EVALUATION OF IMPACTS AND METHODS FOR THE ASSESSMENT OF WALKING TRACKS IN PROTECTED AREAS

Wendy Hill and Catherine Pickering
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SUMMARY

Objectives

Protected area managers need to monitor the ecological effects of visitor use and assess their performance in managing visitor use. To assist this process, Sustainable Tourism Cooperative Research Centre (STCRC) has established a series of projects to develop indicators and protocols for monitoring visitor use and its impacts that can be used as part of an integrated monitoring system for protected areas. This is the third report in a series examining terrestrial ecological impacts of visitor use.

The aims of this report were to:

- briefly evaluate biophysical impacts of walking tracks in protected areas
- describe how evaluating the condition of walking tracks fits into an Integrated Framework for Developing Ecological Indicators of Visitor Impacts (Castley et al. 2007)
- evaluate the main methods and indicators used to assess condition of walking tracks including decision trees for selecting methods
- give examples of the use of different walking assessment methods and indicators in Australian protected areas
- show how examining walking track assessment contributes to effective visitor monitoring.

STCRC report series on terrestrial ecological impacts of visitor use

Castley, J.G., Hill, W. and Pickering, C.M., Hadwen, W. and Worboys, G. (2008) An Integrated Framework for Developing Ecological Indicators of Visitor Use of Protected Areas. Report for Sustainable Tourism Cooperative Research Centre. Griffith University, Gold Coast. This is a desktop evaluation of indicators of ecological impacts of visitor use in protected areas. Based on the evaluation a new framework for development of these indicators has been developed.


Hill, W. and Pickering, C. (In review a). Evaluation of Impacts and Methods for the Assessment of Walking Tracks in Protected Areas. Sustainable Tourism Cooperative Research Centre, STCRC Press, Gold Coast. Technical Report. This is a desktop evaluation of the ecological impacts of walking tracks in protected areas and the main approaches, methods and indicators used to assess their condition. Illustrates how specific indicators of visitor impacts can be developed within the integrated framework presented in Castley et al. (2008).

Hill, W. and Pickering, C. (In review b). Comparison of Condition Class, Track Problem Assessment and Point Sampling Methods in Assessing the Condition of Walking Tracks in New South Wales Protected Areas. Sustainable Tourism Cooperative Research Centre, STCRC Press, Gold Coast. Technical Report. Three common walking track assessment methods were field tested on tracks in three New South Wales protected areas. The methods differed both in resources required to use them and the detail and type of information obtained. This research report describes the outcome of this field testing including the strengths and limitations of each of the three methods.

Pickering, C.M. and Hill, W. (In review c) Walking Track Assessment Manual. Sustainable Tourism Cooperative Research Centre, STCRC Press, Gold Coast. User Manual. This final report consists of a manual describing how parks agency staff can select which track assessment method is most appropriate to use, and gives the practical hands on details of how to use the methods including data sheets etcetera.
EVALUATION OF IMPACTS AND METHODS FOR THE ASSESSMENT OF WALKING TRACKS IN PROTECTED AREAS

Methods
Walking tracks are a fundamental part of park infrastructure, providing recreation opportunities, access and resource protection by concentrating use. However, degradation of tracks is widespread and this is of concern both to managers and users. Chapter 1 provides a short review summarising the environmental impacts from the construction, maintenance and use of walking tracks in protected areas.

Chapter 2 shows how assessment of walking tracks is likely to be one of the most common components of an Integrated Framework for Developing Ecological Indicators of Visitor Impacts and gives an example of how the framework could be used to identify sites for monitoring (Castley et al. 2008). It also highlights the important differences between track inventories, track monitoring and scientific recreation ecology research.

Chapter 3 reviews current track assessment methods and associated ecological indicators. There are three common methods which are utilised for different management purposes. Each method has its own advantages and limitations. The three methods are:

- condition class surveys—which involve qualitative evaluation of continuous sections of tracks using methods that involve dividing tracks into generally uniform sections and assigning a pre-defined ‘condition class’ to each section based on extent of track degradation
- track problem surveys also involve qualitative evaluation of continuous sections of tracks but in more detail than is done for condition class. This method involves recording the location and length of sections of tracks on which predefined impact problems are occurring
- point sampling techniques—which are based on systematically locating transects along the track and quantitatively measuring selected impact indicators and associated environmental variables. Such techniques are repeatable and when used over time they can inform adaptive management decisions. Point sampling techniques can also demonstrate causal relationships between recreational use and impacts and are used by recreation ecologists.

Chapter 4 provides details of Australian examples of the use of these three methods to assess walking tracks clarifying their utility for either inventory or temporal monitoring.

Chapter 5 summarises the outcomes of this report, and makes recommendations for protected area managers. It also demonstrates how this report contributes to the overall research into ecological indicators of visitor use in protected areas.

Key Findings
- There are three main methods used to assess the condition of walking tracks: condition class surveys, track problem surveys and point sampling techniques. Each method has its own advantages and limitations and yields different data which are often utilised for different management purposes.
- There is confusion regarding when to use the different track assessment methods in terms of how the data obtained relates to the goals of management.
- Census techniques are qualitative evaluation of continuous sections of tracks. These methods can be used to survey the condition of a large number of tracks for inventory purposes.
- Track monitoring is the use of the standardised replicable measurement methods and indicators over time.
- Replicable measurement can be used to demonstrate causal relationships between impacts, environmental conditions and the type and amount of track use. This is called recreation ecology.
- Data from replicable measurement can be used for adaptive management by demonstrating the effectiveness (or lack of) of management actions over time.
Recommendations

Protected area managers should use the Integrated Framework for Developing Ecological Indicators for Visitor Use (Castley et al. 2008) to determine if they need to assess walking tracks as a component of a visitor monitoring programme. As part of this process they need to:

- determine the objectives and resources available to them for track assessment, and hence if they need to conduct an inventory or monitoring
- select which assessment methods they will use (condition class, track problem assessment or point sampling)
- implement an assessment protocol, analyse data and use findings as part of an adaptive management process.
Chapter 1

BIOPYSICAL IMPACTS OF RECREATION

History of Recreation Ecology Research

For over 50 years scientists have been studying biophysical impacts from the recreational use of protected areas—a field referred to as recreation ecology (Liddle 1997; Hammitt & Cole 1998; Leung & Marion 2000; Newsome et al. 2002). As a result there is an extensive literature in this area, much of which has directly improved the management of visitor impacts. Cole (2004b) states that over 1000 recreation ecology studies have been published, the majority of which have looked at the impacts of hiking and camping on vegetation and soils. Reviews on impacts on soil and vegetation have been published by Cole (1987, 2004b), Liddle (1997), Hammitt and Cole (1998), Leung and Marion (2000), Newsome et al. (2002) and Pickering and Hill (2007).

Early research focused on describing easily observable impacts of hiking and camping, particularly soil and vegetation loss and change. Less research has been done on impacts to water and wildlife. Subsequent research identified relationships between impacts and factors such as type of use (including horses and bikes), amount of use, and environmental factors. In the last decade considerable work has been done in the U.S. on developing standardised methods to assess and monitor impacts of hiking and camping in wilderness areas (Cole 1989; Cole 2004a; Marion et al. 2006).

In Australia, there are relatively few researchers comprehensively engaged in recreation ecology. Australian research has focused on impacts of trampling, camping and horse riding on vegetation and soils, impact of visitors on behaviour of animals, as well as impacts on aquatic ecosystems (Sun & Walsh 1998; Newsome et al. 2002; Buckley 2004, 2005; Hadwen et al. 2004, in press; Hill & Pickering 2008).

Research on Carrying Capacity

The concept of a carrying capacity for a protected area or a site within a protected area is a complex issue and consensus is by no means close. Resource managers need to be able to: (1) specify desired resource and social conditions; (2) define and quantify indicators and standards of quality; and finally (3) document and monitor severity and extent of impacts (Manning et al. 2006; Marion et al. 2006). While science has traditionally provided information that describes natural environments and explains cause and effect, there remains considerable controversy over the role of science in social value laden issues involving use of protected area resources (Cole 2004b).

The concept of a carrying capacity is now out of favour with many researchers as the conditions needed to establish it are not possible to achieve in the real world (McCool & Lime 2001). Rather managers need to be able to identify the acceptable conditions. Monitoring needs to be conducted within such as a framework of standards defining acceptable limits and conditions. However, in Australia and overseas the development of (1) standards for acceptable conditions and (2) long term monitoring programmes for recreation impacts are in early stages (McCool & Lime 2001; Cole 2004b; Hill & Pickering In review a).

Research on Hiking and Camping Impacts

Most studies of hiking and camping impacts have been conducted in wilderness areas of the U.S. but lately the area of interest has broadened with publications on hiking and camping impacts in tropical areas of Central and South America (Farrell & Marion 2001), Africa (Ouba & Harding 1997) and Australia (Sun & Liddle 1993a; Talbot et al. 2003), temperature areas of Australia (Smith & Newsome 2002; Mende & Newsome 2006); high altitude areas of New Zealand and Australia (Stewart & Cameron 1992; Whinam et al. 1994; Whinam & Chilcott 1999; Dixon et al. 2004), the sub-Antarctic (Scott & Kirkpatrick 1994) and the corals and intertribal areas of the Great Barrier Reef (Liddle & Kay 1987). The most common impacts to soil, vegetation, wildlife and water from the construction, maintenance and use of tracks are listed in Table 1.

Recreation impacts of hiking on vegetation and soil have been examined using a range of scientific methods. Analytical methods compare impacted and non-impacted sites while experimental techniques measure sites.
before, during and after simulated trampling or camping. Analytical studies assume that impacts are due to human disturbance while experimental studies test relationships between impact and type and amount of use (Liddle 1997; Marion et al. 2006). Analytical studies have documented differences in vegetation on walking track verges compared to adjacent natural plots. Changes include differences in species composition (increase in weeds and species resistant to trampling) and a reduction in biomass (e.g. Hill & Pickering 2008). Analytical studies have also documented the spread of weeds and pathogens from track verges into natural areas with tracks acting as effective vectors (Sun & Liddle 1993a; Sun & Walsh 1998).

Accepted sampling methods include permanent and temporary transects with quadrat sampling of track side vegetation and adjacent (control) vegetation established at a pre-defined distance from the track/verge. Long term vegetation monitoring requires quadrat locations to be permanently marked and geo-referenced using GPS (global positioning system). Within quadrats, plants are identified to species level where possible and assessed for cover to enable subsequent estimates of differences in relative cover and species richness. However, such vegetation sampling methods are time consuming and require plant identification expertise. Moreover they are site specific and results may not be broadly applicable (Cole 2004a; Marion et al. 2006).

There is an extensive body of experimental field work testing the resistance and resilience of various vegetation communities to trampling (e.g. Cole & Bayfield 1993; Cole 1995a, b, 2004a; Liddle 1997, Hill & Pickering 2008). Field experiments have examined impacts of trampling on plots of ground before and after various levels of pedestrian trampling (Cole & Bayfield 1993; Sun & Liddle 1993a, b; Cole 1995a, b, 2004a). One method involves determining the number of experimental trampling passes required to halve the vegetation cover on experimental plots (Liddle 1997). The types of impacts commonly measured are change in species composition, species richness, biomass, vegetation height and cover (Liddle 1997; Cole 1995a, b, 2004a). Experimental trampling trials show that proportionally more vegetation damage (reduction in vegetation height and cover) occurs at low levels of use and correspondingly, that as trampling intensity increases, rate of vegetation damage decreases (Cole 1995a, b, 2004a; Cole & Monz 2002).

Table 1 Common impacts of tracks, hiking and camping on natural ecosystems

<table>
<thead>
<tr>
<th>Soil</th>
<th>Vegetation</th>
<th>Wildlife</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Soil compaction</td>
<td>• Reduced height and vigour</td>
<td>• Habitat alteration</td>
<td>• Introduction of exotic species</td>
</tr>
<tr>
<td>• Loss of organic litter</td>
<td>• Loss of ground cover</td>
<td>• Loss of habitats</td>
<td>• Increased turbidity</td>
</tr>
<tr>
<td>• Loss of soil</td>
<td>• Loss of fragile species</td>
<td>• Introduction and spread of exotic animals</td>
<td>• Increased input of nutrients</td>
</tr>
<tr>
<td>• Reduction in moisture, microbial activity</td>
<td>• Loss of trees/shrubs</td>
<td>• Wildlife harassment</td>
<td>• Increased levels of pathogens</td>
</tr>
<tr>
<td></td>
<td>• Increase in resistant species</td>
<td>• Modification of wildlife behaviour</td>
<td>• Degraded water quality</td>
</tr>
<tr>
<td></td>
<td>• Introduction &amp; spread of exotic plant species (weeds)</td>
<td>• Displacement from food water shelter</td>
<td>• Reduced health of aquatic ecosystems</td>
</tr>
<tr>
<td></td>
<td>• Introduction &amp; spread of fungal pathogens</td>
<td>• Reduced health and fitness</td>
<td>• Compositional change</td>
</tr>
<tr>
<td></td>
<td>• Exposed roots</td>
<td>• Reduced reproduction</td>
<td>• Excessive algal growth</td>
</tr>
<tr>
<td></td>
<td>• Tree trunk damage</td>
<td>• Increased mortality</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Compositional change</td>
</tr>
</tbody>
</table>

Research on Walking Track Impacts

Walking tracks are a fundamental part of most park infrastructure, providing recreation and access, as well as resource protection by concentrating use. Walking tracks contribute to the sustainable visitor use of protected areas as they protect the environment by controlling erosion, damage to flora, fauna and ecosystems, damage to places of heritage and cultural importance, and reduce visual impact and social intrusion. They are among the most common types of infrastructure provided by park agencies. Although the area of tracks can be small, impacts can be locally severe, and often have larger scale ecological and social effects (Leung & Marion 2000; Monz 2000; Cole 2004a; Marion et al. 2006).

In areas accessible by road, engineered tracks are often provided with surfaces hardened with gravel and stone, cement pavers, bitumen or wooden planks (Cole & Wright 2003). In more remote areas, hardened tracks are neither appropriate nor feasible. In backcountry and wilderness areas there can be extensive systems of unhardened tracks; many of which have developed from former grazing trails or off road vehicle trails (Cole 2004a). The majority of tracks through wilderness areas of the U.S. were not specifically designed for heavy use and were not located in areas resistant to heavy use (Marion 2007). This may also be the case in Australia.

On well-constructed and maintained hardened walking tracks, impacts are limited to those from construction and maintenance. However, on unhardened tracks, overuse or poor design and maintenance can contribute to ongoing deterioration of the surface, which can vastly increase the area of impact beyond that from initial track construction (Cole 2004a). Cole and Wright (2003) state that in the U.S. wilderness areas, more money is spent on mitigating track impacts than on any other form of visitor impact (Dixon et al. 2004).

The deterioration of walking tracks is associated with four key issues for protected area managers (Cole 2004a; Marion et al. 2006):

- Deteriorating tracks can cause ongoing ecological damage to valuable and vulnerable protected habitats. In particular, soil erosion (track deepening), track widening and the proliferation of unplanned tracks can damage ecological integrity which affects the natural, social and economic values of the protected area.
- Mitigating impacts and rehabilitating degraded areas is expensive. For example, in the Tasmanian Wilderness more money is spent on track impacts than any other form of visitor impact (Dixon et al. 2004).
- There are safety issues arising from visitors using eroded muddy tracks.
- Degraded overused tracks reduce the quality of the visitor experience and thus reduce the tourism value of the protected area.

Data on track condition can be used to: (1) compile detailed track profiles; (2) identify track problems so that maintenance can be undertaken strategically; (3) determine trend in condition over time; and (4) demonstrate if management action and interventions were effective e.g. adaptive management (Leung & Marion 2000; Monz 2000; Cole 2004a).

Track erosion and widening

Erosion is the most important type of track degradation and may be ecologically irreversible once soil is removed off track and into adjacent areas where it can smother vegetation or enter water bodies where it can remain suspended or settle out and harm aquatic life (Liddle 1997; Jewell & Hammitt 2000; Cole 2004a). The resulting rutted tracks then intercept and transport greater volumes of water, accelerating soil erosion and altering natural patterns of water runoff. The loss of soil and organic litter and exposure of roots and rock can retard recovery of vegetation. On highly overused tracks on erodible soils or in wet areas so much soil is lost that the surface can be metres below the surrounding ground. Soil eroded from tracks can expose tree roots, creating a rutted and uneven walking surface with safety issues for users (Leung & Marion 2000).

Obtaining accurate and precise measures of soil erosion along tracks is challenging. Researchers have developed numerous methods including rapid qualitative estimates based on use of condition classes census techniques and replicable sampling methods based on quantitative measurements of maximum incision (track depth) post construction or current incision (Marion & Leung 2001). Intensive sampling techniques have also been developed that measure the cross sectional area of track ruts to estimate soil loss across path transects.
These methods detect subtle changes but are time consuming and only provide specific data on localised track conditions (Cole 1991; Monz 2000; Marion et al. 2006).

Track widening is another impact related to both overuse and environmental conditions—particularly rainfall and soil type. In wet conditions excessive muddiness forces users to spread laterally to avoid wet and muddy areas. This increases the width of the track through formation of multiple, braided or parallel tracks (Leung & Marion 2000; Marion 2007). To examine track widening, researchers measure several qualitative indicators of track width, including the width free of vegetation, width of vegetation visibly affected by trampling and/or erosion and width free of both vegetation and organic litter (Marion & Leung 2001; Dixon et al. 2004).

Unplanned tracks

A significant ecological impact of track use is the proliferation of user created trails as hikers go off track to access focal points or take shortcuts. This increases the spatial extent of existing track impacts. Trampling damage to natural vegetation occurs rapidly when users go off-track (Cole 2000, 2004a). Most impacts to soil and vegetation occur with initial low use and in sensitive vegetation types permanent track lines can develop rapidly (Cole & Bayfield 1993; Marion & Leung 2001).

Assessment techniques have been developed to document the extent of informal tracks that have developed along track systems (Marion et al. 2006). Aerial photographs have been used to assess this on a regional scale and this can be an efficient method if suitable coverage is available over a sufficient period of time (Hammitt & Cole 1998; Jewell & Hammitt 2000). This method has potentially significant limitations and when interpreting aerial photographs, the distinction between trampled, dying, dead or damaged vegetation and eroded segments is far from obvious. Furthermore, the financial commitment and high level of training necessary to interpret photos raises serious concern about its utility. However, in combination with other methods, aerial photography and global information systems may enhance the data that managers use to make track resource decisions (Jewell & Hammitt 2000).

Social impacts from deteriorated tracks

Deteriorated tracks have undesirable social consequences. For example, eroded and/or muddy tracks reduce the quality of the recreational experience through loss of visual appeal, increased evidence of human disturbance, perceived crowding and user conflicts (for example encounters between walkers and bike riders). Also, the functionality of the resource is decreased in increased travel difficulty and visitor safety problems (Leung & Marion 2000) (Table 2).

<table>
<thead>
<tr>
<th>Impact</th>
<th>Environmental</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Soil erosion</td>
<td>• Soil &amp; nutrient loss, water turbidity, alteration of water runoff</td>
<td>• Increased travel difficulty, reduction of visual appeal, safety</td>
</tr>
<tr>
<td>• Exposed roots</td>
<td>• Damage to trees/shrubs. Reduce vigour intolerance to drought</td>
<td>• Reduction of visual appeal, safety</td>
</tr>
<tr>
<td>• Unplanned tracks</td>
<td>• Vegetation loss, habitat fragmentation</td>
<td>• Evidence of human degradation, reduction of visual appeal, safety</td>
</tr>
<tr>
<td>• Increased/excessive width</td>
<td>• Vegetation loss, exposed soil</td>
<td>• Reduction of visual appeal, safety</td>
</tr>
<tr>
<td>• Wet soil</td>
<td>• Soil compaction, increased water runoff</td>
<td>• Increased travel difficulty, reduction of visual appeal, safety</td>
</tr>
<tr>
<td>• Running water</td>
<td>• Accelerated erosion</td>
<td>• Increased travel difficulty, reduction of visual appeal, safety</td>
</tr>
</tbody>
</table>

Source: Leung and Marion 2000
Factors affecting track degradation

Environmental factors
Models of the relationship between track degradation (e.g. width and erosion) and environmental factors that were thought to affect impacts have been developed and tested (e.g. Cole 2004a). Impacts are affected by season of use, vegetation type, rainfall and topography. Tracks that are fairly flat are susceptible to muddiness particularly if located in high rainfall areas, while tracks with slopes greater than 10 degrees have problems with erosion (Sun & Liddle 1993a, b; Bratton et al. 1979; Marion & Olive 2006). On steep slopes, water runoff is the main cause of track degradation but slippage of feet and the skidding of off road bicycle tires also contribute (Sun & Liddle 1993a). Track widening and braiding is greater on flat, wet surfaces (Calais & Kirkpatrick 1986). Impacts from all activities are often greater after rain when soils are saturated. Impacts on vegetation are often greatest early in the growing season when new vegetation is produced (Cole 1991).

Many studies have reported that environmental factors can be relatively more important than use levels. Erosion, for example appears to be more a function of slope and water flow, than use. Widening of tracks was recorded in studies of alpine tracks e.g. Calais and Kirkpatrick (1986) in Tasmania, and Bayfield (1979) in Scotland. Moreover, erosion continues even when track use has ceased (Calais & Kirkpatrick 1986).

Type and amount of use
Numerous studies have demonstrated non-linear relationships between use and impacts on soils and vegetation (Kuss 1986; Calais & Kirkpatrick 1986; Liddle 1997, Cole 2004a) with relatively more impacts occurring at low levels of use. Studies have also shown that impacts on unhardened tracks, particularly increased track width, increase with the level of use (Calais & Kirkpatrick 1986; Cole 1983). Track erosion, on the other hand, is less affected by use levels than by environmental factors—particularly slope, rainfall and soil type (Bratton et al. 1979; Kuss 1986). Calais and Kirkpatrick (1986) studied impacts on tracks in the Tasmanian Wilderness World Heritage Area and found width was related to vegetation type—with tracks being wider in low open vegetation and narrower in confined vegetation such as forests. This is because walkers will tend to spread out and widen tracks on sections where it is more difficult to walk on compared with the surrounding vegetation.

Not surprisingly, the type of use also affects impacts, with mountain bikes and horse riding causing more damage to vegetation and soil erosion than hiking. Horse riding was the most damaging activity, with soil erosion greatest on steep slopes and along stream banks (NPWS 2003) or when horses were descending down tracks (Wilson & Seney 2004).
Chapter 2

HOW ASSESSING WALKING TRACKS FITS INTO AN INTEGRATED FRAMEWORK FOR DEVELOPING ECOLOGICAL INDICATORS OF VISITOR USE OF PROTECTED AREAS

We developed a framework (and associated guidelines for its use) which integrates visitor impact monitoring and evaluation with the cycle of management for protected areas and produces feedback that enables managers to improve management (Castley et al. 2007). The integrated framework is linked to the expanded-WCPA management effectiveness evaluation framework (Worboys 2007) and uses, as far as possible, existing management processes for focusing monitoring effort and selecting ecological indicators.

Focusing monitoring effort is achieved through a process of prioritising natural assets used by visitors or likely to be affected by visitor use. The prioritisation is based on the value of natural assets, vulnerability of natural assets and the type and severity of visitor use.

The framework consists of six steps that demonstrate how ecological indicators for specific sites and activities relate to the overall management goals for the protected area, and how they should be used for adaptive management (Figure 1). To show how assessing walking tracks fits into this framework, a step by step guide including an example is shown here.

Step 1: Determine management objectives for the park and evaluation subject/s relevant to visitor impacts on natural values

It is necessary to identify management objectives relating to conservation and protection of natural assets and visitor use before implementing this framework. Objectives for the management of park types are usually set out in relevant State and Commonwealth legislation and are also stipulated in documents such as plans of management, State of Parks reporting and World Heritage reporting etcetera. The primary management objective of most national parks is to protect and conserve representative samples of flora, fauna and scenery and to conserve cultural heritage, with other areas reserved primarily for recreation and open space values. Management goals relating to walking tracks and their impacts include conserving natural values while providing for appropriate visitor use.

Step 2: Prioritise natural assets and threats to assets

In order to focus monitoring effort natural assets are prioritised for monitoring based on three characteristics: (1) the importance/value of assets, (2) the vulnerability of assets, (3) threats to assets from visitor use. For example where walking tracks occur in areas of high conservation value, the assets would be the areas with tracks, and threats would be those listed in section 1 that are associated with walking tracks.

Step 3: Prioritise assets used by visitors for assessment

Identify natural assets used and/or impacted by visitors. These assets will be a subset of all assets identified in step 2. From among those assets used and/or affected by visitors, prioritise assets for assessment. This will be based on the importance and fragility of assets and the types of visitor activities and the severity of impacts. Again, for walking tracks this might involve identifying if there are tracks in areas that are particularly vulnerable to the threats listed in section 1, or identifying tracks that have very high usage and hence may need to be upgraded. In the example, asset 1 may be a walking track through a sensitive wetlands area, and asset 2 may be a high use degraded track and asset 3 might be a track that was upgraded based on previous monitoring (Figure 2).
Step 4: Select ecological indicators of severity of the threat from visitor use for priority sites identified at step 3

Indicators are selected based on the particular characteristics of the asset as well as on type of visitor activity. In section 1 of this report we provided details on common impacts of walking tracks. For assets identified in step 3, identify if appropriate visitor impact monitoring is already occurring. If not, identify relevant indicators of change in condition of asset. Ecological indicators associated with walking tracks could be loss of vegetation cover (total width of track), exposure of roots, soil erosion (maximum depth of track), and area of bare ground (width of track with no vegetation). How these impacts could be monitored is outlined in chapters 3 and 4 of this report and in two other STCRC Technical Reports on Terrestrial Impacts of Tourism in Protected Areas (see summary section of this report page 9).

Step 5: Develop assessment programs for indicators

Assessing change in condition of assets as a result of visitor use is achieved by implementing ongoing temporal monitoring at a discrete natural asset or sites representing the asset being assessed. The following chapters outline what has been done overseas and in Australia in this regard. Further details of these methods are available in two other STCRC Technical Reports on Terrestrial Impacts of Tourism in Protected Areas (see summary section of this report page 9).

Step 6: Develop guidelines to mitigate impacts

Information on how to mitigate the impacts of visitors can be found in technical and management reports as well as in recent reviews of visitor impacts. For example, strategies to limit the soil erosion include reduced use of track, introduction of drainage features etcetera, diverting the track to a less sensitive area or upgrading the track to include sections of boardwalk over sensitive vegetation. An adaptive management approach is recommended allowing managers to assess changes in natural ecosystems and respond accordingly. This includes evaluating the success of previous management decisions such as for asset A in this example (Figure 2).
Figure 1 Integrated framework for developing ecological indicators of visitor impacts in protected areas

Key: The framework consists of 6 steps: (1) identifying management objectives and relevant evaluation subjects, (2) classifying natural assets and threats to those assets, (3) prioritising sites for visitor monitoring, (4) selecting ecological indicators of visitor impacts, (5) developing monitoring program for indicators and (6) using results to improve future management (adaptive management). Guidelines for Steps 1–6 are provided in following text.
Figure 2 Example of use of the integrated framework (Figure 1) for walking tracks
Chapter 3

ASSESSING THE CONDITION OF WALKING TRACKS

Protected area managers conduct track assessments for a number of reasons particularly for inventory and for temporal monitoring. The difference between track assessment and recreation ecology should be understood. Recreation ecology is a scientific methodology where the purpose is to clarify/demonstrate causal relationships between impacts, environmental conditions and the type and amount of track use. Relationships are summarised in Figure 3.

Figure 3 Schematic representation of the relationship between track assessment techniques, recreation ecology and management purpose
Track Assessment Approaches

A number of track assessment techniques and associated ecological impact indicators have been developed, principally by North American researchers. There is no single all purpose technique (Marion et al. 2006). Three common methods are condition class surveys, track problem surveys and point sampling methods. Each uses different techniques and indicators which yield different data which are often utilised for different management purposes (Figure 4). Each technique has its own advantages and limitations which are summarised in Table 3.

The three approaches are:
- census based survey techniques which involve qualitative evaluation of continuous sections of tracks. Two main census techniques are used—rapid condition class surveys and more thorough track problem surveys. Condition class surveys involve dividing tracks into generally uniform sections and assigning a pre-defined ‘condition class’ to each section
- track problem survey assessments which involve recording the location and length of sections of tracks on which predefined impact problems are occurring. Census techniques are used to inventory track systems but are not suitable for repeated temporal monitoring
- point sampling methods which are based on systematically locating transects along the track and quantitatively measuring selected impact indicators and associated environmental variables. Such techniques are repeatable and when used over time they can inform adaptive management decisions. Point sampling techniques can also demonstrate causal relationships between recreational use and impacts and are used by recreation ecologists (Leung & Marion 1999a, b, 2000; Marion & Leung 2001; Dixon et al. 2004; Marion et al. 2006).

**Condition class surveys**
In this census based technique, tracks are divided into relatively homogenous sections in terms of environmental conditions, and estimates are made for the percentage of each track subject to pre-defined categories of impact (also called condition class) by field staff who walk the entire track system (Marion et al. 2006).

**Indicators**
Condition class category descriptions are determined by disturbance of vegetation and litter, width of track, depth of soil erosion, presence of wet soil and running water, root exposure, and multiple tracks. For example, Bratton et al. (1979) estimated the proportions of entire track sections that were subject to various depths of erosion. Dixon et al. (2004) rated track sections for width, erosion depth and a number of other parameters. Nepal et al. (2003) assigned an aggregate assessment to each track section based on condition classes defined by Cole (1983).

**Advantages**
- techniques are relatively rapid and easy to use
- findings can be presented simply and clearly
- a comprehensive picture of track condition can be achieved
- can identify major change over time.
EVALUATION OF IMPACTS AND METHODS FOR THE ASSESSMENT OF WALKING TRACKS IN PROTECTED AREAS

Disadvantages

- data is ordinal
- defining condition class ratings is subjective
- judgments are required to distinguish between classes
- subtle change cannot be detected
- not an appropriate method for quantifying trend in condition over time i.e. different surveyors can have different views on severity of impact
- location and severity of track problems cannot be identified (Dixon et al. 2004; Marion et al. 2006; Mende & Newsome 2006).

Management objective

- compiling an inventory of track condition
- objective basis for assigning work priorities
- can be used to compile an inventory of large track systems in protected areas where field staff and financial resources are limited.

Track problem assessment

This is another census based technique which provides information on the location, frequency, extent and severity of selected track impacts including excessive erosion, width muddiness and root exposure and locations of informal tracks. This method is based on identifying and tallying the locations and lengths of track segments impacted by predefined track surface problems (such as excessive width, muddiness and erosion) by field staff hiking all or most of the selected track systems. Location and extent of maintenance factors can also be recorded. An estimate can be made of the effectiveness of drainage/maintenance features (Leung 1998; Leung & Marion 1999a, b; Marion et al. 2006).

Indicators

Excessive width, muddiness, water on track, erosion measured in 10 centimetre increments, root exposure, number and location of informal/unplanned tracks.

Advantages

- relatively rapid assessment of a trail system
- produces detailed information on the frequency, extent and distribution of problems
- provides a useful overview of the extent and frequency of predefined problems
- preferred for characteristics that are easily defined (e.g. excessive erosion) or are infrequent, particularly when information on location and lineal extent of specific problems is needed.

Disadvantages

- the problem census method requires subjective judgments in terms of where some impact problems begin and end (e.g. where excessive muddiness begins) (Mende & Newsome 2006)
- the problem census method does not provide information on average track conditions
- resource intensive for track sections that are heavily impacted or have extensive maintenance works (Leung 1998; Marion et al. 2006)
- different field staff will potentially show variation in determining beginning and end points of impacts.

Management objective

- compiling an inventory of track condition which records every occurrence of predefined track problems and track maintenance parameters over a track system or track sections
- can be the basis for ongoing monitoring as it provides detailed track profiles (Leung 1998; Leung & Marion 1999a)
- objective basis for assigning work priorities (Leung 1998)
- this procedure can be used for repeated assessment of the same tracks over time however different field staff will potentially show variation in determining beginning and end points of impacts.
EVALUATION OF IMPACTS AND METHODS FOR THE ASSESSMENT OF
WALKING TRACKS IN PROTECTED AREAS

Point Sampling
Sampling is based on measuring indicators of track condition at numerous points along tracks using either systematic sampling at fixed intervals or stratified sampling where environmental factors (vegetation type, slope and substrate) and use factors (amount and type of use) are accounted for in the sampling design. Sampling points can be permanent or non-permanent. Design and maintenance factors are also recorded (Leung 1998; Leung & Marion 1999a; Dixon et al. 2004; Marion et al. 2006).

Indicators
Three types of impact indicators are recorded: (1) soil erosion; (2) track width; and (3) informal/unplanned tracks. These provide useful estimates of system wide track condition. Soil erosion (track depth) is seen as a very important indicator of severity of track condition and can be estimated in a number of ways including maximum incision post construction, current maximum incision and cross-sectional area. Track width is measured as width of bare ground and width affected by trampling.

Advantages
- yields accurate and precise measurements of frequent track condition characteristics
- provides data on average/general conditions
- provides data on variability across particular areas
- provides data that is sensitive to change over time.

Disadvantages
- poor at estimating infrequent but potentially important impacts such as excessive width, braiding, or the number of informal tracks branching from main tracks
- there is no automatic need for permanent sites however if used for monitoring, time in marking sites and difficulties of relocation must be considered. Loss of precision occurs when sites/transect/points are not relocated however, this can be compensated for by measuring more points
- frequency of occurrence of track problems cannot be measured
- location of track problems is not recorded.

Management purpose
Point sampling techniques have been widely used, particularly in the U.S. as they allow for relatively rapid assessment of average track condition and estimates of spatial variation in track condition relative to environmental conditions (Cole 1991; Marion & Leung 2001; Dixon et al. 2004; Marion & Olive 2006; Marion 2007). Point sampling techniques are repeatable and when used over time they can inform adaptive management decisions. Point sampling should be used where monitoring trends in condition over time is required.

However, point sampling has limited use for inventory purposes as it provides data on average track conditions but does not provide information on the extent of specific degradation problems in relation to environmental variables and design and maintenance features.

Point sampling techniques can also demonstrate causal relationships between recreational use and impacts and are used by recreation ecologists (Leung & Marion 1999a, 2000; Marion & Leung 2001; Dixon et al. 2004; Marion & Olive 2006; Marion et al. 2006). The relationship between use related factors (type of and amount of use), environmental factors and impacts can be assessed based on data from this method. Data such as these can assist managers in understanding the track degradation process and identify factors that might be manipulated to facilitate sustainable use (Marion 2007).
### Table 3 Comparison of three track assessment approaches

<table>
<thead>
<tr>
<th>Assessment approach</th>
<th>Technique</th>
<th>Indicators</th>
<th>Advantages</th>
<th>Limitations</th>
<th>Management objective</th>
<th>Example of use in Australia</th>
</tr>
</thead>
</table>
| **Rapid Condition class survey** | Qualitative census assessment | Tracks divided into environmentally similar sections
Estimates made of % of track section subject to pre-defined categories of impact by surveyor who walks entire track system | Environmental & impact data for each track section are recorded in categorical form
A range of pre-defined impact/condition classes are described based on impacts such as: average width, maximum erosion, rate of deterioration & braiding | Rapid
Comprehensive picture of track condition
Can identify major change over time | Ordinal data
Cannot detect small changes
Not suitable for repeated surveys over time i.e. different surveyors can have different views on severity of impact | Inventory & survey
Objective basis for assigning work priorities | Used to compile an inventory of the 1000 km track system in the Tasmanian Wilderness World Heritage Area in the early 1990s over an eight year period (PWS 1994a,b) |
| **Track problem assessment** | Qualitative assessment | Continuous assessment of track problems & maintenance factors by surveyor who walks entire track system | Uses standardised indicators & protocols to identify location & extent of predefined unacceptable conditions such as erosion, water on track, multiple & parallel tracks | Provides detailed track profiles
Documents location & extent of specific track degradation problems in relation to environmental variables & design & maintenance features | Doesn’t generate qualitative data on width or erosion/incision
May not be accurate for repeated surveys over time i.e. different surveyors can have different views on beginning or end points of impacts | Inventory & survey
Objective basis for assigning work priorities | Track problem & point sampling assessment was used in Stirling Range National Park Western Australia to determine the effectiveness of each method on mountain track systems (Mende & Newsome 2006) |
| **Point sampling** | Transects systematically located at permanent or non-permanent points
Impacts indicators measured—environmental & track maintenance factors recorded at each point. | Impacts indicators—primarily track width & maximum depth of erosion but also environmental factors—soil & vegetation type, elevation as well as track maintenance features such as slope. | Repeatable, standardised
Describes average track conditions
Can identify subtle changes over time | Intensive—time consuming, costly, requires high level of training
Samples only a small portion of the track | Adaptive management
Suitable for assessing change in condition over time in relation to environmental variables
Recreation ecology—demonstrate causal relationship between use & impact and between impact and environmental variables | Used to model relationship between track impacts & environmental conditions in the Tasmanian Wilderness World Heritage Area in 1990s (Dixon et al. 2004)
Used to model impacts of recreation on soil, water, vegetation
Relates recreation impact to environmental and use related factors. | |

Source: Leung 1998; Leung and Marion 1999a, b; Marion and Leung 2001; Dixon et al. 2004; Nepal 2003; Marion 2007.
Chapter 4

AUSTRALIAN EXAMPLES OF TRACK ASSESSMENT METHODS

Three examples of the use of condition class assessment, track problem assessment and point sampling methods in Australian protected areas are given to illustrate the usefulness and limitations of the different methods.

1) Condition class survey methods were used to compile a comprehensive inventory of the 1000 kilometres of tracks in the Tasmanian Wilderness World Heritage Area in the early 1990s (PWS 1994a, b).

2) Track problem assessment and point sampling methods were used in Stirling Range National Park Western Australia to determine the effectiveness of each method on mountain track systems (Mende & Newsome 2006).

3) Point sampling methods were used to model relationship between track impacts and environmental conditions track in the Tasmanian Wilderness World Heritage Area in the late 1990s (Dixon et al. 2004).

These three studies are summarised in terms of:
- the purpose for the assessment
- sampling protocols (methods)
- track impact indicators
- environmental and track maintenance indicators
- utility of the method (i.e. benefits and limitation).

Condition Class Assessment Applied to the 1000 Kilometre Walking Track System in the Tasmanian Wilderness World Heritage Area

Management objective
A census based inventory of the condition of the 1000 kilometre track system in the Tasmanian Wilderness World Heritage Area (TWWHA) was conducted in the early 1990s by the park service. A variation of the condition class census method was considered to be the best way of gaining a comprehensive picture of track conditions in a relatively short period of time. It also provided an objective basis for assigning work priorities (PWS 1994a; Dixon et al. 2004).

Sampling methods
Tracks were divided into broadly homogenous sections on the basis of environmental conditions. Estimates were made of percentage of track sections subject to categories of impact by park staff members who walked the entire track system. Impact categories were: (1) degree of track development, (2) average width, (3) track condition (maximum erosion), and (4) rate of deterioration. Environmental categories were also recorded for geology, soil profile, vegetation type and average slope. Correlations were made between impact categories and environmental categories.

Indicators

Impact indicators: (summary of some categorical impacts recorded (PWS 1994a).
Degree of track development based on three predefined condition classes (% of assessed track):
- No pad
- Pad—visibly trampled route with original vegetation mostly intact
- Track—visibly trampled route mostly covered with bare soil or moss litter.
Average width: average width (including sum of widths of braided sections) based on five predefined condition classes (% of assessed track):
- Pad = <0.5 m
- 0.5–0.9 m
- 1–1.9 m
- 2–2.9 m
- 3 m

Track condition (maximum depth/erosion) based on three predefined condition classes (% of assessed track):
- Moderate > 10 cm
- Heavy > 25 cm
- Severe > 50 cm

Rate of deterioration based on five predefined condition classes (% of assessed track):
- Stable
- Slow = (conditions appear likely to remain stable over 90% of section for at least 20 years)
- Moderate = (percentage of section subject to erosional factors likely to increase significantly and/or severity over at least 20% of the track in 10–20 years)
- Fast = as for moderate but 5–10 years
- Very fast = as for moderate but < 5 years.

Environmental parameters
- Categorical information was recorded for: geology, soil profile, vegetation type, and average slope > 20°.

Design and maintenance parameters
- Track hardening (paving, boardwalk etc.) was recorded if it occurred on more than 10% of the track section under assessment.

Was the method useful?
The reliability of the census method was tested by three independent staff inventories of a 70 kilometre section (30 sections). This showed the technique was sufficiently accurate for inventory but not accurate enough for ongoing monitoring. In order for the data to be useful as a baseline from which further monitoring can be conducted assessment methods should be robust to sampling by multiple surveyors, with different experience and backgrounds.

Thus, while the census techniques were effective as an inventory, they were not sufficiently accurate to be used for long term monitoring because indicators could not be re-measured reliably (Dixon et al. 2004).

Track Problem Track Assessment and Point Sampling Methods Applied in Stirling Range National Park, Western Australia

Management objective
Two assessment methods, track problem assessment and point sampling were applied in Stirling Range National Park, Western Australia to test their suitability in providing comprehensive baseline data on the condition of walking trails in a low mountain environment (Mende & Newsome 2006). A variation of the track problem assessment method (developed in the U.S. by Leung 1998; Leung & Marion 1999a, b) was used as it generates comprehensive data on the location extent and severity of impact problems and provide information on effectiveness of track maintenance. Point sampling procedures were applied to three descriptive variables (trail width, slope and rockiness). Intervals of 100 metres were also applied as staff decided some indicators were better suited to point sampling.
Sampling methods
Field staff working in pairs recorded track problem impact indicators and environmental and maintenance parameters by walking along selected tracks pushing a measuring wheel. Impact indicators were recorded along with the cumulative distance from the track start point. The environmental parameter soil texture was also recorded to allow relational analyses. The presence of continuous maintenance features (e.g. boardwalks or wood chip surfaces) was documented by recording start and end points from measuring wheel and point features (such as water bars) were recorded using a single distance.

Indicators

Track problem impact indicators
- Erosion: Erosion.E1 (A segment of the track eroded 5–10 centimetres below estimated original surface); E2 (A segment of the track eroded 11–15 centimetres below estimated original surface); E3 (A segment of the track eroded 16–20 centimetres below estimated original surface); E4 (A segment of the track eroded >21–25 centimetres below estimated original surface); E5 (A segment of the track eroded 25–20 centimetres below estimated original surface)
- Excessive track width: (segment of a track that exceeds 130 centimetres)
- Multiple tracks: (number and location)
- Exposed roots: tops and sides of many roots exposed.

Track problem environmental parameters
- Soil texture was recorded to allow relational analyses.

Track problem maintenance parameters
- Constructed features recorded were: benches, boardwalks, bridges, boot cleaning stations, retaining walls, sand traps, sign posts, stairways and water bars.

Point sampling impact indicators
- Track width
- Track slope
- Rockiness (% cover).

Were the methods useful?
The variables track width, slope and rockiness were best suited to point sampling. The variables track depth (erosion) and excessive widths were better suited to track problem assessment. In particular soil erosion which was recorded in increasing increments of 5 centimetres provided an effective track inventory that identified track problems. However, the track problem method would be resource intensive for track sections longer than 5 kilometres (Mende & Newsome 2006).

Point Sampling Track Assessment in the Tasmanian Wilderness World Heritage Area

Management objective
The condition class inventory of the walking track system in the early 1990s had shown that most tracks in the TWWHA are unimproved and were considered to be unstable and had little or no artificial drainage. Therefore, a long term monitoring programme was established in the late 1990s to provide a systematic basis for assessing and predicting track conditions and rates of deterioration (Dixon et al. 2004). Another (but less important objective) was to understand mechanisms of track deterioration.
Sampling method
Impact indicators and environmental and design and maintenance parameters were measured at permanently marked and widely dispersed sites. Each site comprised ten transects located at 2 metre intervals. Sites were ‘typed’ on the basis of track slope, drainage and substrate characteristics and were homogeneous in terms of type. Stratified random sampling was used to select sites representing a wide range of environmental conditions.

The time required to initially mark and measure sites was about 20 minutes with re-measuring an established site taking about 10 minutes. Field staff covered about 10–15 sites over about 12 kilometres of track per day. Repeated measurements have been taken at 250 sites at 2–3 yearly intervals since 1994.

Indicators

Impact indicators
- Erosion: maximum depth below original ground surface
- Track width: two measures—width of track free of living vegetation and total width of track visibly affected by trampling and or track erosion.

Environmental parameters
- Geology, soil profiles, vegetation type and slope were recorded.

Design and maintenance parameters
- Drainage was classified as one of three categories: frequent water flow, boggy or neither
- Rates of deterioration were estimated subjectively by soil stability and water flow/drainage.

Was the method useful?
The purpose of applying point sampling to a limited number of permanent sites was to assess and predict track conditions and rates of deterioration. Models of relationships between impact variables and type of track and use of track were derived from the data and assessments of track conditions and rates of deterioration in specific areas were made. Staff reported that the impact-development model has the potential to be used to predict impacts on ‘typed’ tracks over extensive areas (providing information is available on projected drainage and substrate). The data showed that track depth and rates of erosion were strongly influenced by track type and to a lesser extent by usage, while track width was influenced mainly by usage and track bogginess (Dixon et al. 2004).
Chapter 5

NEXT STEP

Conclusions

This review highlights that it is important to assess track conditions but as yet there is no standardised assessment system. Considerable work has been done in the U.S in developing and applying track assessment methods (Marion et al. 2006). In Australia there is less consistent application of standardised track assessment methods, with a range of approaches taken among protected areas.

As described in sections 3 and 4, there are three main types of track assessment approaches: condition class surveys, track problem assessment and point sampling. The best method to use depends on whether measurements (assessments) need to be made for entire tracks/track sections (census techniques) or at points along tracks. Each assessment method yields distinctly different information and can be used for different management purposes (Marion et al. 2006, chapter 3).

Recommendations

Using the Integrated Framework for Developing Ecological Indicators for Visitor Use managers of protected area with walking tracks need to determine if they should assess walking tracks. As part of this process they need to:

- determine the objectives and resources available to them for track assessment, and hence if they need to conduct inventories, monitoring or conduct recreational ecological research
- select which methods they will use (condition class, track problem assessment or point sampling method)
- implement an assessment protocol, analyse data and use as part of an adaptive management process.

The Next Step

The next stage in this research was to field test condition class assessment, track problem assessment and point sampling assessment on different types of tracks in three protected areas in New South Wales (Hill & Pickering In review b). The report based on these trials compared and evaluated the three assessment methods. Detailed track/track section profiles were compiled and the utility of each method for characterising track conditions and identifying the location and severity of track impacts are described. In addition, the efficiency and precision of each method in terms of the ease of application and the potential for it to be used for monitoring are assessed.

From the critical review track assessment presented in this report and the field trials of the three assessment methods, a track assessment manual (Hill & Pickering In review c) has been developed. The manual provides detailed procedures and associated pro forma’s for conducting condition class survey, track problem assessment, and point sampling assessment.
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EVALUATION OF IMPACTS AND METHODS FOR THE ASSESSMENT OF WALKING TRACKS IN PROTECTED AREAS

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EVALUATION OF IMPACTS AND METHODS FOR THE ASSESSMENT OF WALKING TRACKS IN PROTECTED AREAS


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