CURRENT ISSUES IN TOURISM

Horse Riding in Protected Areas: A Critical Review and Implications for Research and Management

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Horse riding is a popular, high-impact recreational activity that occurs worldwide. The United States and Australia have a long history of recreational horse riding in protected areas and controversy accompanies this activity in both countries. This review describes and critiques research to date, and then draws out the implications for future research and management. Previous research has been experimental (using trampling lanes to determine impacts away from trails) and quasi-experimental (based on existing use of trails and describing impacts). The off-trail experimental research clearly demonstrates that horses can cause considerable damage. The trail-based quasi-experimental research also showed degradation from horses; however, critiques of this methodology make it more difficult to draw robust conclusions. In addition to biophysical impacts, social research based on surveying users has identified a number of issues associated with horse riding (e.g. conflict with other users) as well as exploring horse riders' preferences for management actions. A major gap in current research is evaluating the effectiveness of management actions, such as trail construction and codes of conduct. Recommendations for future research include more attention to experimental design, research across and into new ecosystems to improve the generalisation of findings, and attention to researching management effectiveness.

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Introduction

Horse riding is a popular recreational activity throughout the world, with horses often seen as part of an area's cultural and historic heritage. In addition, many young people like to work with and ride horses, hence the widespread occurrence of pony clubs, equestrian centres, riding schools and horse riding magazines. Often, images and pleasures are associated with horse riding in outdoor settings, particularly those perceived as natural. And in many countries, especially developed ones, protected areas such as national and regional parks and wilderness areas, are recognised and used for recreational horse riding. This is particularly the case in the United States and Australia, where large areas of public land are set aside as national parks and forests, and where there is a strong cultural heritage of horse use.

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In Australia, Cubit (1990) noted that many horse riders wished to emulate the endeavours of early explorers and mountain cattlemen. Accordingly, the image of the bushman on horseback has become iconic in Australia (Beeton, 1999b). In this country, horse riding in protected areas usually occurs on designated bridle or multiple use trails, but there is also cross-country riding where no designated trail exists (Cater *et al.*, in press; Newsome *et al.*, 2002a, 2004). Peri-urban protected areas experience moderate to high levels of equestrian activity (Landsberg *et al.*, 2001).

The United States, similarly to Australia, has a long cultural history of horse riding. Horses were an essential participant in pushing forward and opening 'the frontier'. Widner and Marion (1993) note that pack stock travel was such an important part of wilderness travel in the United States that wilderness itself was defined as an area large enough to accommodate a horse trip of up to two weeks duration. Today, horses continue to provide transportation and companionship for many wilderness users in the United States and are an integral part of many outdoor recreational activities in Australia, South Africa and Europe. For example, there are as many as 2.4 million horse riders in the United Kingdom alone, and up to 20 million people across the developed world (Ollenburg, 2005). Overlaps clearly exist between recreational and commercial horse riding and tourism based on horse riding operations. Tourism activities include guided horse treks, tours and trail rides, which may include overnight accommodation or camping. Trail rides commonly take place on established trails, but horse treks of several days or longer often take place off trails, through protected areas and spanning a wide range of environments (Ollenburg, 2005).

Horse riding in protected areas brings to the forefront the central dilemma facing protected area managers and society more generally, the compatibility of visitor use, in this case horse riding, and protection of the cultural and environmental values of protected areas. Many protected areas, such as national parks, have a dual mandate of protecting the natural environment while at the same time providing opportunities for visitors without degrading this environment (Worboys *et al.*, 2005). This dilemma can be summarised by the question 'How much environmental change is acceptable?' (Prosser, 1986; Stankey *et al.*, 1985). Numerous authors and researchers have pursued this question with regards to a number of activities, including hiking, horse riding, camping and white water rafting.

Most of the research addressing horse riding has concentrated on its physical and ecological impacts and social impacts on other users, such as hikers. Most of this research has been conducted in the United States and Australia, for the reasons given above. The growing number of scientific studies demonstrates the high impacts of horse riding, both on the natural environment and on other users (Cater *et al.*, in press; Newsome *et al.*, 2004). However, even in the face of this growing evidence, debates between horse riders and protected area managers continue; and the associated conflict is a particular issue in Australia (Beeton, 2006; Cubit, 1990; Vollbon, 1990; Whinam, 1990).

Central to the debate is the efficacy of the research findings and perceived gaps. Horse riding lobbyists claim there is a dearth of evidence from many environments regarding high impacts and that further investigation is needed before any actions are taken. At the same time, they acknowledge that a national

united approach, based on improved education and public relations between horse riders, protected area managers and the general public, is needed. The remaining elements of the debate include: conflicting values about the appropriateness of horse riding in many protected areas; disagreements about the validity of the available scientific evidence; and some lobby groups wanting more areas for horse riding.

Given this debate and the associated conflict, it is opportune to critically review the research to date on horse riding in protected areas, drawing predominantly on the rich research history on this topic in the United States and Australia. The following critical review synthesises and analyses the available knowledge to identify the gaps and strengths and then determine what is needed to further inform and resolve the current debates about allocation and intensities of use. This review is wide-ranging. Rather than being restricted to considering the environmental impacts of horse riding, also addressed are social impacts on other visitors, as well as research into the effectiveness of management practices. It also covers areas that are not currently being researched, such as gender and other socio-demographic influences.

Biophysical Impacts of Horse Riding in Protected Areas

A number of parts of the natural environment are impacted by horse riding and, as such, have provided a focus for research. Included are soil, surface water, vegetation, structural changes (e.g. trail widening) and introduction of foreign material. The impacts determined from research efforts to date are summarised in Table 1. As indicated in this table, horses can have a high impact, especially on soils, surface water, and vegetation.

Newsome *et al.* (2004) noted that the most common and widely recognised impact was ground level damage caused by horse's hooves. This damage results from the large force applied to the ground through the horse's weight being transferred on four relatively small, sharp points. Cole (1989) and Newsome *et al.* (2004) also recognised that many of the horse riding impacts were similar to those caused by hikers, except they were more pronounced and occur more rapidly.

Liddle (1997), Weaver and Dale (1978) and Deluca *et al.* (1998) all argued that horse riding impacts were quantitatively greater than those caused by hikers. Additionally, factors such as long and steep slopes, high elevation, high rainfall events, unvegetated or unsurfaced slopes, low soil organic matter, poor soil structure, fine texture, impeded infiltration of water and close proximity to streams or groundwater discharge areas all contribute to trail degradation (Newsome *et al.*, 2002a).

Off-trail impacts of horse riding

Research into the impacts of horse riding has been both experimental and quasi-experimental. Experimental approaches have been used for off-trail research, whereas both approaches have been applied to studies of existing trails. In the off-trail studies, the impacts to the experimental plots are taken as being representative of the impacts associated with riding in off-trail environments. The results from these experimental studies clearly demonstrate that the impacts caused by horses in an off-trail situation have the potential to cause considerable damage to soils and vegetation in the studied environments.

Table 1 Biophysical impacts of horse riding in protected areas

Impact	*Significance*	*Impact on other users*
Soil		
Soil erosion	Soil and nutrient loss, water turbidity, sedimentation, alteration of water runoff.	Reduced aesthetic value, decreased functional value, visitor safety risk.
Soil compaction	Reduced infiltration, reduced germination, reduced vigour and growth of certain plant species.	Reduced aesthetic value, reduced biodiversity values.
Churning and lifting of surface soil particles	Accelerated erosion rates.	Decreased functional value.
	Changes in soil depth.	
Water movement		
Reduced water infiltration rates	Strong contributor to tread widening and multiple trail creation as users seek to circumvent muddy sections of trails.	Decreased functional value, reduced aesthetic value.
Increased surface run-off	Accelerated erosion rates.	Decreased functional value, decreased visitor satisfaction.
Vegetation		
Trampling and loss of vegetative cover	Vegetation loss, replacement by trampling resistant species, increased amount of bare ground, reduced vegetation height.	Reduced aesthetic value.
Alteration of plant species composition	Species that are less tolerant to trampling are replaced by species that are more resistant to trampling such as more aggressive native colonizers (e.g. grasses and/or exotic species).	Reduced aesthetic value, reduced biodiversity values.
Tree damage and root exposure	Root damage, reduced tree health, intolerance to drought.	Degraded aesthetic value, visitor safety risk, decreased functional value, reduced biodiversity values.

(*Continued*)

Table 1 (*Continued*)

Impact	*Significance*	*Impact on other users*
Plant defoliation through grazing	Reduction in plant vigour, damage to aerial parts of some plants thereby reducing flowering ability and hence reproductive success.	Reduced aesthetic value.
Structural changes to trail		
Increased trail width	Vegetation loss, increased amount of bare ground.	Reduced aesthetic value.
Informal and multiple trail development	Vegetation loss, wildlife habitat fragmentation.	Evidence of human disturbance, reduced aesthetic value.
Introduction of foreign material		
Manure on trails	Introduction of weed species.	Reduced aesthetic value.
Spread of plant disease	Vegetation loss, reduction in plant vigour.	Reduced aesthetic value, restriction of access due to quarantine areas.

Source: Burden and Randerson (1972), Cater *et al.* (in press), Hammitt and Cole (1998), Huxtable (1987), Liddle (1997), Marion and Leung (2001), Newsome *et al.* (2002a, 2002b, 2004), Sun and Liddle (1993).

Cole and Spildie (1998) investigated the impact of llama (140–155 kg), horse (450–500 kg) and hiker traffic (75–80 kg) in two forested vegetation types in the northern Rocky Mountains, Montana, USA. Intensities of 25 and 150 passes were applied to experimental trampling lanes 0.5 m wide and 3 m in length. Measurements were taken prior to and after trampling (within two weeks) and one year after trampling. In both vegetation types examined, relative vegetation cover was significantly lower after horse traffic than after llama or hiker traffic. Only horse use caused mineral soil exposure. One year after trampling, the vegetation cover trampled by horses was still significantly less than in the lanes trampled by hikers or llamas. They concluded that horses have more potential to disturb vegetation and groundcover than llamas or hikers. Whinam *et al.* (1994) investigated horse riding in the alpine and sub-alpine environments of the Tasmanian Wilderness World Heritage Area, Australia. They measured trampling and horse trail formation in previously undisturbed environments (shrubland, grassland and fen sites). Intensities of 2, 10 and 30 passes were applied to 1.5 m wide by 5 m long plots. Horses were shod and weighed approximately 265 kg without riders. The passage of 20–30 horses had substantial immediate and delayed effects on the soils of shrub land, herb field and bolster heath, but little affect on dry grassland soils, and resulted in significant damage to the shrubland vegetation. Horse manure trials were also conducted and showed that the highest mean number of

manure-sourced weeds (292) was found in the shrubland where grazing was excluded and the soil disturbed.

Following on from this, Whinam and Comfort (1996) measured the impacts of high level horse usage (142–231 horse riders per month) at Cradle Mountain in Tasmania. Measurements were taken in heathy sedgeland, *Eucalyptus delegatensis* open forest, alpine shrub land mosaic and temperate rainforest. The results of two years monitoring showed that soil loss was greatest in the first 12-month period with most soil loss occurring in eucalypt forest. During the survey period, new tracks appeared, percentage cover of live vegetation declined, and the amount of bare ground increased over a one year period. Further, faint 'pads' turned into new tracks in buttongrass moorland, with loss of vegetative cover in as little as three months.

Some of these results should be treated with caution due to variations in the site conditions that may influence impact. For example, the transect in the eucalypt vegetation included a site where horses had to step over a log and, as noted by the authors, all the horses tended to step in approximately the same spot. Additionally, the study measured changes in cross sectional profile (vertical difference between original trail condition and post pass multiplied by width of transect (1.5 m) to give a cross sectional area of soil lost). This does not account for soil compaction or its redistribution. The authors thus state that the churning and reworking of humus between roots may be partially responsible for soil gains experienced in one site (Whinam & Comfort, 1996). Notwithstanding the methodological problems of investigating changes in soil condition, there was clear evidence from this study of an increase in new tracks and a decline in percentage cover of live vegetation.

Further support for the high impact potential of cross country horse riding or riding on poorly defined trails is afforded by Phillips and Newsome (2002). The study, conducted in a vegetated parabolic dune area in a sub-Mediterranean coastal environment in D'Entrecasteaux National Park, Western Australia, set out to determine the impact of horses by measuring changes in species composition, vegetation cover and height, soil micro-topography and soil penetrometry on previously undisturbed plots. Horse intensities of 20, 100, 200 and 300 passes were systematically applied to each treatment transect and resampled after each level of horse trampling intensity. The horses were of a similar size (400–500 kg), unshod and included a saddle plus rider.

The results showed that horse trampling caused a decrease in vegetation cover and height, a change in species composition, a reduction in the frequency of plant species, and increase in soil depth and amount of bare ground. The most impacted portion of the treatment cross-sectional profile was the central portion (40–60 cm). Field observation showed that horses tended to walk through the centre of the treatment transects following the defined paths made by previous horses. They naturally follow trail lines created by the horses ahead. This study illustrated that there can be significant damage to vegetation if horses are taken cross country or stray from formed trails.

Impacts of horse riding on trails

Multiple use trails (e.g. trails used by hikers, horses and bikers) and those specifically designated for horse riding (bridle trails) provide an important means of access into protected areas. They are also vitally important for

containing and managing impacts. If, however, they have been poorly planned, designed or located or are not managed, then deterioration of the trail itself and the associated protected area is inevitable. The susceptibility of a trail to impact is also dependent on local environmental conditions; the types, intensity and patterns of usage; and the style and effectiveness of trail management systems (Newsome *et al.*, 2002b).

Leung and Marion (1996) commented that trail impact studies generally focus on one of three situations:

(1) at a landscape scale that considers the presence of trails as an impact on the natural landscape;
(2) how trails as a resource can be protected from degrading;
(3) assessments of processes and consequences of erosion on the trail itself.

The research in this area has included both experimental and quasi-experimental approaches. A weakness and source of criticism in horse riding impact research is the lack of standardisation in the methodologies employed and the variables studied, which can hinder comparisons between studies. Additionally, variation in environmental conditions further hinders and complicates such comparisons (Leung & Marion, 1996).

Despite these potential limitations in judging trail degradation from a comparative standpoint, a number of studies conducted in the United States provide firm evidence that horses are degrading trails. For example, Weaver and Dale (1978) examined the effects of trampling due to hikers, horses and motorcycles on multiple use trails in the northern Rocky Mountains, Montana. Level and sloping (15°) sites were chosen in an alpine forest and meadow. The sites were subjected to 50, 100 and 1,000 passes by horses, hikers and motorcycles. On level ground, horses were the most destructive and hikers the least destructive, but on grassy slopes motorcycles were more destructive than horses. Similarly, horses had a greater effect on vegetation than either motorcycles or hikers. On both level and sloping sites, trail width was greatest for horses and least for hikers. Compaction was greater under horses than hikers or motorcycles because horses tended to exert the greatest downward pressure on the soil.

Wilson and Seney (1994) also examined the relative impact of various users on water runoff and sediment yield on multiple use trails in the Gallatin National Forest, Montana. The sites were subjected to 50 and 100 passes by horses, hikers, motorcycles and off-road bicycles. Measures were taken on 108 sample plots on the trails. Multiple comparisons tests showed that horses and hikers made more sediment available than wheels (motorcycles and off-road bicycles). This effect was most pronounced on pre-wetted trails. Of all users, horses produced the greatest sediment yield on both pre-wetted and dry trails.

Deluca *et al.* (1998) conducted a study on trails in the Lubrecht Experimental Forest, Montana. Horse, llama and hiker traffic were applied to 56 plots at intensities of 250 and 1000 passes and compared with a control under both pre-wetted and dry trail conditions. Horses consistently liberated more trail sediment, which was then available for erosion, than either llama or hiker traffic. This was especially noticeable following 1000 horse passes. However, pronounced impacts were detectable after 250 passes suggesting that the initial traffic created the bulk of environmental damage.

Furthermore, sediment yields were higher on dry trail plots than on pre-wetted plots, indicating that dry trail conditions made the trail more susceptible to sediment detachment. Surface runoff, however, was significantly greater on pre-wetted trail plots compared to dry plots, indicating that traffic moving on wet trails fosters increased runoff, which could result in greater down slope channelling of water and associated sediment transport. It was concluded that horse traffic tends to cause more trail erosion than hiker or llama traffic with the major reason being that horses are heavier and their weight is carried on a shoe with a small bearing surface, moreover, horses' shoes are typically metal and frequently cleated. The observation was also made that horses are less careful and deliberate than llamas or humans about where they place their feet.

Royce (1983) attempted to obtain an overview of horse use in John Forrest National Park, Western Australia, on both designated bridle trails (primarily fire management access tracks) and multiple use trails. A major objective was to quantify the environmental impacts of horse use in the Park by analysing trails used by horse riders, that were subject to different levels of use. Usage was determined from estimations made by Park staff as no statistics on trail use were available. Royce (1983) measured soil compaction on the designated bridle trail and on multiple use trails that were off-limits but used by horses. Soil erosion as indicated by trail width and depth were measured along a cross section profile to calculate compacted soil-loss volumes. Trail anastomosis was assessed along the total length of the main bridle trail and multiple use trails used by horses. Grass tree (*Xanthorrhoea preissii*) cropping; weed cover in 1 m^2 quadrats adjacent to trails; floristic health and cover reduction in 1 m^2 quadrats both immediately adjacent to the trails and 10 m away were also assessed. The presence of dieback, an exotic plant disease caused by the introduced cinnamon fungus (*Phytophthora cinnamomi*) (Buckley *et al.*, 2004), was measured by the number of dead plants in 2 m belt transects adjacent to trails. A comparison was made to an earlier (1980) study where a photographic record of new bridle trails was made.

Royce (1983) showed that soil compaction was significantly higher on all trails examined than in areas 1–3 m off the trail and that the volume of soil-loss (soil erosion) increased with slope (≥8%). There was some proliferation of alternative trails and evidence of severe grass tree cropping on heavily used trails and an increase in weed cover with increasing trail use. Weeds were observed growing from piles of horse manure and noted to be more prolific on trails with heavier use. Floristic health was observed deteriorating adjacent to trails with high levels of use, improving with distance from trails. The extent of cinnamon fungus infection, as measured by the number of dead plants, was also observed to increase with higher trail usage.

Royce (1983) concluded that horse riding had caused a significant deterioration in the environmental quality of large areas of the Park. He recommended that horse riding trails should be prohibited from all national parks in Western Australia, where trails have not already been approved, and that horse trails in John Forrest National Park should be phased out. The methodological limitations of this study, which have made its use as a basis for management decisions particularly problematic, are discussed below. In the case of John Forrest National Park, well informed horse riding lobbyists have been able to argue against the recommendations from this study by critiquing the study's design

and execution. Associated issues include over-reliance on a single study for management recommendations and concerns regarding the accuracy of the usage figures.

A particular concern, and relevant to Royce's (1983) study, is that the multiple use nature of some trails potentially confounds the findings from studies that focus on horse usage (Dehring & Mazzotti, 2002). One or more of the trails that Royce (1983) investigated were also used by hikers. Also problematic for the Royce (1983) study is clearly demonstrating that trail damage and degradation of adjacent vegetation are due to horse use rather than other uses or a combination of use-related factors. For example, soil compaction was analysed using a 'drop block' soil penetrometer to 300 mm depth on the trail and 1–3 m from the trail edge on non-designated trails, included fire management tracks not designated for horse use and a Ranger-constructed trail. The finding that soil compaction was higher on all trails when compared to areas 1–3 m off-trail is not surprising as these trails (fire management tracks) were constructed using mechanical means (e.g. bulldozers and front-end loaders) and one of the trails was cleared using rake hoes.

Such an approach is problematic because the study was dealing with a constructed trail where a managerial footprint was already imposed. Dehring and Mazzotti (1997) also commented on the importance of recognising that constructed equestrian trails cause changes in vegetation and microhabitat conditions of an area, due to trail construction. When the managerial footprint is taken into consideration, compaction cannot be solely attributed to horse use. Similarly, conclusions about floristic health, reduction in cover and weed invasion did not take into consideration that the study trails were multiple-use (used by hikers, horses, off-road vehicles and service vehicles) and constructed by mechanical means. Summer (1980) cautioned that horse traffic may not be the only single dominant process affecting trails, nor may degradation always be a direct result of horse use.

One final concern regarding the Royce (1983) study is the attribution of plant deaths to the cinnamon fungus. Dieback is a soil-borne disease, yet its presence was estimated by counting the number of dead plants in belt transects. No soil tests were taken to determine its presence, so attributing plant death to it is therefore questionable. Despite the limitations and potential criticisms of the utility of his findings, Royce (1983) did describe a proliferation of non-designated trails, identified soil erosion on trails increasing with slope, and documented evidence of the grazing of native vegetation (grass tree cropping). The presence of horse manure on trails, thus increasing the chance of horses as a vector of weed spread, was also noted. His study illustrates the benefits of using multiple variables to address the horse riding issue.

The presence of weeds in natural areas poses a significant biodiversity conservation problem and reduces the aesthetic appeal and inherent value of native vegetation. Various studies have also shown that there is potential for horses to act as a vector of weed spread (Barrett, 1999; Campbell & Gibson, 2001; Weaver & Adams, 1996; Whinam *et al.*, 1994). These studies showed that weed species could be germinated from horse manure. Nevertheless, Campbell and Gibson (2001) found that of the 23 weed species found in manure samples collected

from trails in southern Illinois, USA, only one species was found in trail plots. Similarly, Whinam *et al.* (1994) found that four weed species germinated from manure collected in Tasmania, Australia, in the glasshouse but not in field conditions. Field experiments show that weed establishment is highest in areas of previously disturbed ground and where grazing animals had been excluded. Barrett (1999) found a lack of viable weed seeds in horse droppings collected on bridle trails in Western Australia.

Weaver and Adams (1996) recorded 29 weed species germinating from horse manure samples collected from bridle trails in Victoria, Australia. The presence of weed seeds in horse manure highlights that horses have the capacity to disperse viable propagules of both woody and herbaceous weeds. This is also born out by field observations of the rampant weed Veldt Grass (*Ehrharta calycina*) germinating from horse dung along trails in John Forrest National Park in Western Australia (Newsome, 2005). If invasive weeds are germinating from horse dung as observed, then the use of trails by horses, especially through good quality and mostly undisturbed vegetation with no prior weed invasion, is contributing to degradation by facilitating weed spread through trail corridors (Newsome *et al.*, 2002a, 2002b). Users may find trails degraded by weeds unsightly and not in keeping with the overall concept of protected areas (Table 1).

Weed seeds can also be dispersed by various means such as wind or water, and by ingestion or attachment to hair (or clothing) on native, feral and domestic animals, including humans, and by vehicles through mud encrustations, especially in tyres (Liddle, 1997; Weaver & Adams, 1996). As such, horses are only one of a number of vectors. They are, however, an important one because of their ability to transport large numbers of seeds, and then deposit them, complete with fertiliser, in areas that are otherwise remote from weed sources. Additionally, horse riding can result in the development of new trails which other vectors, such as hikers and wildlife, can subsequently use and move weed material into previously less inaccessible areas.

In contrast to the issues reviewed so far concerning the high damage potential of horse riding in protected areas, Landsberg *et al.* (2001), who examined horse riding in a peri-urban nature reserve in Australia, reported that riding horses on existing trails may cause negligible damage in some environments such as dry, level landscapes. However, these findings are based on an absence of reports of damage, rather than any evidence that damage does not occur. Newsome *et al.* (2004) maintain that horse riding is a legitimate and significant recreational activity but caution on its high impact potential. This latter assertion is based upon the accumulating research reviewed here, especially how horses damage vegetation and soils, and cause deterioration in trail conditions.

A final comment is worth making regarding the nature and extent of this damage. Damage is highly context-dependent. The Australian continent, for example, is characterised by the widespread occurrence of sandy and nutrient poor soils. These soils have a low resilience to human sourced disturbance, and this, combined with arid and semi-arid climates with long dry seasons and the presence of diverse, complex ecosystems that are susceptible to infection by

introduced pathogens such as the cinnamon fungus (Newsome *et al.*, 2002a), makes impacts from horse riding highly likely. Additionally, these factors mean that recovery from impacts is likely to be a long, rather than short, term venture. In the United States, extensive damage is also a very real possibility, but for very different reasons. Much of the horse riding in protected areas takes place in montane wilderness with the associated issues of waterlogged soils, and a short growing season making recovery difficult.

Social Impacts of Horse Riding in Protected Areas

In addition to the biophysical effects of horse riding in protected areas, trail impact studies are also concerned with social impacts such as user conflict, perceptions of users and depreciative behaviour. Conflicts with other users include objection to the presence of horse faeces, increased incidence of insects attracted to manure, introduction of smells and the sight of horses and horse related infrastructure, and general feelings of the inappropriateness of horses in wilderness areas that may conflict or accord with visitors' wilderness values. Information on social impacts has generally been collected using visitor surveys. In most, but not all cases, surveys include horse riders and other visitors to protected areas.

Some of the most cited work is that by Watson *et al.* (1993, 1994). In their 1993 study, they surveyed hikers and stock users in June to November 1990 in three wilderness areas: John Muir Wilderness ($n = 501$) in California; the Sierra and Inyo National Forests, Sequoia-Kings Canyon Wilderness ($n = 389$) in California; and the Charles C. Deam Wilderness ($n = 502$) in Indiana, USA. The objective was to gain a perspective on the interaction between hikers and recreational livestock (primarily horses). Their findings showed that up to 44% of hikers disliked encounters with horseback riders, although not all hikers disliked these encounters. In Deam Wilderness, of the hikers who encountered horses, 20% enjoyed meeting them and about half reported that they did not mind. Only 4% of horse users disliked their encounters with hikers.

A strong predictor of conflict between hikers and horse users were general feelings of inappropriateness of horse use in wilderness. Hikers also rated encounters with horses as somewhat undesirable with almost half indicating the behaviour of horseback riders interfered with their enjoyment of wilderness. The main behaviour of concern in John Muir and Sequoia-Kings Canyon Wilderness was horses defecating in places (mainly along trails) where hikers would have to walk, and horse groups making too much noise and being rude. In Deam Wilderness, the main behaviours of concern were horse groups making too much noise and damaging trails. When asked to evaluate the problems they encountered, horse users tended to evaluate problems as less severe than hikers, with litter and human damage to vegetation as the most severe problems. Alternatively, hikers rated impacts to trails by horses, horse manure on trails, and vegetation damaged by horses as most severe.

Udelhoven (2003) surveyed beach visitors ($n = 100$) over a four day period in June/July 2003 on the North Beach section of the Seashore Conservation Area, Washington, USA. Respondents were asked which activities they participated in while visiting the Beach, 18% were involved with horse riding whereas

the majority visited the area for walking/jogging/running and sun bathing/relaxing. When asked if visitor enjoyment would change if horses were no longer present on the beach, 60% of respondents indicated that their enjoyment of the area would not change. Further, 44% of respondents felt that the presence of horses had no effect on their feelings with 28% indicating it evoked happiness. And 59% of respondents felt that there were no attributes about the horses that affected their feelings.

Studies conducted in Australia (e.g. Barrett, 1999; Beeton, 1999a, 1999b; Davies, 2004; Priskin, 2003) have surveyed visitors regarding their attitudes to horses and their perceived impacts. Barrett (1999) surveyed visitors (n = 703) to Bold Park, Perth, Western Australia, in December 1998 and September 1999. No horse riders were surveyed. Respondents were asked for their views on the impact of horse riding in Bold Park: 14% said horse riding would improve usage, 57% thought there would be no impact, and 29% said horse riding would detract from Park values. A survey of visitors (n = 135) in 2001 found that 104 users were aware of horse riding in the Park but only one person objected to it (Recreational Riding for Bold Park, 2001).

A further survey was conducted in 2004 (Davies, 2004). She surveyed visitors (n = 200) over the period May to August 2004. No horse riders were surveyed. Respondents were asked about the impact potential of the main uses, including horse riding. The majority of respondents visited the park to walk (52%) or to exercise their dog (27%). There was a high level of support for horse riding in Bold Park (77%). When asked what activities had the potential to have an environmental effect, 18% of respondents listed horses as an activity that caused environmental impacts with 12% of these indicating that horses caused damage to soils.

Beeton (1999a, 1999b) surveyed visitors (n = 62) to Alpine and Mt Buffalo National Parks, Victoria, Australia, in January 1997 regarding their attitudes to horse riding in these areas. All respondents were involved in bushwalking (100%) and many were camping (68%), with only 6% horse riding. There was a strong negative attitude towards horse riding groups at their campsite, with a high percentage either staying but not enjoying themselves, or moving to another location. Further, a majority of respondents perceived horse tour groups as environmentally careless with concern expressed regarding the prevalence of horse dung. However, the low number of responses in this survey does not permit any firm conclusions to be drawn; rather it raises indicative concerns for consideration.

Priskin (2003) conducted surveys of visitors (n = 702) to protected areas in the Central Coast Region of Western Australia to access their views regarding the effects of recreation activities on sandy coastal environments. Horse riding was one of the activities. Respondents considered that horse riding was moderately harmful to the environment, with 24% of respondents participating in horse riding. Concerns regarding the impacts of horse riding, on this sandy environment, were expressed by both riders and non-riders.

Some of the most recent work carried out in Western Australia reports on a survey of horse riders themselves (Mulders, 2006). Respondents indicated that their riding had minimal impact providing that they remained on designated trails. Despite this perspective, 16% reported that they rode off-trail in order to

access another track or for some other reason. Concerns raised by respondents included a lack of suitable trails, poor trail maintenance, inadequate signage, a lack of information on the location of designated (approved) bridle trails and the influence of other uses such as trail and mountain bikes, and off-road vehicles. More trails were requested for horse riding purposes. Mulders (2006) noted that poor trail management by the managing authority could lead to liability claims if injuries to horse riders or other users were sustained.

Effectiveness of Management Practices

Horse riding can be deemed an appropriate activity where it is environmentally acceptable and compatible with other uses. Similarly to managing all other visitors, the approaches taken to managing the impacts of horse riding can include:

(1) zoning,
(2) site (trail) management,
(3) managing the visitors themselves (through information and education, and through regulating numbers, length of stay and so on) (Newsome *et al.*, 2002a) (Table 2).

Beyond zoning, either through preventing access or restricting horse use to certain areas, the management of horse riding currently relies predominantly on two strategies – voluntary codes of conduct and trail and site management.

Landsberg *et al.* (2001) suggested management principles for horse riding, similar in range to those developed more generally for visitor management in protected areas by Newsome *et al.* (2002a). In detail, these principles are: management to construct and maintain trails and to implement a monitoring system, and then acting if unacceptable impacts are detected; and for riders to use designated bridal trails, and apply a code of conduct. Newsome *et al.* (2002a) caution that voluntary codes of conduct are only as good as the level of user compliance.

Numerous studies have been undertaken of the impacts of visitors on the natural environment in the backcountry areas of national parks and wilderness areas in the United States (Leung & Marion, 2000). A small subset of these includes measurements of the effectiveness of management actions, such as construction of bars and installation of other drainage measures on trails (e.g. Leung & Marion, 1999). In studies such as the one undertaken by Leung and Marion (1999), assessing trail conditions and their management in Great Smoky Mountains National Park, USA, the impacts from horses were not separately considered from those caused by other users.

There have been few, if any, studies specifically directed towards assessing the effectiveness of the management of horse riding. This is both surprising and unsurprising. Given the growing body of research evidence regarding the potentially high impacts of horse riding in protected areas, it would seem logical for this concern to have translated into management action. Once action is undertaken, it then again seems logical for the effectiveness of this action to be determined through monitoring. This reasoning is, however, potentially flawed on two counts – that management action is possible (often there are not the resources available for managers to take action) and, that there are the resources

Table 2 Management strategies for horse riding in protected areas

Management strategy	*Details*
Zoning	
Use-specific zoning	1. Set aside areas for horse use only, for example, designated bridle trails.
	(2) Locate trails near edges of protected areas or in modified zones.
	(3) Exclude horse riding from ecologically sensitive areas.
Site (trail) management	
Locating trails	(1) Locate trail on contour and on level ground, trail grade to be below 10%.
	(2) Control water, for example bridges, drainage dips, outsloped treads, water bars and ditches.
	(3) Re-route short sections of trail to stop trail degradation in problem areas.
Managing trails	(1) Apply trail hardening and surfacing techniques, for example, materials such as gravel, earth, crushed stone and geo-synthetics (e.g. geo-textiles).
	(2) Reinforce soil structure, for example, use chemical binders such as liquid concentrates and latex polymer products.
	(3) Clear overhanging vegetation.
Visitor management	
Information and education: Codes of conduct	(1) Ride and stay on designated trails.
	(2) Ride in single file on trails to reduce width.
	(3) Use facilities provided.
	(4) Pass other people quietly on a track.
	(5) Keep horses under control at all times.
	(6) Spread out in untracked country.
	(7) If possible, do not shoe a horse before a trip as new shoes cut up the ground more.
	(8) Feed horses on commercial, processed feeds prior to and during trip to reduce likelihood of introducing weeds. Feed horses using a nosebag while in the protected area.

(*Continued*)

Table 2 (*Continued*)

Management strategy	*Details*
	(9) Hold horses at least 30 m from water sources, for example, lakes and streams, huts and camping areas. Water downstream and at least 30 m from camping areas on lake foreshores.
	(10) Use hitching rails or other holding facilities provided. Keep horses away from tree trunks and roots. Use a low power electric portable fence or tether where facilities are not provided.
	(11) Avoid crossing areas easily damaged by horses such as sphagnum moss beds, swamps and steep or boggy creek crossings.
	(12) Introduce horse users to consequences of use and encourage them to adopt low-impact practices.
Regulating visitor use: Numbers of horses	(1) Visit in small groups (4–8 people/horses).
	(2) Limit use, for example, number of horses that visit per year.
	(3) Limit the number of groups with horses.
Length of stay	(4) Limit the length of time horse users can access the area, most often applied to campsites.
Feed type	(5) Encourage use of 'permitted feeds' such as good quality, clean chaff, cracked grain and processed feed. All feeds must be as weed free as possible.

Source: Australian Alps National Parks (2005), Australian Horse Alliance (2006), Cater *et al.* (in press), Landsberg *et al.* (2001), McClaran and Cole (1993), McCool and Cole (2000), Newsome *et al.* (2002, 2004), Parks Victoria (2004), Recreational Riding for Bold Park (2001), Royce (1983), Widner and Marion (1993).

and intentions to accompany management action with monitoring. Hockings (1998, 2003) and Hockings *et al.* (2004) have commented on a number of occasions that protected areas are plagued by a lack of reporting on management effectiveness. Thus, this lack of research into management effectiveness is not surprising: a similar problem faces protected area management in general (Pullin & Knight, 2005).

A limited amount of research and reporting has been undertaken regarding the perceived preferences of horse riders for particular management strategies and the associated responsibilities. Whinam (1990) commented that horse riders should have a more positive attitude to the management problem by acknowledging that there are sensitive areas from which high impact activities, such as horse riding, should be excluded. Some areas will be available to horse riding whereas others remain closed. This view was elaborated by Vollbon (1990), who commented that although all individuals have the right to access protected

areas, this does not imply that everyone has an equal right to engage in their preferred recreational activity. Equal rights imply responsibility and respect for rules that may be in place.

Mulders (2006) reported that horse rider groups are prepared to abide by access restrictions, employ a code of conduct, clean horses' hooves and select appropriate feed before entering a protected area. Both Recreational Riding for Bold Park (2001) and the Australian Horse Alliance (2006) maintain that horse rider groups will self manage to a high standard. The former group refer to the use of accredited food sources, restriction to designated bridle trails, manure brochures and the dissemination of material supplied by park management. The latter group stated that 'horse riders have no desire to see bushland destroyed'. They promise responsible horse riding on designated trails and the avoidance of sensitive areas.

Implications for Research and Management

Implications for research

The choice of methodology and experimental design has important implications for the reliability and robustness of the subsequent findings from research. One of the notable strengths of the off-trail horse riding research is its strong experimental approach, with general application of experimental treatments against an untreated control. The only concern is having sufficient replication of plots in highly variable vegetation types such as those found in biodiverse regions (e.g. southwest Australia). In contrast, the quasi-experimental approach used for much of the trail work, where conclusions are drawn based on relating impacts to approximated visitor numbers and through comparing changes over time rather than across replicated plots, is potentially problematic. These problems are confounded by the lack of separation of effects from hikers and horse riders, given that much of this research has been conducted on multiple use trails.

For trail-based work, there is clearly a benefit in using an experimental approach (e.g. Deluca *et al.*, 1998; Weaver & Dale, 1978; Wilson & Seney, 1994). Similarly to the off-trail work, a sufficient number of replications is essential to account for variability within the landscape or protected area of interest. These methodological comments apply to research seeking to quantify damage, assess recovery from various levels of horse riding activity, or both.

The results to date suggest that the impacts of horse riding, although generally being high, depend greatly in their magnitude and type, on the particular ecosystem being impacted. There is a dearth of information on horse riding activities and potential impacts in arid, semi arid, and tropical rain forest ecosystems and biodiverse ones such as open eucalypt woodlands and non-coastal heathlands in Australia. Research in other ecosystems, especially those subject to high levels of horse riding (e.g. close to urban centres, societies with a culture of horse riding for recreation) and with fragile or highly valued natural environments, is a high priority. With this broadening of research attention, the extent of this apparently high impact activity can be better determined and subsequently managed. Also of benefit would be comparative studies from similar ecosystems (e.g. Mediterranean ecosystems with high biodiversity values and increasing visitor pressure given their proximity to population centres).

This review has made it very clear that the findings from a number of research projects, especially those based on trails, are uncertain at worst and confusing at best, because of the problems in separating out the effects of different users. Where there are multiple use trails, such as in the study by Royce (1983), it is impossible to clearly assign causality to either riders or hikers. This type of quasi-experimental research could be greatly improved by a stronger experimental design, where (if possible) there are controlled segments of trails, and then segments used only by horse riders, only by hikers, and so on.

There is a particular need for research that investigates evidence of environmental damage caused specifically by horses when they are ridden along constructed, maintained trails. Areas requiring research include assessing trail degradation due to horse riding, the spread of pathogens such as the cinnamon fungus in Australia, and the level and significance of weed spread. Additional research such as this will go a long way in helping to resolve the current conflict.

Also helpful in dealing with both managing the impacts of horse riding and addressing potential conflict, is gaining further information on the attitudes, expectations and reactions of horse riders to the resource and social conditions, impacts, and any proposed management strategies. Such research is essential if socially acceptable management practices are to be identified and implemented. Without societal support, protected area managers can struggle to achieve the outcomes they have identified as desirable, which often have an environmental protection focus (Newsome *et al.*, 2002a).

To date, a narrow selection of social research methods has been used, predominantly surveys of visitors to protected areas or targeted surveys of horse riders. Such social research must include horse riders, where opinions regarding horse riding are being sought. Where studies survey only non-horse riders about the future for horse riding, the credibility of the results seems questionable. In addition to visitor surveys, a number of other techniques have been successfully used in protected areas – observations by rangers, visitor trip diaries, participant observation (where the researcher participates in and observes on horse riding trips), and surveying managers to obtain their preferences. All can potentially contribute to better understanding horse riding and riders.

Implications for management

Monitoring is important to assess management effectiveness in reducing undesirable impacts, and to provide valuable information for planning, public accountability purposes and resource allocation (Newsome *et al.*, 2002b). Table 3 lists the variables for measuring resource and social conditions that can be used to assess management effectiveness and user compliance. Although this review has identified a number of approaches to the management of horse riding in protected areas (Table 2), few studies exist that fully evaluate the effectiveness of operational management strategies. Many existing bridle trails, therefore, need to be audited for impact management effectiveness. In addition, there is very little information on the attitudes, expectations and reactions of horse riders to proposed management strategies. A further problem is the availability and broad-scale adoption of monitoring systems that can be used by managers for key performance reporting and auditing the effectiveness of bridle trail

Table 3 Variables for monitoring the impacts of horse riding on bridle trails

Resource condition variables	*Other potential resource condition variables (context-specific)*	*Social condition variables*
Soil erosion	Spread of disease	User conflicts on multi-use trails
Root exposure	Introduction of weeds	Unsafe or difficult traveling conditions
Increased trail width	Trampling of adjacent vegetation	Manure on trails
Informal trails	Plant defoliation	Visitor satisfaction
Tread incision	Change in plant species composition	
Wet, muddy trails	Fauna disturbance	
Increased surface run-off		
Increased amount of bare ground		

management. Monitoring systems (including key performance indicators) also need to be designed and tested for their effectiveness.

Horse riders and associated lobbyists continue to profess enthusiasm for and laud the effectiveness of codes of conduct in reducing impacts. Research is urgently needed to test the effectiveness of this management strategy, both against the 'do nothing' option as well as other management possibilities, such as reducing numbers, restricting the season of use, intensive trail design, construction and maintenance activities. For reasons given earlier, protected area agencies have a poor history of reporting on the management effectiveness of their actions.

Recent work in Western Australia has emphasised the need for more bridle trails. However, given the poor history of research and management, the most sensible approach seems to be a planned one, where development, maintenance and monitoring is achieved via a trail management plan. Such plans would draw on the management strategies available in Table 2 and monitor according to a selection of variables from Table 3. They should detail trail location and design, erosion and drainage controls, approaches to trail hardening, aspects of visitor regulation, educative strategies, and policy on policing and enforcement (Newsome *et al.*, 2004). Joint management agreements between protected area managers and horse riders would also be part of this integrated management approach.

Conclusion

This review has synthesised and analysed horse riding research to date, with the central intention being to better inform the current debate regarding horse

riding in protected areas. Despite the site-specific nature of most studies, there is sufficient evidence and insight gained from this research to conclude that horse riding is potentially a high impact activity. Nevertheless, many impacts can be contained given appropriate user and management actions. Successful management depends, however, on an understanding of impacts. For many Australian ecosystems, such as tropical rain forest ecosystems and non-coastal heathlands, this understanding does not exist. As such, research in a number of ecosystems is a logical progression. Such research will also improve the generalisability of the associated findings.

There is also an insufficient emphasis, in a number of previous studies, on robust experimental design. In future experimental work, which has and should continue to be both off and on-trail, robustness could be enhanced by ensuring there are sufficient replications to cover the variability of the ecosystems being studied. In the quasi-experimental work, which has generally been confined to trails, having control trail segments as well as those exposed to only one treatment (e.g. horses or hikers but not both), would greatly assist in determining causality. Trail research urgently needs to separate the effects of different users, given the problems with multiple use trail research where the causal factors (i.e. are the impacts due to horses, hikers or some combination?) are impossible to separate. How trails influence the spread of pathogens and weeds is also an important focus for future research.

Although horse riding research has explored the preferences of this user group for different management strategies, there has been little concerted research into the effectiveness of management strategies. Such research is essential to determine whether management resources are being used wisely and to make longer-term decisions about whether horse riding in protected areas is environmentally sustainable. Table 2 provides management actions, which can in turn be researched, whereas Table 3 lists the variables available for monitoring effectiveness. In particular, the enthusiasm by horse riders for codes of conduct would benefit from research to determine if such codes are effective in reducing impacts.

Lastly, in terms of future research needs, a final gap warrants mentioning. Most visitor research includes an interest in visitor characteristics (Newsome *et al.*, 2002a). Generally included are visitor demographics (e.g. age and gender), place of origin, and group characteristics (e.g. size and type for example). One or more of these characteristics often influences the type and extent of impacts and preferences for management (Newsome *et al.*, 2002a). For example, there may be a relationship between group size and the extent of impacts, or between gender or age and management preferences. Apart from the work of Beeton (1999a, 1999b) in eastern Australia and that of Watson *et al.* (1994) in the United States, previous research has paid limited attention to the importance of visitor characteristics. Knowing these relationships could then help managers manage in ways that are effective as well as socially acceptable.

This review paves the way for further research and marks an important step forward in addressing the 'horse riding access controversy' for researchers, managers and horse riders themselves. It helps address the controversy by clarifying that horse riding is a potentially high impact activity, with present research providing a reasonable basis on which to make this judgment.

Limitations in this research, however, mean that further attention is essential, as well as a commitment to management. A critical element is determining the effectiveness of management actions, given that the high impact nature of horse riding is going to necessitate active management intervention. Such intervention will be expensive either in terms of resource through having to construct and maintain bridle trails and associated engineering works, or politically, through having to exclude horse riders from some areas and redirect them to others. Both expenses warrant monitoring to ensure that money and managers' time is being spent wisely and the desired outcomes being achieved. No matter what the associated value judgments, horse riding is one of a number of uses of protected areas and, as such, demands the research and management attention that will enable its continuation over time with minimal impacts to the protected areas on which it depends.

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