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Environmental Impacts Associated with Recreational Horse-riding

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Introduction

This chapter provides a state of knowledge review of some of the most recent research concerned with the environmental impacts of horse-riding. Our perspective is derived from studies carried out in the USA and Australia, but the results and conclusions derived from this work are applicable in the global situation. The focus is largely on trail examples from the USA but also considers the case of free range riding in Australia. We provide the context of horse-riding as a recreational activity and summarize the spectrum of impacts brought about by recreational horse-riding. This is followed by three case studies concerned with the assessment and measurement of impacts in important conservation areas. The case study from Yosemite National Park in the USA considers the associated impact of grazing effects, while the Big South Fork study, also from the USA, highlights impacts on trail networks. The final case study explores the quantifiable damage to soils and vegetation when horse-riding occurs in a random dispersed fashion off-trail networks. The final section of this chapter provides insight into three different management situations. The first relates to reducing impacts at campsites used by horse-riders in the USA, the second management perspective, also from the USA, explores the management of horse-riding in a multiple-use recreation area. The third management scenario examines the management of horse-riding in Australian protected areas.

Horse-riding as a Recreational Activity

Horses originally evolved to live in open environments in North America. Today wild equids can be found living on the grasslands and plains of Mongolia (Przewalski's horse), the Russian steppe (tarpan), and in the grasslands of Africa (zebra). The domestic horse (*Equus caballus caballus*) has been associated with humans for about 4000 years. Initially utilized for meat and their milk, domestication of horses also meant they could be used as draft animals. Once horses could be tamed and trained for riding, they became inextricably linked with humans and were used to carry people in armed conflict and as a means of travel to new lands. Recreational pursuits in the form of horse racing are recorded from the time of the ancient Greeks. Today horses are still used for a variety of purposes, but globally their role as a recreational animal is highly significant as indicated by the science, health aspects, business and retailing, printed matter, clubs and societies devoted to horses and associated activities. Furthermore, horses have also been introduced into a range of environments (e.g. forests) that are quite different from those in which they originally evolved (grasslands and open areas). These aspects raise three important points in relation to the recreation ecology of horse riding. First, horse-riding will continue to be a significant recreational activity in an increasingly crowded world with diminishing and increasingly impacted natural ecosystems. Secondly, horse-riding is seen by many as a legitimate activity in natural areas that are already under pressure from a variety of recreational interests that may be competing for the same space. Thirdly, protected areas are often poorly funded and frequently lacking in adequate management. This presents natural area managers with the difficult task of achieving conservation objectives in an atmosphere of increasing recreational pressures.

Horse-riding today is a major tourist/recreational activity and takes place in a wide spectrum of environmental situations and countries. Horse-riding tours and treks, for example, are widely marketed and available in Australia, New Zealand, Scotland, Spain, USA, Canada, Thailand and South Africa. Such tours are often combined with other activities such as camping and fishing. In addition to this, particularly in the USA, Europe and Australia, there are a large number of private individuals and horse-riding clubs (e.g. 1.3 million people engage in horse-riding activities each year in the UK), who seek to ride in natural areas such as local open spaces, nature reserves and national parks. In these areas horse-riders can utilize multipurpose trails, specifically designated horse trails that non-horse-riders may or may not use, and engage in cross-country riding where there is no designated pathway. Even though, in many cases, access is approved and available to horse-riders, conflicts continue to arise in two situations. The first concerns conflicts where other users, such as hikers and mountain-bike riders, object to impacts such as horse faeces on the track, the increased incidence of flies that are attracted to dung, and the sheer presence of large domestic animals in conservation reserves. Secondly, non-horse-riders also state that the erosion caused by horse-riding far exceeds any that is caused by other users, such as cyclists or hikers. Moreover, these assertions are supported by research (for example, see Dale and Weaver, 1974; Wilson and Seney, 1994; Deluca *et al.*, 1998). The fact that horse-riders (lobby groups and commercial operators) argue they also have the right to use reserved areas brings them into potential conflict with natural area resource managers over issues of restricted access to reserved areas, perceived environmental impacts and the fact that managers have to respond to complaints from non-horse-users.

Newsome *et al.* (2002) considered the experience horse-riders sought or operators marketed in the context of Australian national parks. The experience is advertised by many commercial horse-riding operations as an 'ecotourism experience'. Horse-riders wish to experience natural environments and enjoy working with the animals as they move through the landscape, but Newsome *et al.* (2002) questioned whether this really reflected ecotourism, where minimal impact is the key feature in entering and utilizing natural areas. In contrast to a dominantly environmentally sensitive approach, the image portrayed in many horse-riding operations is more of a historical pioneering concept. There is now irrefutable evidence that horse-riding is an environmentally damaging activity (e.g. Widner and Marion, 1993; Phillips and Newsome, 2002). It also appears that in many cases horse-riders are indifferent to or unaware of their effects on the environment (UK CEED, 2000; D. Newsome, personal observation).

In the USA, horse-riding has been an important recreational activity for more than a century. At one time, packstock (primarily horses and mules) were the primary mode of transportation in large wild lands (e.g. wilderness areas and the backcountry of national parks). Packstock were such a traditional part of wilderness recreation that Leopold (1921) defined wilderness as lands large enough to absorb a 2-week packstock trip. Similarly, when Sumner (1942) first introduced the carrying capacity concept (referred to as the recreation saturation point) he was commenting on concerns about excessive packstock use in California's Sierra Nevada. Packstock use of wilderness lands probably exceeded backpacker use until sometime in the 1960s (McClaran and Cole, 1993). However, the proportionate increase in backpacker use results more from increased backpacking than from decreased use of packstock. McClaran and

Cole (1993) estimated that about 11% of wilderness use in the USA, in 1990, was by people with packstock.

In wildlands of the USA, some horse-riding involves people riding horses for the day. This use causes impacts to the trails and to any places where people stop and tie up their horses. Much more problematic, however, are the impacts that occur when riders take overnight trips. On such trips, riders bring along pack animals, to carry their gear, as well as the animals they ride on. In the past, some groups rode through the wilderness with more than 100 animals, and outfitters would sometimes leave their horses and mules in the backcountry for the entire summer. Today, most wilderness areas place limits on the maximum number of animals in one group. However, the most common limit, 25 animals (Cole, 2002), is suggestive of the magnitude of impact that a single group can still cause.

In addition to damage to trails, overnight stock use damages campsites and grazing areas (Cole, 1983). Horses are usually allowed to graze freely and they need to be confined for long periods. While grazing, they defoliate plants, urinate and defecate, and trample soils (McClaran and Cole, 1993). The soils of meadows, where forage is abundant, are frequently moist, making them particularly prone to trampling impact. They are often tied to trees, which results in loss of soil and damage to tree roots. Sometimes, they are tethered to a stake in the ground. Unless they are moved frequently, this can also be highly damaging. Less destructive – but still problematic – confinement techniques include tying stock to a rope tied between trees (a high line) and confining stock inside an electric fence.

Overview of Environmental Impacts

Horses have the potential to cause considerable damage to soils and vegetation (Table 5.1). While many of these impacts can also be caused by hikers, impacts caused by horses generally occur to a greater degree. Horse-riding impacts are quantitatively greater than those caused by walkers (e.g. see Liddle, 1997). There is also a qualitative difference, in the sense that certain types of impacts, such as grazing and confinement, are unique to horse-riding.

Of all the impacts that have been identified, the most common and widely recognized is the ground-level damage caused by horses' hooves. The main problem is the large force applied to the ground because the horse's weight is transferred to ground level on four relatively sharp points – the hooves. As the horse and rider move along a trail or across vegetation there is much potential for the activity to damage vegetation and soils, particularly in fragile plant communities.

Direct impacts on horse trails include damage to stable soil systems, in the form of displaced sediments and surficial soils. Horses' hooves dig into the surface, pushing particles across the surface. This is often associated with some form of compaction in clay soils, but predominantly manifests as displacement in sandy, weakly cohesive soils. As Wilson and Seney (1994) noted, a critical issue in bringing about erosion is the detachment of soil particles that can then be readily transported by water, especially on steep slopes. Figure 5.1 illustrates the way surficial soil is damaged by horses' hooves. The hoof incision has destabilized the surface, displacing soil to one end and forming a depression at the other. The displaced soil can be mobilized more easily because any organic layers are disrupted and/or surface crusts are broken, allowing rain-drop splash dispersion of soil particles to be more effective. Soil structure is also broken down, especially at the embedded end of the hoof print (Fig. 5.1). In fine-grained and organic soils, such depressions can fill with water and can become quagmires with frequent horse use. On sloping ground and in wet climates the displaced soil is readily mobilized and can be transported downhill. Such processes can lead to deepening of trails and trail proliferation as users seek to avoid wet and/or deeply incised segments of trail.

Such trail degradation also constitutes a social and potential ecological impact. Other users find degraded trails unsightly and not in keeping with the overall concept of natural area integrity. Other users of such degraded trails may exacerbate the situation by developing parallel informal trails in order to avoid unsafe, deeply incised or boggy segments. Widespread erosion problems may undermine the soil-rooting zone

Table 5.1. Environmental impact of horse-riding in natural areas.

Activity	Recognized impacts: User conflict	Damage to soils and trail incision	Trail deepening	Erosion	Degradation of existing trail network	Development of multiple informal trail networks	Loss of vegetation height and cover	Browsing of shrubs and grazing	Seed dispersal of introduced species	Transport of fungal pathogens	Change in plant species composition	Nutrient enrichment from faeces and urine scalds	Fouling of water holes	Collapse of wildlife burrows	Disturbance to wildlife
Multiple-use trails	✓	✓	✓	✓	✓**	✓	✓**	✓	✓	✓	✓□	✓			✓
Designated horse-riding trails		✓	✓	✓	✓**	✓	✓**	✓	✓	✓	✓□	✓			✓
Cross-country riding (no designated pathway)	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
Horse party camping and tethering sites	✓*			✓			✓	✓	✓		□	✓	✓		✓

* If also used by other recreationists; ** if horses stray off trails; □ weed communities often well established.

of nearby vegetation, causing localized loss of individual plants and an extension of the erosion problem, as the protective function of plant cover continues to be lost. The extent to which all of this occurs is somewhat dependent on the intensity and frequency of use, although even low levels of usage can cause significant damage (Phillips and Newsome, 2002). Clearly, if large numbers of horse-riders utilize a wide area there is a greater degree of biophysical impact and area at risk of being impacted. However, the level of damage is also dependent on the nature of soils, slope, climate, relative sensitivity of the vegetation and the effectiveness of any management that may be in place. Horse-riding that takes place on erodible soils in steeply sloping terrain in the absence of management constitutes a major impact risk.

Ecosystem-level impacts can especially occur when there is widespread damage to vegetation as a result of trampling or the accidental spread of introduced organisms. Plant damage should not be a feature on designated trail systems except where trail proliferation has occurred in response to trail degradation, or where horses are allowed to stray off the trail. Loss of vegetation height and cover readily occurs where horse-riding occurs off designated pathways (Weaver and Dale, 1978; Cole and Spildie, 1998; Newsome *et al.*, 2002). Vegetation is particularly at risk where upright and shrub forms readily snap in response to trampling. This, in combination with slow-growing species/plant communities that are adapted to coping with natural limiting factors such as aridity, low temperatures and nutrient poverty, means that the vegetation is likely to have a long recovery time and may even continue to die after the initial impact has occurred (Whinam and Comfort, 1996; Whinam and Chilcott, 1999; Newsome *et al.*, 2002; Phillips and Newsome, 2002).

Local-scale impacts can evolve into larger scale impacts as a result of widespread erosion,

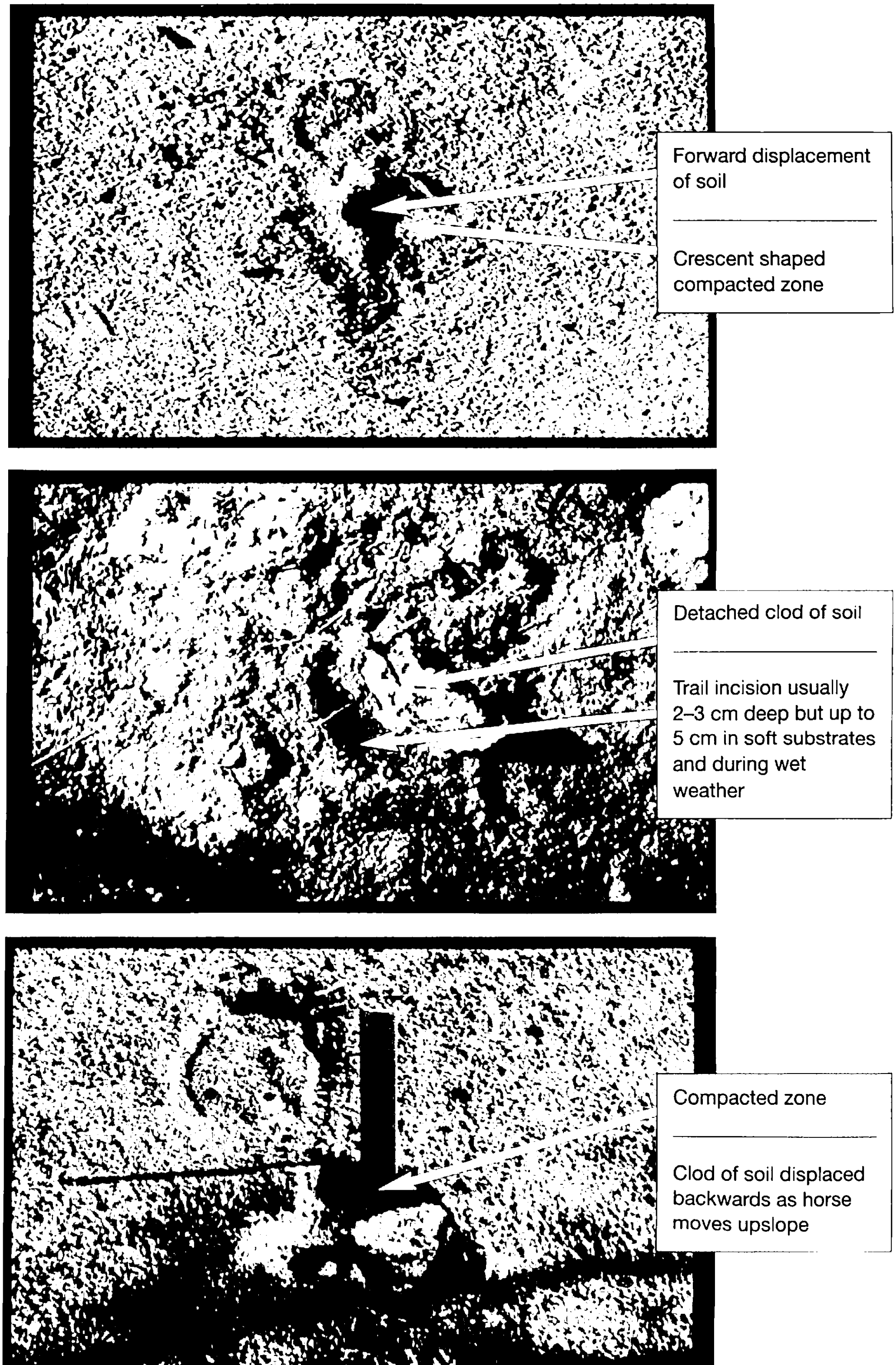

Fig. 5.1. Hoof imprints on a multiple-use trail following a single horse pass in John Forrest National Park, Western Australia.

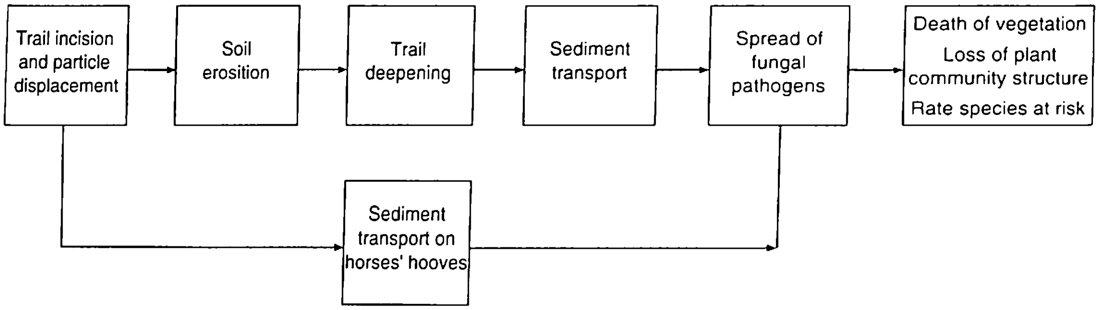

Fig. 5.2. Direct, indirect and potential extended biophysical impacts of horse-riding in Australian ecosystems.

weed invasion and the introduction of fungal pathogens. For example, Fig. 5.2 illustrates how pathogenic organisms may be translocated from an infected area to what was a disease-free area. This is a pertinent issue in Western Australia, where the accidental transport of fungal pathogens poses a serious risk to biodiversity (Newsome, 2003). Because horses disturb soil, particles can be readily transferred from place to place on their hooves. The presence of horses in conservation areas that are at risk because of existing infection by exotic organisms thus poses a major risk of exacerbating the problem and/or spreading the problem from one site to another. Soil erosion on horse trails can therefore bring about wider and extended impacts if soil is moved from one site to another.

Assessing and Measuring the Environmental Impacts of Horse-riding

Grazing impacts to subalpine meadows in Yosemite National Park, USA

The lack of empirical information regarding the effects of grazing by recreational packstock on remote meadows in wilderness and national parks was the motivation for a study of grazing impacts in Yosemite National Park (Cole *et al.*, 2004). Three different meadow types were studied: (i) a high elevation (3100 m), xeric shorthair sedge (*Carex filifolia*) meadow; (ii) a somewhat mesic shorthair reedgrass (*Calamagrostis breweri*) meadow (2600 m); and (iii) a more mesic tufted hairgrass (*Deschampsia cespitosa*) meadow (2285 m). None of the specific meadows that were studied had been grazed in the past century.

In each of the three meadows, horses and mules were allowed to graze at specified intensities each year for four successive years. The intention was to have four replicate blocks of four grazing intensities (0, 25, 50 and 75% forage removal) in each meadow. This was accomplished by tethering animals to a stake, using a 4-m-long rope, for as long as was required to remove the target level of forage. This produced ~50 m^2 grazing plots, which were monitored before and after grazing for each of the 4 years of grazing, as well as 1 year after the final grazing treatment (Fig. 5.3).

As described in Moore *et al.* (2000), grazing at these intensities caused substantial changes in meadow conditions. In all three meadows, meadow productivity (vegetation biomass 1 year after grazing) was reduced significantly after the second season of grazing. Other changes apparent in all meadows after two seasons were increases in basal cover of bare soil and changes in species composition. Basal vegetation cover declined in one meadow, but not the others.

The most consistent and predictable impact of grazing was the reduction in meadow productivity. In the shorthair sedge meadow, for example, our data fit the regression equation $Y = 16 + 0.0075X + 0.02X^2$, where X is the percentage of biomass removed by grazing and Y is the percentage decline in productivity ($r^2 =$ 0.68). Based on this type of data, managers can establish grazing intensities that are likely to

Fig. 5.3. Researchers taking field measurements on grazed plots in the shorthair reedgrass meadow, Tuolumne Meadows, Yosemite National Park, USA.

avoid unacceptable impacts on meadow productivity. In the three meadows we studied, if a limit of 10% decline in productivity is established, maximum permissible levels of forage removal range from 17% in the tufted hairgrass meadow to 36% in the shorthair sedge meadow. A common rule of thumb for grassland vegetation is to leave 50% of the biomass at the end of the grazing season. Our data suggest that this level of defoliation would result in a loss of productivity on the order of 25–30% in these meadow types.

Much less consistent and predictable were changes in species composition. Although differences in species composition between grazed plots and control plots increased with each successive season of grazing, ordinations suggest that the magnitude of shift in composition due to grazing was minor. Using canonical correspondence analysis, plots and species were ordinated such that the first axis of the ordination was constrained to reflect grazing intensity (percentage utilization). Eigenvalues for the first axis indicate that, after 4 years of grazing, grazing intensity explains only 6–10% of the variation in species composition between plots. Eigenvalues for the second axis, not constrained to reflect grazing intensity, are three to five times as great. The ordination of plots and species (Fig. 5.4) shows little variation between plots, no consistent distinction between control plots and plots grazed at different intensities, and little influence of grazing intensity on composition.

In detrended correspondence analysis, axes are not directly constrained to reflect grazing intensity. We did multiple regression analyses using first- and second-axis detrended correspondence analysis (DCA) scores as the dependent variable and percentage utilization, seasons grazed and dummy variables for replicate blocks as independent variables. In all meadows, the influence of grazing intensity was minimal, with replicate block usually being the primary influence on species composition. Plot ordinations typically showed plots clustered by replicate block rather than treatment. Together, these analyses suggest that species compositional changes due to grazing, although measurable, were less substantial than compositional differences between replicate blocks that existed prior to grazing.

Given that species compositional change was small in magnitude, it is not surprising that effects of grazing on species diversity measures (species richness, Shannon's evenness and Shannon's diversity) were generally small and inconsistent. In all three meadows, variation

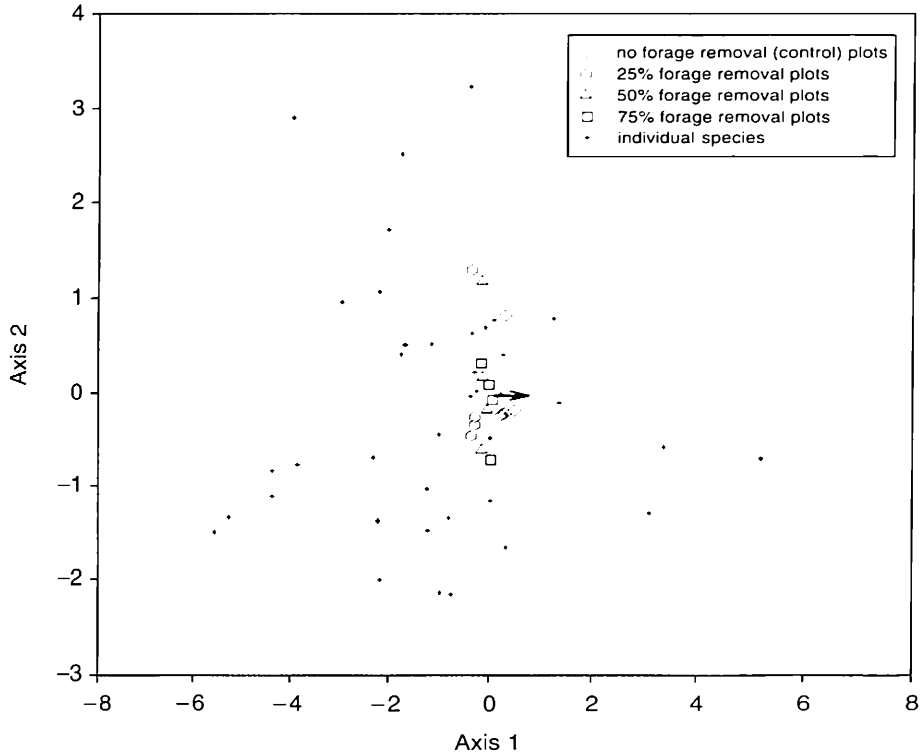

Fig. 5.4. Ordination of plots and species, using canonical correspondence analysis, after 4 years of grazing. The degree to which plots cluster in locations divergent from other treatments, and the length of the arrow (located at the centre of the ordination) along Axis 1 are indicative of the influence of grazing intensity on species composition. (After Cole *et al.*, 2004.)

between years in mean number of vascular plant species per 1.25 m^2 sample was virtually identical on grazed and control plots. Grazing reduced the relative cover of graminoids in all three meadows, but differences were statistically significant only in the shorthair reedgrass meadow. No other growth forms differed significantly between grazed and ungrazed plots.

This case study illustrates the difficulties of conducting research on the impacts of grazing. Environmental heterogeneity, variation in the behaviour of grazing animals, the lag time between cause and effect and the need to assess long-term effects, all conspire to reduce the precision of attempts to estimate the likely effects of specific levels of grazing. Nevertheless, this research clearly shows that even modest levels of grazing can cause substantial impacts to meadows intended for preservation. Moreover, these data provide a first approximation of the likely effects of specific grazing intensities. It also suggests that monitoring of productivity (biomass) may be more effective than monitoring species composition.

Assessing and monitoring the impacts of horse use in a multiple-use recreation area: Big South Fork, USA

The Big South Fork National River and Recreation Area is a US National Park Service unit encompassing 50,588 ha in northern Tennessee and southern Kentucky. The area consists of upland plateaux separated by cliff lines from deeply cut river and stream drainages. Big South Fork (BSF) receives nearly 900,000 visitors annually, with trail-related activities accounting for a large portion of total use. The area has 365 km of trails and primitive roads that have become popular among horseback riders, although off-road/all-terrain vehicle (ORV/ATV) use and hiking are also common recreational activities. Preparation of a road and trail management plan prompted research to develop and apply trail impact assessment and monitoring methods, which are considered here.

Many of Big South Fork's trails are multiple use, including many that receive heavy horse traffic and/or motorized uses. Resource impacts associated with these activities are substantial on some trails, few of which have received adequate management work, due to limited agency budgets and staffing. Trail system impacts are further aggravated by: (i) highly erodible soils and steep terrain; (ii) improper construction and maintenance; (iii) inappropriate stream crossings; (iv) high use by horseback riders and motorized vehicles; and (v) improper location (e.g. steep grades or floodplain settings). Lack of information regarding horse-trail use and impact, and the identification and management of sustainable horse trails, prompted managers to issue a moratorium on new horse-trail construction. This research sought to provide essential information for planning and management decision-making purposes by: (i) identifying and characterizing current resource impacts through development of trail-monitoring procedures; (ii) collecting baseline data from a random sample of Big South Fork trails; and (iii) conducting relational analyses to evaluate the role and influence of causal and non-causal factors to inform the selection of effective management interventions.

The park's Geographic Information System included a database for roads and trails. Improved roads and graded gravel roads were removed from the sample population, along with some gravelled 4-wheel drive roads not considered part of the recreational trail system. Longer trails were subdivided into 9.5 km segments to avoid undersampling. This process yielded a sample population of 365 km and 182 segments, from which a statistical randomizing procedure was used to select a 34% sample. This large sample (48 trail segments, 124 km) was necessary to ensure adequate representation of diverse use-related, environmental and managerial factors, and adequate documentation of baseline conditions for comparison with future monitoring. A knowledgeable park manager assigned percentage use estimates for each use type (horse, ATV and hiking) to each surveyed segment; segments with 75% or more use from a single-use type were categorized as representative of that type of use for analyses (including 91 km of trails).

Elements of two trail survey methodologies were integrated in developing monitoring procedures for the BSF. A point measurement method with a systematic sampling scheme at 152 m intervals, following a randomized start, was the primary method (Leung and Marion, 1999b; Marion and Leung, 2001). At each sample point, a transect was established perpendicular to the trail tread, with endpoints defined by visually pronounced changes in non-woody vegetation height (trampled versus untrampled), cover, composition, or, when vegetation cover is minimal or absent, by disturbance to organic litter. Representative photo sets were used to promote consistent judgement. The objective was to select boundaries that contain the majority (>95%) of traffic. Temporary stakes were placed at these boundaries and the distance between was measured as tread width. Maximum depth from a taut string, tied to the base of these stakes, to the trail surface was measured as maximum incision, an indicator of soil erosion (Farrell and Marion, 2002). Tread composition characteristics (e.g. vegetation cover, organic litter, soil, mud, rock) were defined to be mutually exclusive and assessed as a percentage of tread width.

A problem assessment method was integrated into the monitoring procedures to provide census information on specific trail-impact problems, including excessive erosion and muddiness (Leung and Marion, 1999c). Excessive erosion was defined as sections of tread (>3 m long) with tread incision exceeding 13 cm. Excessive muddiness was defined as sections of tread (>3 m long) with seasonal or permanently wet, muddy soils that show imbedded foot- or hoof prints (>1.3 cm deep). This approach provides data on the frequency, lineal extent of occurrence, and location of specific pre-defined problems, facilitating management efforts to rectify such impacts. A trail-measuring wheel was pushed along each trail to measure distance to each sampling point and beginning/ending distances of each trail problem.

Table 5.2. Big South Fork trail condition assessment data from the point sampling method.

Indicator	N	Mean	ANOVA statistic F	P
Tread width (cm)			273.2	0.000
Horse	276	208 (a)[1]		
Hiker	300	82 (b)		
ATV	29	238 (c)		
Max. incision (cm)			49.7	0.000
Horse	276	7.7 (a)		
Hiker	300	2.3 (b)		
ATV	29	9.7 (a)		
Muddiness (%)			15.6	0.000
Horse	276	9.3 (ac)		
Hiker	300	0.0 (b)		
ATV	29	2.6 (c)		

ATV, all-terrain vehicle.
[1] Means with the same letters are not statistically different; Duncan's test ($P<0.05$).

Table 5.3. Big South Fork trail condition assessment data from the problem assessment method.

Indicator	Occurrences (No.)	Occurrences (No./km)	Lineal distance (m)	Lineal distance (%)	Lineal distance (m/km)
Soil erosion					
Horse	232	4.8	3302	7	69
ATV	30	6.8	1039	24	236
Hiker	53	1.4	565	1	15
Muddiness					
Horse	203	4.2	3762	8	79
ATV	29	6.6	345	11	78
Hiker	15	0.4	234	1	6

ATV, all-terrain vehicle.

Representative monitoring data are presented in Tables 5.2 and 5.3 and Fig. 5.5, to illustrate the types of trail condition data yielded by the two survey methods. The point sampling method provides the most efficient, accurate and precise measures for monitoring trail characteristics that are continuous (e.g. tread width, incision and composition) (Marion and Leung, 2001). For example, Table 5.2 compares tread width, incision and muddiness measures taken at sampling points for horse, hiking and ATV trails. Horse trails were significantly wider (2.5×) and deeper (3.3×) than hiking trails, although ATV trails were in the poorest condition (Table 5.2). Muddiness was not a problem on hiking trails but, on average, 9.3% of horse-trail treads were muddy. An examination of tread compositions for the different trail use types (Fig. 5.5) reveals other substantial differences. Organic litter comprised an average of 61% of tread surfaces for hiking trails, reduced to 32% on ATV and 25% on horse trails. Gravel, applied on high-use horse trails to enhance their resistance, comprised 19% of horse trail tread substrates. Interestingly, hiking and horse trails had 5% vegetation cover but ATV trails had more than four times as much (Fig. 5.5). Field staff attributed this to the growth of vegetation between wheel ruts and to vegetative recovery occurring between the autumn, when most of the hunting-related ATV use occurs, and early summer, when fieldwork was conducted. These data may also be used for comparing conditions among different trails, or for the same trail or group of trails over time.

A problem assessment method is a preferred method for characterizing uncommon characteristics (e.g. muddiness) and for documenting the frequency, lineal extent and location of specific trail-impact problems (Marion and Leung, 2001). Horse trails were intermediate in the number of occurrences of soil erosion (4.8/km) and lineal distance (69 m/km) but had the greatest lineal extent (3302 m), due to the larger sample size of horse trails (47.9 km) (Table 5.3). ATV trails were the most severely eroded, however, with 23 m/km of soil erosion exceeding 13 cm, 24% of their length. Similarly, horse trails were intermediate in the number of occurrences of excessive muddiness (4.2 per km) and lineal distance (79 m/km), though similar to that of ATV trails (78 m/km) (Table 5.3). Muddiness affected only 1% of hiker trails but was more prevalent on horse trails (8%) and ATV trails (11%). These results are similar to those found in other studies (see Table 5.1 and Fig. 5.1), which have concluded that horse impacts to trails are similar to, but more pronounced than, hiking impacts (Nagy and Scotter, 1974; Weaver and Dale, 1978; Cole, 2002; Newsome *et al.*, 2002).

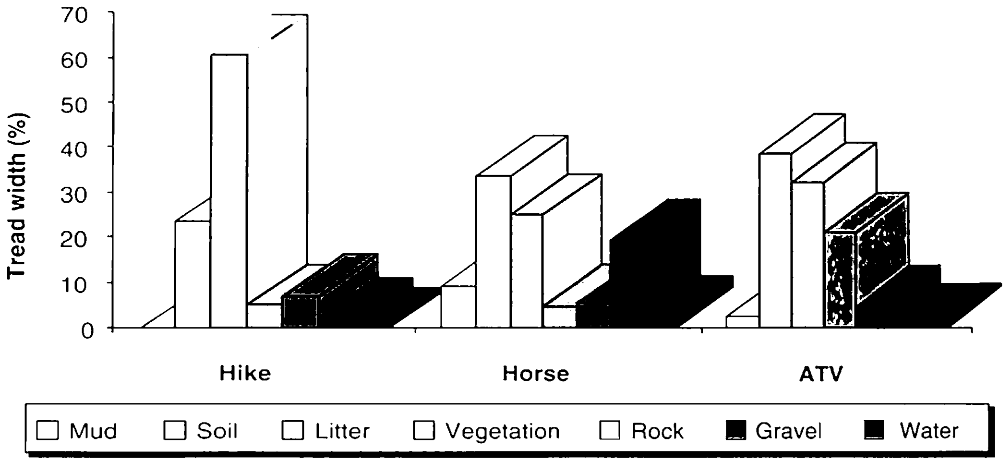

Fig. 5.5. Tread composition for Big South Fork hiking, horse and all-terrain vehicle (ATV) trials.

Quantifying horse-riding damage to soils and vegetation: D'Entrecasteaux National Park, Western Australia

D'Entrecasteaux National Park is situated on the southern coastline of south-west Western Australia. Soil-vegetation systems comprise various age fixed dune communities that contain a mosaic of vegetation types, ranging from heath and low sedgelands to woodlands and forests. At present, casual public horse-riding is prohibited in the park, but commercial horse-riding tours are allowed, according to a permit system that allows for riding on 'off-road' vehicle and designated bridle trails. In addition to this, free-range or off-track riding is allowed in designated areas where low, open vegetation occurs. Until recently there were no data on the nature and degree of damage to soils and vegetation as a result of horse-riding in the park or anywhere else in Western Australia. Experiments carried out by Phillips (2000) and Phillips and Newsome (2002) quantified horse-riding damage on transects under controlled conditions, and provided an important reference point from which to assess the nature of horse-riding impacts where horses ride in un-tracked areas.

The assessed parameters were soil micro-topography, penetrometry, species composition and extent of bare ground, vegetation cover and height of vegetation. Changes to all parameters occurred after only very low levels of horse trampling.

Figure 5.6 shows a typical cross-sectional profile of changes in soil surface condition following various intensities of horse trampling. In the most impacted central portion of the trample line, microtopography has decreased by 17.9 mm between 0 and 300 horse passes (Fig. 5.7). These changes demonstrate the capacity for soil disturbance. The same transect line also showed a decrease in soil penetration resistance from baseline condition, reflecting a dominance of soil loosening and particle detachment (Fig. 5.8). However, in most cases horse trampling, will result in soil displacement in association with some degree of soil compaction (see Fig. 5.1). This combined feature of horse damage to soils is evident in the data set provided by Phillips and Newsome (2002), where transect line DE1 shows a decrease in soil penetration resistance, contrasting with transect line DE3, which shows a progressive increase in soil compaction with increasing intensities of horse passes.

The changes in soil surface condition mentioned before are also reflected in a progressive increase in bare ground. Data collected from transect line DE2 show a baseline condition of 5.4% bare ground, increasing to 8.9% following 20 horse passes. This value increased to 25.6% after 300 passes. Changes in the relative frequency of various plant species are also evident, with the low-growing (<60 cm) shrub *Loxocarya cinerea* decreasing from 65.9% to 56.7%, and *Pimelea rosea* decreasing from

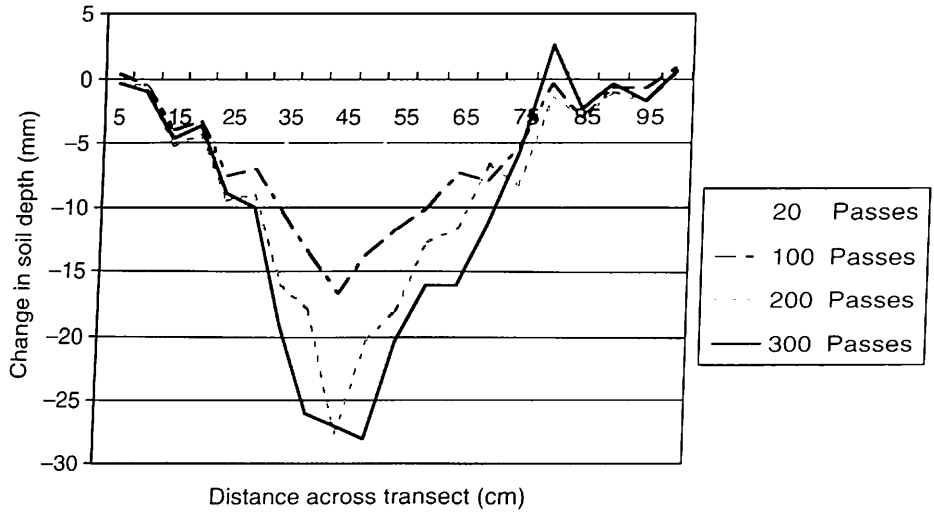

Fig. 5.6. The change in soil depth from the baseline microtopography across 5–100 cm of the cross-sectional profile of the treatment transects, after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

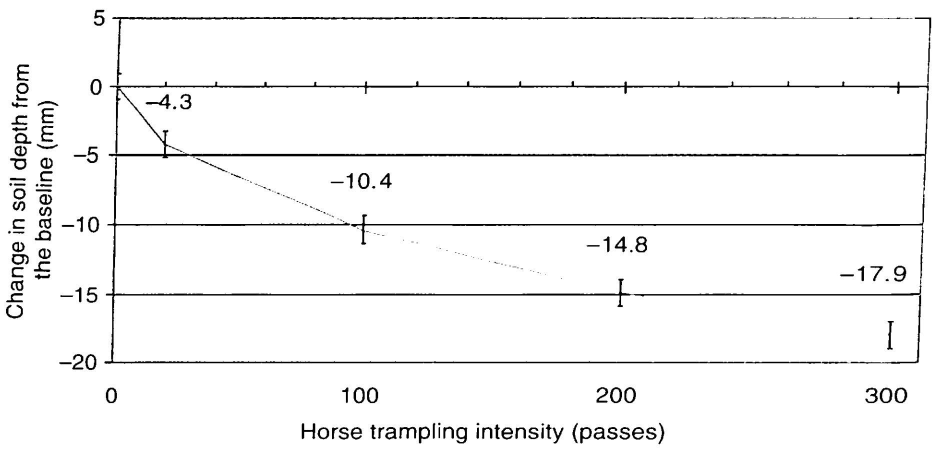

Fig. 5.7. The change in the soil depth from the baseline microtopography averaged across the central 30–75 cm of the cross-sectional profile of the treatment transects, after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

17.8% to 9%, following 300 horse passes (Fig. 5.9). The data clearly demonstrate the potential for change in species composition.

Figure 5.10 shows the corresponding loss in overlapping vegetation cover on transect DE2. Cover declined from 122% to 112% following 20 horse passes and was reduced to 56% following 300 passes (Fig. 5.11). Structural changes to vegetation are depicted in Fig. 5.12. The largest decrease in vegetation height, along the most impacted central portion of the trample line, occurred between 0 and 100 horse passes (Fig. 5.13). In comparing these data it is noteworthy that a tenfold increase in horse use decreased cover by about 50%, whereas a fivefold increase reduced vegetation height by about 50% (Figs 5.11 and 5.13), demonstrating that structure is rapidly altered and is a sensitive indicator of horse-riding damage to vegetation (Fig. 5.14).

The changes and damage to soils and vegetation described here are especially important

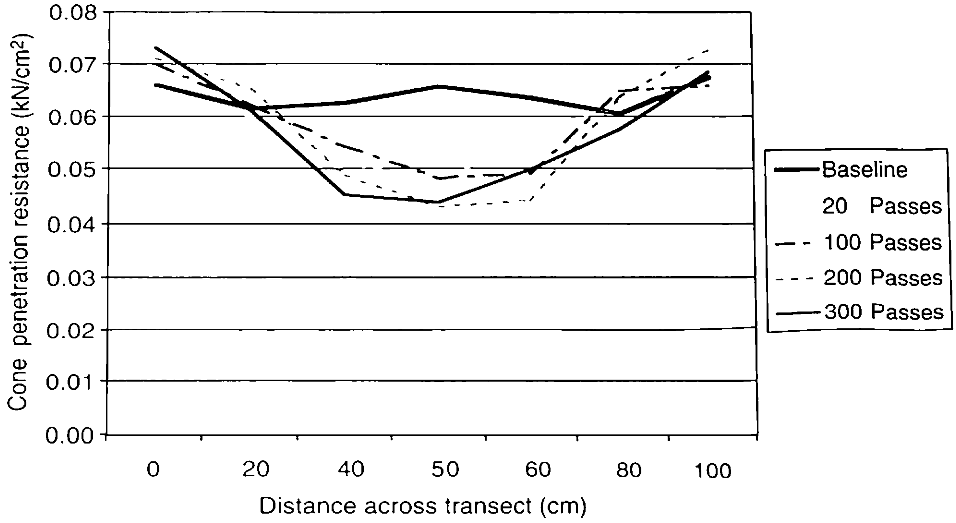

Fig. 5.8. Cone penetration resistance at a soil depth of 5 cm, measured across 5–100 cm of the cross-sectional profile of the treatment transects, after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

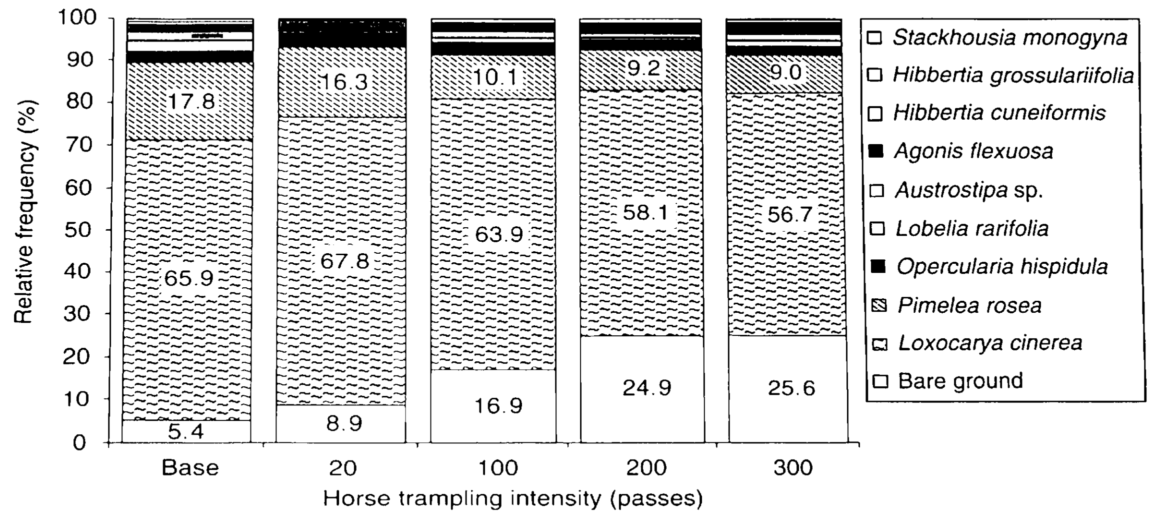

Fig. 5.9. Relative frequency of plant species and bare ground after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

in sensitive environments that exhibit slow recovery rates and low resilience, as in the case of arctic–alpine areas, many arid environments and in the nutrient-poor ecosystems of much of Australia. Moreover, soil movement both on and off designated tracks is a critical issue in those ecosystems that are vulnerable to plant disease and important as biodiversity hotspots, as in the case of Western Australia.

Managing the Environmental Impacts of Horse-riding in Natural Areas

North American perspectives 1: the case of a confinement strategy for reducing impacts at campsites

Cole (2002) provides an overview of the five primary strategies available for managing

Fig. 5.10. Percentage of overlapping vegetation cover across 5–100 cm of the cross-sectional profile of the treatment transects, after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

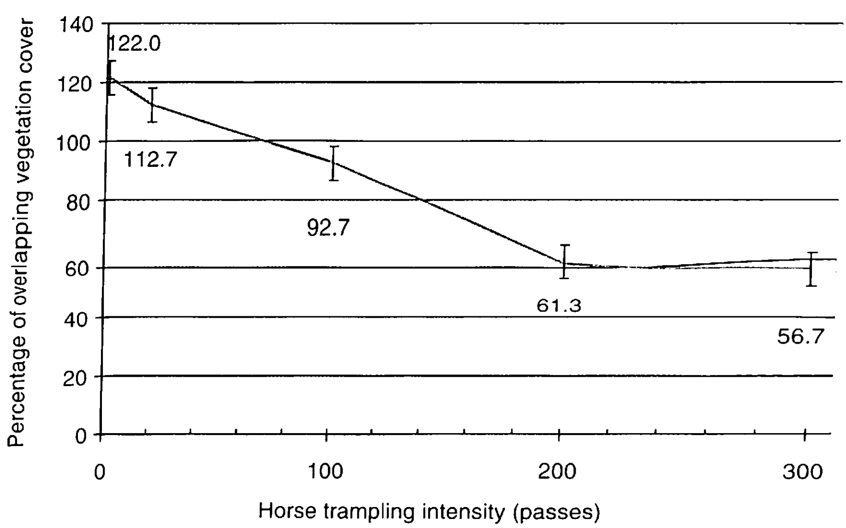

Fig. 5.11. Percentage of overlapping vegetation cover averaged across the central 30–75 cm of the cross-sectional profile of the treatment transects, after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

packstock impacts in wilderness areas and national parks in North America. Amount of use can be reduced, for example by prohibiting stock use or by closing overgrazed meadows. Behaviour can be changed, either through restrictions or low-impact education. Critical behaviours include group size, stock-confinement techniques, carrying feed, and steps to insure against the introduction of exotic species. The timing of use can be managed. It is often critical for horses to stay off trails and out of meadows shortly after snowmelt, when soils are water-saturated. Trail impacts, particularly, can be mitigated by hardening trails, such as

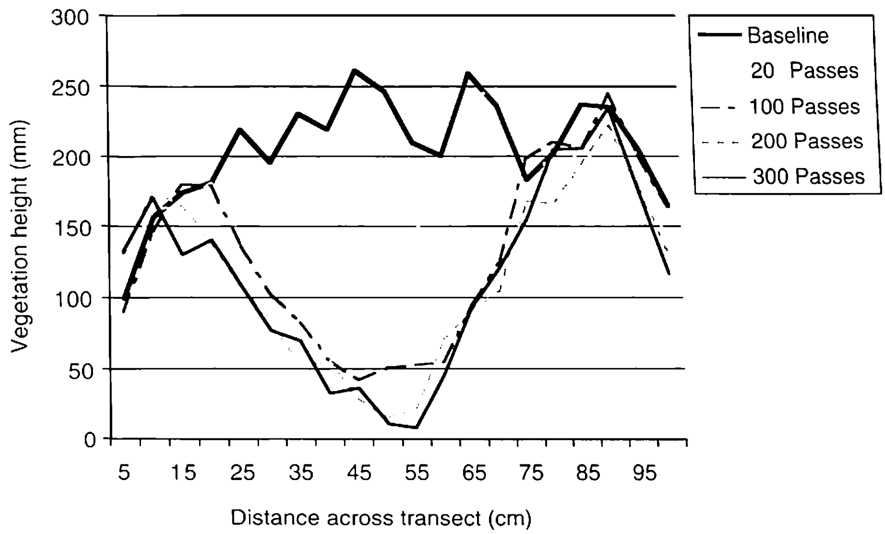

Fig. 5.12. Vegetation height across 5–100 cm of the cross-sectional profile of the treatment transects, after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

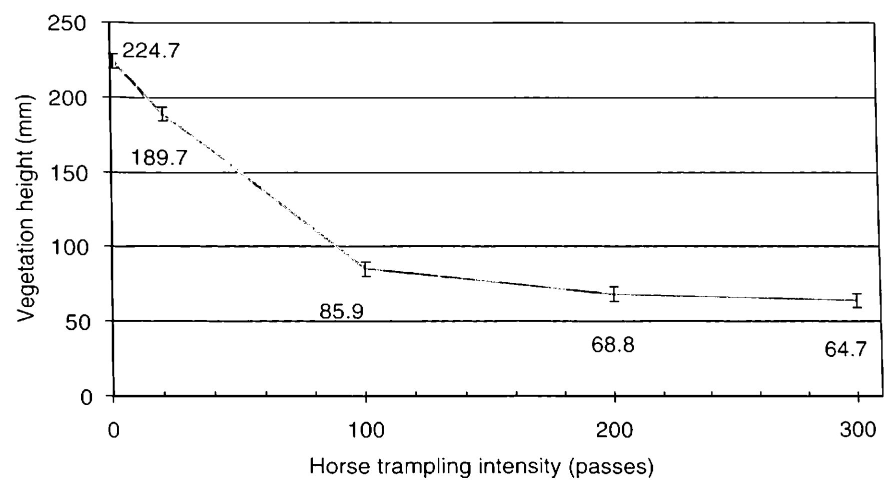

Fig. 5.13. Vegetation height averaged across the central 30–75 cm of the cross-sectional profile of the treatment transects, after various intensities of horse trampling. Transect DE2, D'Entrecasteaux National Park, Western Australia. (From Phillips, 2000.)

reinforcing the trail with log cribbing. Finally, impacts can be confined by only allowing stock use on certain trails and in certain locations.

Management generally involves balancing demand for access with the desire to avoid impairment of the natural environment sought out by ecotourists. Particularly where tourist activities have a high potential to cause impact, as is the case with horse-riding, confinement of activities is a highly effective way to minimize impacts without curtailing use. This management strategy has also been referred to as use concentration and use containment (Cole, 1981; Leung and Marion, 1999a; Marion and Farrell, 2002). A good example of the efficacy of this strategy is provided in the following case study of Seven Lakes basin in the Selway-Bitterroot Wilderness, USA, a destination area

Fig. 5.14. Experimental transect (DE1) in D'Entrecasteaux National Park, Western Australia, showing damage to vegetation following 200 horse passes. (From Phillips, 2000.)

in which there were excessive numbers of campsites, many of which were severely degraded by stock use (horses and mules). More detail on this case example can be found in Spildie *et al.* (2000).

The Seven Lakes basin (an area of about 500ha) contains 11 lakes and is located at an elevation of 1860–2000m. It can be accessed within 1 day but requires a climb of about 1000m in the last 10km of the 19km trail. Use levels in the basin are moderate. Records show that there are virtually never more than four other groups in the basin at one time. Monitoring showed that previous recreation use, particularly by groups with packstock, had left 26 substantially impacted campsites in the area. Associated with these campsites were 47 distinct stock-holding areas that had been damaged by tying horses and mules to trees, often overnight. Management objectives were to reduce campsite density by about 50%, eliminate most of the stock-holding areas and reduce the number of intensively impacted campsites, while leaving at least one campsite open for stock use at each of the major lakes.

These objectives were to be met by implementing the following management actions: (i) the designation of three day-use stock containment areas and six overnight stock containment areas, where stock were to be tethered between designated trees with a high line, rope or electric corral; (ii) the prohibition of stock containment on other campsites or other parts of designated campsites; and (iii) the prohibition of all camping on four campsites. Tying stock directly to trees or in places where tree roots can be damaged was prohibited. Stock numbers were limited to a maximum of ten animals per group. Regulations on where to camp and contain stock were communicated to the public on a brochure, signs on bulletin boards at the trailhead and at the entry point to the lake basin on all trails, in local newspapers and by frequent visits of wilderness rangers to the area. Compliance was enforced through special orders and heavy ranger presence.

Some trails in the basin were reconstructed; about 1 km of trail was re-routed, and another 1 km of trail was closed and rehabilitated. Two bridges were built. Forty-seven former stock-holding areas were closed to stock containment. These areas were generally adjacent to clumps of trees with roots and mineral soil exposed by decades of tying horses to trees. These 47 areas were on 12 campsites that were closed to stock use, six campsites that remained open to stock use and one former campsite where day-use containment only of stock was allowed. Designated high-line trees were signed at each of the six open stock campsites with a designated stock-holding area and the three day-use stock-holding areas. These campsites, where stock use was still allowed, were signed, as were four campsites that were closed to all use. Most closed areas were intensively restored. Seeds were collected, and about 2000 seedlings of three species were propagated in nurseries and packed up to the basin. Soils were scarified, organic matter was added to soils, and large rocks were used as 'icebergs' (placed to protrude from the ground, making the site undesirable for camping). Stumps were flush-cut and tree wells were filled with soil.

Pitch and charcoal were applied to trees to minimize evidence of tree scarring. Propagated seedlings, locally collected seed and local transplants were used to revegetate areas. Finally, some areas were covered with a mulching material. Campsite impact conditions were monitored over the period.

This work was largely accomplished, over a 5-year period, by two people who shared one seasonal wilderness ranger position. They were assisted by volunteer crews who provided a total of almost 4000 person hours of volunteer labour over the 5 years.

In its first 5 years, the Seven Lakes basin restoration programme was highly successful in reducing impacts associated with camping. Campsite densities decreased slightly. The magnitude of impact decreased on virtually all campsites and decreased greatly on many sites. In just 5 years, the total area of disturbance in the Seven Lakes basin decreased by 37%, from 3518 m^2 to 2205 m^2. Total bare area (places devoid of vegetation) decreased by 43%, from 1222 m^2 to 699 m^2. Disturbed area and bare area declined by at least 10% on 16 of the 26 campsites. Tree scarring declined, although primarily from masking scars with pitch and charcoal. Vegetation cover has increased and mineral soil exposure has decreased. Only root exposure has worsened. Moreover, if the management programme is continued, the greatest positive changes are still to come. Disturbed area and bare area are likely to decline in a few decades to just 36% and 24%, respectively, of what they were in 1993.

Most of these positive changes came from confining where camping could occur, particularly by groups with packstock. Improving conditions on former stock-holding areas have more than compensated for the increased impact on newly designated stock-holding areas. The closure of some campsites to all use and efforts to reduce the size of open campsites, through both closure and restoration of portions of large sites, have also been highly effective. Reductions in maximum group size have undoubtedly contributed to success. For these benefits to continue or increase in the future, the programmes need to remain in effect.

These management actions clearly reduce the original freedom that horse-riders had to go and to camp wherever they wanted. However, since there are no limits on amount of use, no lakes where camping is not allowed, and no groups excluded from visiting the basin, experiential costs seem minor. Fiscal costs of this programme are another matter. The 5-year costs exceeded US$135,000, although the Forest Service was able to reduce out-of-pocket costs by more than 50% by using volunteer groups extensively.

In conclusion, the Seven Lakes basin management programme illustrates that the confinement strategy can be highly effective, particularly with types of use that have high impact potential, such as stock groups. It also illustrates the need to prevent problems in the first place, rather than attempt to correct them after they have already occurred, particularly with the types of use that can cause substantial disturbance. It is important to anticipate where impact is likely to occur and to take effective, preventive actions, even if they need to be restrictive. Finally, in addition to being costly, restoring recreation impact will be a slow and never-ending process. At Seven Lakes, the management programme can now shift into a maintenance mode. However, in the maintenance mode, restrictions must be kept in force, and frequent ranger presence is still needed to obtain reasonable compliance. Given the minimal budgets for on-the-ground management, even the maintenance mode will stretch available resources.

North American perspectives 2: the horse-trail management experience at Big South Fork

The trail assessment and approaches to monitoring discussed earlier set the scene for the following comments relating to issues surrounding horse-trail management at Big South Fork. Historically, the application of gravel to replace or cap wet or eroding tread soils has been the primary management response at Big South Fork. Initial work along riparian trails that had become muddy quagmires employed full-size bulldozers and dump trucks to replace wet soils with up to 30 cm of gravel (up to 3 cm in diameter). Horseback riders complained about the use of these 'road-construction' techniques, particularly the excessive trail width and clearing of vegetation. The use of gravel also drew complaints, though after several years the gravel packed down and became less conspicuous and artificial in appearance. Vegetation growth has narrowed the treads, which have remained in excellent condition despite heavy horse traffic. Seasonal mowing, vegetation trimming and occasional grading are the only maintenance actions required on gravelled horse trails in flatter terrain.

The park maintenance division recently purchased narrower-gauge equipment for trail construction and maintenance work. Current horse-trail standards for high-use trails call for hard surfaced (gravel) treads 1.8–2.4 m wide, with water-bars constructed of a soil and gravel mixture. Vegetation clearing is 4.5 m wide by 3 m high. Standards for intermediate-use trails call for application of gravel only as needed for muddy or eroding sections. Tread width is 1.8–2.4 m wide, with earth water-bars and vegetation clearing as above.

The application of gravel on trails in sloping terrain has been less successful. Horses' hooves and water runoff during heavy rainstorms move gravel downslope, particularly on grades exceeding 8%. Efforts to apply larger gravel (4–7 cm) capped with finer gravel (up to 3 cm) have met with limited success. Horses' hooves and water move the finer material downslope, exposing the larger gravel. The size and angular edges of the large gravel are uncomfortable to horses. Grading work to move gravel back upslope or to reshape treads also mixed the gravels, bringing some of the larger material to the surface. Furthermore, the use of heavy equipment for such grading restricts the type of tread drainage features to tread outsloping, drainage dips and grade dips (reversed grades). Frequent grading has been required to maintain proper outsloping and drainage dips. Shorter sections of horse trails that descend steeply through gaps in the cliff line have required wooden structures filled with rock and gravel. These locations are often difficult to access and require shifting the gravel from large trucks, to smaller trucks, to motorized tracked wheelbarrows.

The numerous stream crossings throughout Big South Fork have been a particular management challenge. Wooden bridges have been constructed for stream crossings on the heaviest-use horse trails. Trail erosion into streams is a substantial and continuing problem within the park, which has inadequate funding to bridge every stream crossing. Most horse-trail bridges have planking along the edges to contain a bed of soil that covers the bridge deck. This is done to allow use by horses that shy away from travel across wood planking. Unfortunately water often drains to the bridges, contributing to tread muddiness and overflowing directly into streams during storms (Fig. 5.15).

In preparing the Road and Trail Management Plan, park staff have been re-evaluating all park roads and trails for their suitability to sustain horse use. Careful attention to the relative resource resistance of alternative routes, including trail grade, alignments and substrates, will avoid the inclusion of trails that would require substantial reconstruction or ongoing maintenance. Management emphasis will continue to rely primarily on tread-hardening techniques. Experimentation with geotextiles is just beginning, and managers expect their use will resolve problems in some of the worst locations, while reducing the need for large amounts of gravel in less accessible settings.

An Australian perspective

Landsberg *et al.* (2001) provide a useful overview of the issues surrounding the management of horse-riding in Australia. They note that where horses are allowed to stray off trails, or where horse-riding takes place on poorly maintained or constructed trails, or in steep and/or waterlogging prone environments, a high impact potential exists. The first part of any management system should therefore consider the risk potential for horse-riding damage. Conservation reserves and highly valued natural areas with at-risk environmental characteristics, such as steep slopes, high soil erosivity, poorly drained areas and those infected with readily transportable fungal pathogens, should not be available for horse-riding activities. In some areas, however, where horse-riding is already established because of tradition or precedent, prohibiting horse-riding may be dif-

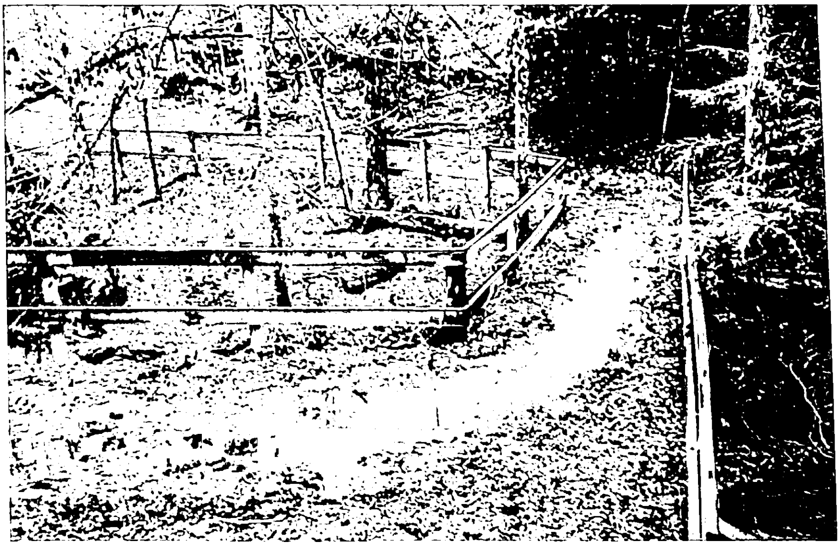

Fig. 5.15. Muddiness on a Big South Fork horse-trail bridge.

ficult to achieve. In relation to this, Landsberg *et al.* (2001) also raise the issue of equity in providing outdoor recreational opportunities. Indeed, it is worth noting that hiking and mountain-biking also pose a risk of environmental damage in susceptible environments, and raise the question that if horse-riding is prohibited, why not also prohibit other recreational activities. Restricting horse-riding, however, can be justified on the basis that the activity causes the greatest amount of impact.

Landsberg *et al.* (2001) have developed ten principles (Table 5.4) to guide the management of public horse-riding in a peri-urban nature reserve in eastern Australia. These principles provide a useful basis from which to develop management strategies elsewhere in Australia.

Newsome *et al.* (2002) explored various options for managing horse-riding in more remote locations, such as D'Entrecasteaux National Park in Western Australia. One important issue to arise from their work was the assertion that if a management strategy was in place, management capacity was often insufficient to police, enforce and monitor the situation. Moreover, interpretive material, public seminars, education and voluntary codes of conduct are ostensibly a good idea, but it only takes a small percentage of users to ignore them and significant impacts can occur.

Newsome *et al.* (2002) explored three management options in relation to the situation in D'Entrecasteaux National Park in Western Australia. Prohibiting use, although the most effective in eliminating impacts, was seen to be problematic, because national park policy provides for a spectrum of recreational opportunities and raised questions of equity and honouring traditional usage of the area. Despite this, Newsome *et al.* (2002) assert that national parks should not be opened up to any new horse-riding operations. They also viewed unrestricted open access in conservation reserves as unacceptable, due to the dispersed and possibly cumulative nature of impacts, especially where plant disease is present in vulnerable plant communities.

One of the most effective means of managing horse-riding in conservation areas would be to prohibit random, unsupervised public access and authorize access via licensed tour operators. Licensing and the allocation of permits provides incentives for the operator to reduce impacts, via controlling the numbers of users, adhering to guidelines and keeping horses to designated bridle trails. This, in conjunction with applying the principles developed by Landsberg *et al.* (2001), provides for a management framework in which horse-riding can occur alongside other recreational activities in conserved environments (Table 5.4).

Table 5.4. Principles to guide management of public horse-riding in a peri-urban nature reserve in Australia (according to Landsberg *et al.*, 2001).

1. Provide for recreational horse-riding only
2. No dogs allowed
3. Confine horse-riding to specific trails
4. Locate trails near perimeter of reserves and/or in modified zones
5. Construct and maintain trails to a standard (drained and hardened/stable surface of suitable width)
6. Exclude horse-riding from ecologically sensitive areas
7. Rationalize existing trail networks where horse-riding is currently allowed with a view to closing trails and developing alternative routes and/or construct trails to acceptable standard
8. Develop a code of conduct that fosters rider compliance to management system in place
9. Develop monitoring systems to measure rider compliance and impacts of horse-riding
10. Modify management programme if unacceptable impacts are detected

Conclusion

Recreational horse riding is a legitimate and important recreational activity. However, it is well established that the activity carries a high impact potential. The nature, extent and degree of impact are related to the intensity of usage. High-use situations, as in some parts of the USA, can result in high levels of campsite and trail degradation. Furthermore, differing environmental resilience may dictate that some parts of the world are more susceptible to ecological degradation that others. This is certainly the case where horse-riding occurs in fragile Australian ecosystems. In response to the need to predict and manage impacts, many recreation ecologists and natural resource managers are developing methods for assessing and monitoring horse-riding damage and activities. However, there is still scope for the development of a database on the relative sensitivity of different environments around the world to horse-riding damage.

Given the plethora of environmental impacts associated with horse-riding, natural-area managers need to assess existing activities and operations, and balance the activity with other recreational uses and wider conservation objectives. Because of the high impact potential, it needs to be emphasized to horse-riders that, for continued access, management is critical. Only with 'best practice' management should horse-riding be allowed in national parks and similar areas. With sustained horse traffic, management may have to include some or all aspects of the following: trail location and design; trail construction (drainage and erosion control); trail hardening, such as the use of gravel, geotextiles or geoblock; trail maintenance; visitor regulation (confinement, amount of use, timing of use); education (user behaviour, codes of conduct); policing and enforcement.

Both land managers and users must take this need seriously. In addition, a universally valid model for natural area planning, such as the Limits of Acceptable Change Planning Framework, needs to be applied in multi-use recreation areas, to help determine what sorts of impacts are acceptable and to guide monitoring of change and application of management actions. Horse-riding is likely to be deemed inappropriate where unacceptable impacts are occurring and where trails and sites need rehabilitation. Where significant conservation and biodiversity values are threatened, it might be necessary to prohibit horse-riding entirely.

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