facts about a problem, these facts would somehow arrange themselves in a compelling and true solution' (Theodosius Dobzhansky).

Typically, this is the point of an article in which the author recommends more research into the problem be undertaken. We don't wish to disappoint. It is our belief that a paucity of unequivocal facts makes decisions surrounding feral horse management more contentious than they otherwise would be. As Beever (2003) highlights, when wildlife management policy becomes socially divisive or controversial for whatever reason, environmental managers and scientists are required to employ more meticulous methods and analysis in order to justify or vindicate management activities.

Such thinking is echoed in Australia by many key stakeholder groups. For example, Australia's most well known animal-welfare group, the RSPCA, states that 'before a control program is developed, it must first be established that it is necessary … This requires a sound understanding of the impacts of feral horses on the native environment' (Jones and Coleman 2006; pp. 39). Similarly, one of the main outcomes of a nationwide feral horse workshop held in Canberra, Australia (see Dawson *et al*. 2006), was a call for research into the effects of feral horses on native species.

We agree with Linklater *et al*. (2002) that the peer-review process is the best mechanism for illuminating the quality of research to the public, by exposing it to criticism from an independent and international audience. In the case of feral horse management, to our knowledge, this standard is yet to be achieved in Australia for both ecological *and* human dimensions research.

When we combine good ecological science with good social science, we believe that wildlife managers give themselves the *best possible* chance of having ecologically and sociopolitically sound management programs. However, as Symanski (1994; p. 262) notes, feral horse management is 'deeply embedded in complex social and political matrices'; highlighting and understanding these matrices is only the beginning of the more complex task of reconciling differing value systems (see Rikoon 2006).

Simply appealing to institutionalised ecological knowledge will not resolve the debate by itself, because, in many ways, feral horse management is contingent upon ethical, political and cultural issues, not just scientific ones (Linklater *et al*. 2002; Chapple 2005). As such, feral horse management plans will always be a compromise between competing values and environmental constructions (see Chapple 2005; Rikoon 2006).

In situations where the public play a prominent role in the formation of natural resource policy, 'ideal' outcomes from a strict conservation point-of-view are not always assured. However, they are often superior to policy outcomes that attempt to *ignore* public sentiment. While in some instances it may be impossible to eliminate feral horse populations from public land (sociopolitically speaking), trying to do so without integrating community opinion can effectively end *all* population control, to the detriment of ecological systems. When, or if, it is determined that feral horse populations require control, government authorities require flexible and adaptive programs that take into account the significance of community opinion in determining the success or failure of management regimes.

There is not likely to be a simple procedure that abates all concerns from all parties, nor one that can be adequately transferred from one situation to another. The only prescription that we believe can consistently accrue 'least contentious' outcomes is the involvement of the community and stakeholder groups in the formation and implementation of management plans. As such, community involvement should be a prerequisite to the management of feral horse populations in Australia and internationally.

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