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A longitudinal study of backcountry track and campsite conditions on the Overland Track, Tasmania, Australia

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ABSTRACT

The 79 km Overland Track is Tasmania's premier overnight walking track (trail) and one of Australia's best-known and most popular backcountry hikes. Trampling impacts (poor track condition) were recognised in the 1970s and degraded campsites were a concern by the 1980s. Despite three decades of intermittent works, many sections of track remained in poor condition in the early 2000s, but targeted works since 2006 have addressed many problem areas. Hardening of campsites at selected overnight nodes commenced in 2000 and a reduction in overall camping impacts followed, presumed due to a greater concentration of camping use at the hardened sites despite unrestricted camping still being permitted. Longitudinal monitoring of both track (8 years) and campsite (16–25 years) conditions, using relatively simple techniques, have successfully described the scale and delineated the location of changes in condition and so provided a useful planning tool for management. In particular, it has contributed to documenting a contemporaneous improvement in track and campsite conditions partly associated with a booking system to regulate walker use of the Overland Track, introduced in 2005. Booking fees have contributed to management successes by providing adequate and consistent resourcing for the repair and maintenance of walking track surface infrastructure.

Management implications:

- Extensive hardening is an effective way to sustainably manage a moderate to high use walking track that has not been initially well-designed.
- Adequate and consistent resourcing for the repair and maintenance of walking track surface infrastructure is necessary to sustainably manage such tracks.
- The provision of inviting facilities, including camping platforms, at selected overnight nodes has resulted in a concentration of visitor camping use on a smaller number of campsites, hence reducing the overall impact of camping along the Overland Track.

1. Introduction

The 79 km Overland Track is Tasmania's premier overnight walking track (trail) and one of Australia's best-known and most popular backcountry hikes. It has a long history of use and consequent development of trampling-related track and campsite impacts. Various management tools have been deployed to address such issues since the 1980s and a relatively-simple monitoring system has documented some of the effects of such tools, particularly since 1999.

Hiking and camping are common recreational activities in many of the world's natural protected areas. The primary goals of management for such areas is limiting the areal extent of human impacts, as well as limiting the severity of impact to levels that are not ecologically, managerially, aesthetically or functionally significant (Marion, Leung, Eagleston & Burroughs, 2016). Managers hence often need to implement measures such as stabilising walking tracks or campsites, or educating or regulating visitors, to limit recreational impacts (Park, Manning, Marion, Lawson & Jacobi, 2008). Monitoring is required so that managers can be informed about usage patterns, determine the location, severity and extent of biophysical and other impacts (Eagles, McCool, & Haynes, 2002; Tanner & Nickas, 2007), and assess the effectiveness of management measures (Newsome, Moore & Dowling, 2013).

1.1. Nature of recreational impacts

The biophysical effects of recreational trampling and camping in natural settings have been well-studied (Cole, 2004; Marion et al., 2016). Impacts typically include damage to and loss of vegetation,

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changes in species composition, soil compaction, erosion, and the development and deterioration of defined walking corridors (i.e. tracks or trails) and campsites (Cole, 2004). Post-impact recovery is often slow, particularly in alpine environments (Leung & Marion, 2000). The relationship between recreation use and impact has often been described as curvilinear, with low usage causing disproportionately high impacts (Hammit, Cole, & Monz, 2015; Marion, Leung, Eagleston & Burroughs, 2016). However, the use-impact relationship can take other forms, and some studies have proposed a sigmoidal relationship (Cole, 2013; Dixon & Hawes, 2015).

1.2. Walking tracks

Walking tracks are generally subject to ongoing physical deterioration unless they are designed sustainably (which generally requires low gradients, with tracks aligned more closely to contours than fall lines) or are located on self-maintaining substrates that resist erosion (Leung & Marion, 2000), otherwise poorly-designed trails require extensive hardening to be sustainable (Marion & Wimpey, 2017). The deterioration of unimproved walking tracks, often visitor-created, on which no stabilisation or hardening works have been undertaken poses a serious management problem in many natural areas worldwide (Leung & Marion, 2000), especially as soil loss is generally considered irreversible (Olive & Marion, 2009). In addition to environmental impacts associated with gullying, track widening, quagmire development and track braiding or duplication, track deterioration can at the same time adversely affect the recreational experience of walkers (Lynn & Brown, 2003).

The factors that predispose unimproved tracks to degradation have been well studied, with key factors being gradient, track alignment relative to topography, drainage and substrate characteristics (e.g. Leung & Marion, 1996, 2000; Dixon, Hawes & McPherson, 2004; Olive & Marion, 2009; Marion & Wimpey, 2017). Impacts on soil (erosion and loss), especially water-based erosion problems, are perhaps the most significant long-term recreation impacts as most are irreversible (Marion, Leung, Eagleston & Burroughs, 2016). Trail conditions typically vary along a trail, indicating that they are a function of trampling magnitude and local physical properties (Olafsdottir & Runnstrom, 2013). Well designed and constructed trails are not only sustainable with respect to trampling impacts (Marion & Wimpey, 2017) but also provide resilience to natural erosional factors such as extreme rainfall events (Tomczyk, White & Ewertowski, 2015).

1.3. Campsites

Campsite conditions have a substantial influence on recreational values because visitor experiences are particularly influenced by what they find at campsites (Flood, 2003). Flood further notes that, whether managers choose to ignore or restore (i.e. harden or close, and perhaps attempt rehabilitation insofar as that may be possible) heavily impacted campsites, their decisions have a significant effect on the quality of visitor experience.

Campsite impact is inevitable with repetitive use, and occurs rapidly but recovers slowly if use ceases (Cole, 1989, 1994, 2004). Cole further notes that the magnitude of impact at a given campsite is determined by environmental characteristics that influence its durability, the frequency of use it receives and the spatial distribution of such use. Smith and Newsome (2002) noted that high-use formal campsites were larger and more severely impacted than low-use, informal campsites. Studies in the USA have concluded that vegetation type is the best predictor of campsite durability (Marion & Cole, 1996). In Tasmania, long term observations of highland campsites suggest grasslands are the most robust alpine camping substrate (Photo 1). This is consistent with the results of experimental trampling studies in both Tasmania (Whinam & Chilcott, 1999) and the Australian Alps (Growcock & Pickering, 2011).

Photo 1. Naturally trampling-resistant grassy campsite (condition class 1; see Table 4) adjacent to old Waterfall Valley hut, Overland Track, Tasmania.

Studies suggest that many substantial changes on some sites occur by the time a campsite receives only 10–15 nights of use per year (Cole, 1995a; Marion, 1996). Specifically, early changes typically include a substantial loss of vegetation and pulverisation and loss of organic litter, whereas the exposure of mineral soil appears later in the progression of impacts and is related to use in a more linear fashion (Marion, 1996).

Marion (2016) observes that campsites are often created by visitors during peak use periods when campsite occupancy rates are high, but that subsequent use of even a few nights/year is then sufficient to prevent their recovery. Cole (1994, 2013) describes a "campsite impact history" involving rapid early deterioration and later dynamic equilibrium (at least with respect to vegetation loss and soil compaction). He further states (2013) that aggregate campsite impact within a region is more reflective of the number of campsites than the magnitude of impact on individual campsites, although on individual campsites, expansion can be particularly problematic (Marion 1996; Marion & Farrell, 2002).

Marion and Cole (1996) studied soil and vegetation impacts at campsites and noted that near-maximum impact intensities were produced very quickly at any location that was repeatedly disturbed. They hypothesised that such relationships were the norm for chronic disturbances of high intensity and low areal extent, concluding that management actions which concentrate the disturbing agent are likely to be most effective in minimising overall impact levels.

Cole and Monz (2004) note, given pronounced differences in the susceptibility of different plant communities, campsite selection is very important as a means of limiting impact but, in discussing the use-impact curve, they note that use levels must be very low and/or resistance very high to capture the portion of the curve below the threshold of rapidly increasing impact.

1.4. Management options

A variety of management techniques have been developed to mitigate recreational impacts (Leung & Marion, 2000; Marion, 2016). They include hardening tracks and campsites, redirecting visitation through regulation or education, modifying visitor behaviour, and modifying visitor expectations. Each technique has its advantages and limitations, and the choice of technique(s) to address a particular impact will depend on a range of factors including cost, likely effectiveness and the impact of the technique on recreational values.

Marion (2016) notes the curvilinear use-impact relationship implies that reducing use on well-established moderate- to high-use tracks and campsites is unlikely to appreciably diminish vegetation and soil impacts, unless very substantial reductions occur. In contrast, limiting use within the low-use zone, where impacts develop rapidly, can lead to substantial reductions in impact. However, this zone occurs at relatively low levels of use, generally between 3 and 15 nights of camping per year or 50–250 passes per year along a trail (Cole, 1995a, 1995b; Marion, 2016).

Hence, reducing use on a heavily used trail by (say) 20% is unlikely to result in any meaningful improvement in trail conditions (Marion,

2016) so, for a track that was never designed with sustainability uppermost in mind and with the use levels of the Overland Track, the only options are to relocate to a stable rocky substrate (where possible) or undertake extensive hardening.

Leung & Marion (1999a) suggest differing management strategies to deal with different campsite impact problems. Controlling the extent of impact by designating specific camping spots or defining site boundaries may be effective for extensively-impacted sites. Intensively-impacted campsites require control of soil erosion by site maintenance or various hardening works. Dixon and Hawes (2015) have shown the installation of camping platforms at major campsites arrested and in some cases actually reversed campsite impacts, broad-scale trampling impacts and ad hoc track development at several of those sites. For moderately-impacted and low-impact campsites, use limits would be potentially effective, as they are at an impact stage that is more responsive to changes in use. Manning (2003) emphasises that the effectiveness of educational approaches in ameliorating trampling impacts at campsites is low.

It is also important to appreciate user perspectives. White, Hall, and Farrell (2001) concluded ecological impacts, such as large denuded core areas (presumably provided they were not quagmires), were usually interpreted by users as amenities that contributed to a site's desirability. Daniels and Marion (2006) note that balancing environmental and social objectives is particularly difficult at high-use/high-impact sites. Nevertheless, they noted that visitors were mostly satisfied with the results of establishment of designated constructed campsites at an Appalachian Trail (USA) camping area. Leung and Marion (2004) caution that while site hardening practices can be quick and effective they often entail irreversible changes to the nature of visitor experiences as well as the environment.

In light of all the above:

- It is best to concentrate use and impact in popular places, both among and within camping areas (maximise the use of well-established campsites, or restrict use to designated sites), and disperse use and impact in relatively pristine places (Cole, 2004, 2013).
- Management efforts should be focussed on preventing the formation of more intensively-impacted campsites, and remediate existing such sites if possible (Monz & Twardock, 2010).
- Where vegetation is resistant enough, campsites can be used repeatedly at low use frequencies without experiencing pronounced groundcover disturbance (Cole & Monz, 2004).

2. The study area

The Overland Track traverses Cradle Mountain – Lake St Clair National Park, in the central highlands of Tasmania, Australia's island state (Fig. 1). The area has a cool temperate climate, with high precipitation and trampling sensitive soils and vegetation. The region is part of the Tasmanian Wilderness World Heritage Area (TWWHA) and is managed by Tasmania's Parks and Wildlife Service (PWS).

The Overland Track is a linear trail with several major side tracks (Fig. 2). Starting near Cradle Mountain, the 79 km route traverses the highest mountain region in Tasmania (with summits adjacent to the track exceeding 1500 m elevation) before entering forested country and descending southwards to the glacial Lake St Clair.

PWS maintain 8 public huts for overnight accommodation along the Overland Track (plus several emergency shelters, and there are an additional 5 private huts for the exclusive use of a walking tour concessionaire). Clusters of campsites have evolved around most of the hut nodes, although there are also many scattered elsewhere along the track, sometimes remote from the main camping areas and in some cases known only to visitors with prior knowledge of the area.

2.1. Recreational history and impact

While based partly on the routes of early snarers, graziers and prospectors, the track was cut during the 1930s in order to provide a recreational asset for bushwalking (hiking) (Haygarth, 1998). It is unlikely the route was designed for sustainability but it has subsequently become Australia's best-known and most popular long-distance back-country walk.

In early 1970s the track was being traversed by some 1500 walkers annually, and this had grown to around 7500 by the early 2000s (Poll, 2005), with about 7% commercially guided. In recent years annual numbers have been around 8000, with up to 25% commercially guided and a high proportion of those utilising the private huts (unpubl. data, PWS, 2014–15). Most Overland Track walkers (>80%) traverse only the 63-km Cradle Valley - Narcissus section of the track (inferred from Knowles, 2011) and an average trip length is five nights (six days).

There is a distinct seasonality to Overland Track walking, with a strong association with prevailing climate and Australian summer holidays (Nov-April, with Dec-Jan peak months). Traditionally, most walkers have been southbound (e.g. 82% in 1999–2000; Poll, 2005) and this is now required as part of the post-2005 booking system (see below). Poll (2005) also noted that group sizes were generally small (median 2, with only 3 groups > 13, the recommended maximum, in 1999–2000).

Poll (2005) further describes the social setting of the Overland Track as cosmopolitan, with almost 20% of visitors of non-Australian origin and 29 nationalities represented in 1999–2000. The proportion of overseas walkers in 2010-11 was similar (22%; Knowles, 2011).

By 1980, 29% of the Overland Track was considered in poor condition (Calais & Kirkpatrick, 1986). Various problems were noted, including both track erosion and braiding, with the ecologically most significant damage occurring in alpine environments which have both low resistance and resilience to trampling impacts (e.g. Photo 2). Soil erosion continued independently of foot traffic in some areas (op. cit.), presumably due to unconstrained water flow on the entrenched track. Calais (1981) found most Overland Track visitors (81%) supported the immediate upgrading of walking tracks in the area. Surveys of peak season walkers in recent years have found that many were still “bothered” by “muddy and eroded tracks”; 47% in 2004-05 and 44% in 2010-11, although only 13% were bothered “a lot” in 2010-11 (Clark & Poll, 2008; Knowles, 2011). A track repair program was ongoing through this period (see Section 2.2) but many areas remained in poor condition.

Data from Overland Track walker surveys in 2006-07 (Clark & Poll, 2008) and 2010-11 (B. Knowles, written comm. 2012) provide some indication of use of the main camping areas by Overland Track walkers. Some camping areas (not the co-located huts) accommodated 1200–1400 Overland Track walkers during the 2010-11 booking season (track use has been regulated since 2005; see Section 2.2), and perhaps somewhat higher during the 2006-07 season (Table 1). This is a minimum because some off-season walkers will also have camped (around 1000 walkers traversed the track during May-October 2011), some camping areas will have had additional use by non-Overland Track walkers undertaking shorter trips (especially Waterfall Valley and Pelion), and some walkers may have stayed > 1 night at specific sites (there is no walker night data available).

A hut and campsite occupancy survey undertaken during the 1999–2000 season indicated that the “comfortable” camping capacity (i.e. utilising only well-defined level sites and without crowding together of tents) of campsites co-located at the hut overnight nodes was rarely exceeded (Poll, 2005). Another survey of walkers during the same season recorded just 16 occasions during a six week period when walkers noted they could not find an unoccupied campsite (PWS, 2000). However, neither of these surveys indicate how often campsites were near-capacity, and it should also be noted there are a large number of campsites (and hence a large area of collective impact) which had developed due to decades of use.

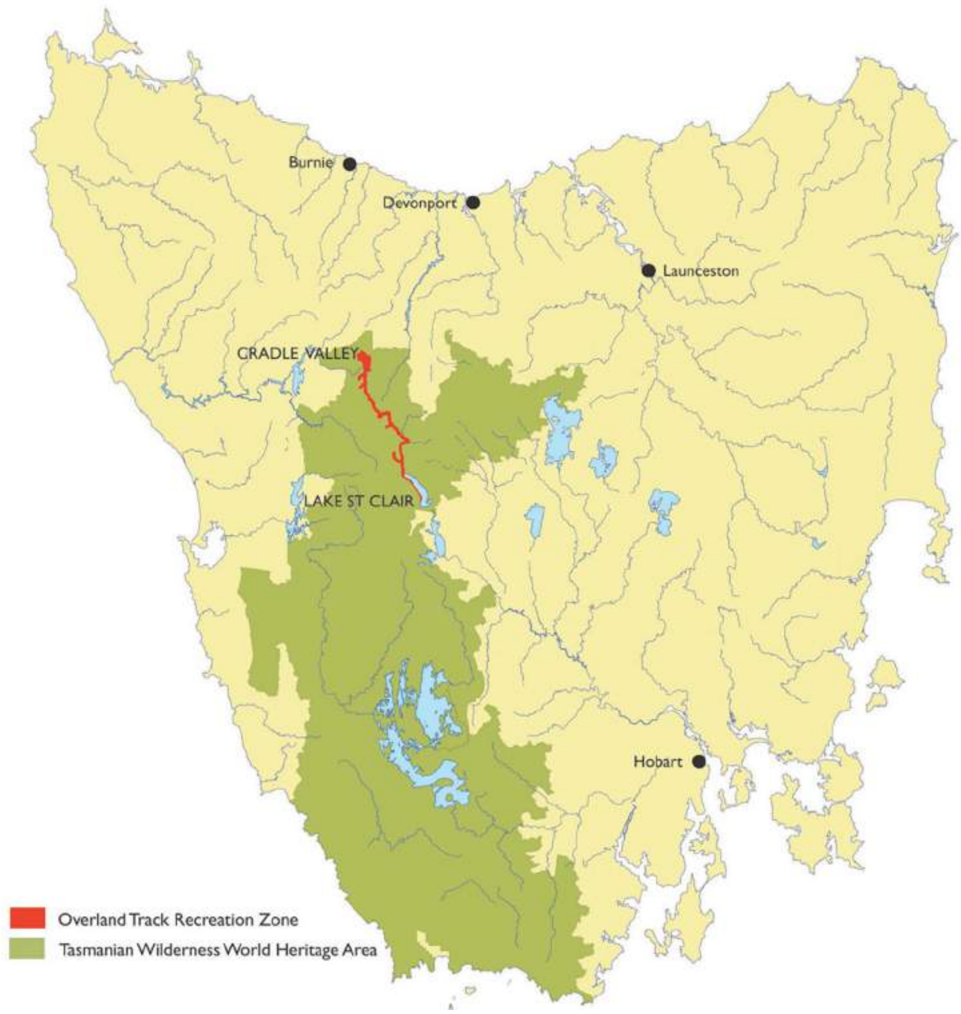


Fig. 1. Location of the Overland Track Recreation Zone and the Tasmanian Wilderness World Heritage Area, within the island state of Tasmania, Australia.

Poll (2005) determined visitor norms for the acceptability of varying levels of impact at campsites on the Overland Track (Table 2), based on the campsite condition categories used in this study (Table 4). He found most visitors (93%) considered condition class 2 campsites acceptable, and well over 50% considered class 3 acceptable, but < 16% were happy with seriously-impacted class 4 or 5 campsites.

Clark and Poll (2008) note the main environmental problems associated with degraded campsites include vegetation and soil erosion which compromise both site usability and walker comfort, and that degraded campsites are not consistent with the aspirational standard of the Overland Track (Photo 3). They also noted concern that proliferation of campsites away from established overnight nodes can also promote improper camp hygiene practices, which may lower water quality.

2.2. Management context

The prescriptive PWS track classification system (PWS, 2014) and Reserve Standards Framework (PWS, 2008a) provide a framework for determining acceptable track and campsite conditions on the Overland Track and all other walking tracks in Tasmania.

There has been extensive track work and general maintenance along the Overland Track over the last three decades. Between 1979 and throughout the mid-1980s, sections of the Overland Track were improved by some local re-routing onto more robust surfaces and the laying of cordwood (timber corduroy) to provide a hard surface in many quagmires. Hardening of sections of the Overland Track continued intermittently through the 1990s, although sections of many side tracks remain to be addressed (Photo 2). The inevitable deterioration of much of the 1980s era cordwood is now the cause of some sections of the Overland Track again being in poor condition some 25–30 years later (Photo 4).

The Overland Track was declared a Fuel Stove Only Area in the late 1980s (with all campfires banned), there was an active Minimal Impact Bushwalking (Leave No Trace) campaign at the same time, and there has been a seasonal ranger presence on the track ever since. Notable improvements to campsite precincts in terms of litter (rubbish) and tree damage through the early 1990s can be associated with these management actions (O'Loughlin, 1997). Furthermore, the lack of campfires means loss of woody debris from and around campsites due to firewood collection (Smith, Newsome & Enright, 2012) is not a problem on the Overland Track.

All campsites on the Overland Track originated informally and it is not until quite recently that attempts have been made to construct or indicate formal campsites. Many campsites in the vicinity of the public huts have been "hardened" by the construction of timber tent platforms since 2000 (most during 2001-08; Photo 5). While several campsites near water bodies have been closed, and camping is not permitted within the Cradle Mountain day walk area, unrestricted camping is still generally permitted throughout the national park. However, walkers are now encouraged to utilise the major camping nodes co-located with the public huts.

In July 2005, PWS introduced a departure-based booking system and fee for walking the Overland Track, which came into effect for the 2005-06 peak season. The system was considered necessary to address the issues of over-crowding and environmental degradation, while

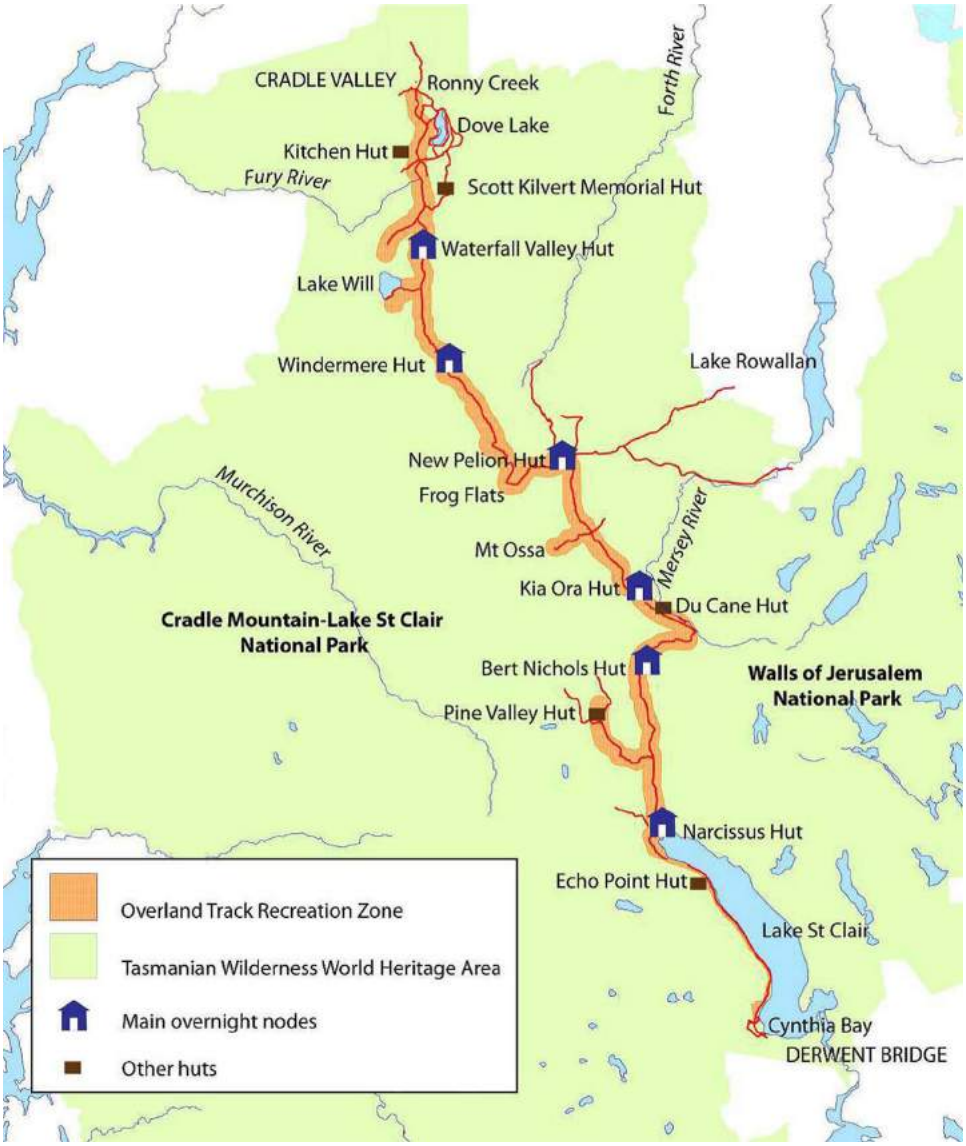


Fig. 2. Overland Track corridor, Tasmania, showing main side tracks and overnight nodes.

avoiding the need to constantly increase the capacity of the infrastructure on the Overland Track (PWS, 2008b). The booking system limits the number of daily departures to 60 walkers (and so the maximum number on the track at any one time), requires all walkers to travel in a north-to-south direction, and limits group sizes to a maximum of 8 (for non-commercial walkers). Since 2005, booking fees have provided reliable funds for an ongoing repair and upgrade program (Photo 6).

3. Monitoring methods

A wide range of techniques has been described for measuring and monitoring recreational impacts in wild settings. The choice of techniques for a particular situation depends on a range of factors including the type and accuracy of information required by managers, the efficiency with which information can be obtained and the resources available for monitoring. The recording of recreational impacts on the Overland Track has formed part of a TWWHA-wide multi-method monitoring program that has developed since the mid-1990s (Dixon, Corbett & Jones, 2016).

3.1. Tracks

Monitoring the condition of entire tracks has traditionally utilised distance based sampling-techniques (Hawes, Candy & Dixon, 2006; Leung & Marion, 1999b). Such a sampling approach can provide a relatively precise overview of track condition in a time and cost effective way (e.g. Olafsdottir & Runnstrom, 2013). Such methods have been used elsewhere in Tasmania (Dixon & Hawes, 2015; Dixon, Corbett & Jones, 2016) and Calais and Kirkpatrick (1986) collected data at 500 m intervals to characterise recreational impacts along the Overland Track in 1978-79.

Such interval-level data (and associated statistical analysis) is generally desirable in such research but, in the exercise on which this study is based, management needs required the full extent of problems to be spatially delineated in order to be able to accurately plan and cost future repair works. PWS asset management systems already took a categorical approach to describing the condition of assets and so their classification (Table 3) was used in track assessments. Modern GPS technology provides the capacity for continuous recording while traversing the track.

Surveys of the spatial distribution of track conditions and surface infrastructure on the Overland Track were first undertaken during March-April 2007 in order to prioritise repair works. The track was

Photo 2. Eroded and braided alpine section of the Mt Oakleigh side track.

Table 1
Non-commercial[a] Overland Track walkers tent camping at the major overnight nodes during 2006-07 and 2010-11 booking seasons.

Camping area	Proportion of non-commercial[a] Overland Tk walkers that camp		Inferred Overland Tk walker camping use2010-11
	2006-07	2010-11	
Waterfall Valley	44%	33%	1226
Windermere	50%	42%	1398
New Pelion	30%	24%	984
Kia Ora	52%	41%	1408
Windy Ridge	51%	27%	858
Narcissus	37%	36%	500
Echo Point	47%	45%	293

[a] Several hundred commercial camping tour walkers also traverse the Overland Track annually but utilise group-specific hardened campsites.

subsequently re-surveyed on three occasions (March-April 2009, 2012 and 2015) in order to track and facilitate adaptive planning of the ongoing repair and upgrade program facilitated by funding from fees from the newly-introduced walker booking system.

The condition of up to nine major side tracks were also surveyed during the 2009 and subsequent surveys, although this was sometimes limited by time or weather conditions (the track monitoring program was undertaken together with the campsite inventories described below, necessitating an 8–10 day self-reliant field trip on each occasion).

In 2012 and 2015, data was recorded using a weather-proof Trimble Juno GPS-enabled personal digital assistant (PDA) running GBM Mobile software. In previous years a weather-proofed Mio Digi-walker PDA was utilised. Tracks were divided into segments on the basis of tread condition categories (Table 3) and type of surface infrastructure. Data recorded for each segment included track width, infrastructure type and dimensions, and track condition (to aid management, recommended infrastructure repair, maintenance and/or upgrade priorities were also linked to the various segment records). Such segments vary in length from around 10 m to several hundred metres.

Observer judgement was used to define the start location of any new recording segment. In many instances this was obvious (a change in tread surfacing technique, for example) but may be more subjective

Table 2
Proportion of Overland Track visitors (n = 566) who considered the spectrum of campsite conditions to be acceptable in 1999–2000 (from Poll, 2005). See Table 3 for definitions of campsite condition classes.

Condition Class	Proportion of visitors who consider acceptable
1	98.6%
2	92.9%
3	63.1%
4	15.6%
5	6.8%

Table 3
Condition categories used for assessment of track (trail) tread condition.

Condition category	Definition
Excellent	Sound condition, no work required
Good	Fit for purpose & safe, minor work may be required
Marginal	Significant deterioration, serviceable but further deterioration likely in short term
Poor (recoverable)	Extensive deterioration, barely serviceable, major work required
Very poor	Failure imminent, urgent works or replacement required, consider closure

when judging a change in condition only (although in many cases this too was obvious, corresponding to a related change in gradient or drainage, for example). Categorical assessment of track condition in this way can be subjective but the technique was developed to serve the specific requirements of management and remain consistent with condition assessments of other assets in PWS's management systems. The technique needs to be undertaken by a trained and experienced observer to optimise precision and minimise bias; the author undertook all measurements in this study.

3.2. Campsites

A “campsite” is defined as an area on which camping and associated activities are undertaken, but the practical considerations of measurement largely guide the in-field definition of what constitutes a campsite. For example, several adjacent clearings all used for camping and separated by dense vegetation are best considered as separate campsites because they are all likely to require separate measurement and/or photography. Also, two adjacent areas could undergo different styles and rates of camping-induced changes and recording them as separate campsites better facilitates the monitoring of such changes. Hence, in one “camping area” there may be a large number of campsites.

The campsite boundary may be defined, on the ground, in a number of ways, none of which are mutually exclusive. Boundary indicators include pronounced changes in vegetation cover, composition or disturbance, topography, scuffing or removal of litter and soil exposure. Marion (1991) provides a useful series of photographs illustrating campsite boundary types.

The campsite monitoring technique used on the Overland Track is a condition class system (Frissell, 1978; Marion, 1991) consisting of several statements linked to a code that describes increasing levels of campsite impact. Class 0 campsites are barely distinguishable whereas class 5 campsites comprise bare soil or rock with obvious soil erosion (Table 4). More information that could be usefully analysed would be available if surveys had consistently collected specific quantitative data on attributes like site size or area of exposed soil but the lack of time and skill of the early observers limited this.

Most campsites were also photographed from a relocatable point during each visit. In some cases these images provided additional insight into changes at individual sites (e.g. nature of surface changes), although photographs don’t often clearly illustrate any boundary changes, and varied lighting conditions between surveys often make

Table 4
Campsite condition classes (modified Frissell condition classes).

Condition class	Definition
0[a]	Campsite is barely distinguishable. There is no physical damage and minimal disturbance of organic litter
1	Campsite is visually distinguishable but has minimal physical damage. Ground vegetation may be flattened but not permanently injured. Minimal disturbance of organic litter
2	Campsite obvious. Ground vegetation worn away and/or organic litter pulverised on primary use area (perhaps up to 25% of the site)
3	Ground vegetation lost and/or organic litter pulverised on most of campsite (say 50–75%). Litter may still be present in many areas. Bare soil exposed in primary use areas, but little or no soil erosion
4	Near total loss of vegetation and/or organic litter. Bare soil obvious and extensive (say > 75% of site). Some soil erosion may be apparent (e.g. tree roots exposed on surface)
5	Bare soil or rock over most of campsite and obvious soil erosion (i.e. obvious soil loss, exposure of tree roots, coarse particles or bare rock)

[a] Condition class 0 (not used in Frissell-based categories elsewhere) exists to record sites where camping is known to occur (or have occurred) but there is virtually no physical evidence.

Photo 3. Campsite on the Overland Track impacted by visitor use, with extensive exposed bare soil and signs of erosion. This site would have a condition class of 5 (Table 4).

Photo 4. Widening trampled corridor as walkers avoid derelict cordwood. Hardwood logs were laid to provide a hard surface in many muddy peat areas along the Overland Track during the 1980s. Many have now rotted and become a derelict, uneven tread surface that requires replacement.

Photo 5. Timber camping platform at Windermere, typical of those installed at most major overnight nodes on the Overland Track since 2001.

Photo 6. “Planking” is a modern track hardening technique that is relatively efficient and cheap to lay. By 2015 planking had been used to harden 13.3 km of the Overland Track.

photographic comparisons challenging. Regardless, such images are useful to provide a snapshot illustration of current conditions for management. This oblique style of photography cannot provide comparative numeric data like the overhead photo method described by Monz and D’Luhosch (2010) but such data collection and subsequent digital image analysis was considered impractical on the Overland

Track given time, resources in the field and the existing historic campsite data record.

An inventory of the condition of all campsites along the Overland Track has been undertaken in 1999, 2003, 2005, 2009, 2012 and 2015. Earlier data is available for some campsites. These earlier surveys were undertaken opportunistically by seasonal track rangers during the 1988-95 period. Some of these early surveys involved the drafting of detailed campsite plans (similar to techniques described by Marion, 1991) which might have facilitated accurate temporal comparisons for specific campsites but this was deemed too time-consuming when undertaking a census of all campsites.

The approach of inventorying all campsites in an area and collecting basic data on the condition of each campsite provides insight into broad-scale change in the number and condition of campsites but the relatively imprecise measures of conditions do not provide reliable information on campsite change at the scale of individual sites (Cole, 2013). Another limitation of the condition class system is that the evaluator is simultaneously examining multiple impact factors which may not co-vary (Monz & Twardock, 2010). Furthermore, this style of data also limits the capacity for statistical analysis, as also noted for the tracks data (Section 3.1). Nevertheless, for the Overland Track the method allowed direct comparison with campsite data collected before 1995 in many cases, and practical considerations limited the capacity to utilise other campsite data collection methods (campsites were often surveyed by a single observer in concert with the aforementioned track condition data collection).

4. Results

4.1. Tracks

As noted previously, the northern 62.6 km of the Overland Track, ending at Narcissus (Lk St Clair), is utilised by the vast majority of walkers and hence has been the focus of this study. GIS software can be readily utilised to process the field data collected using the PDA (see Section 3.1) and so cartographically illustrate infrastructure and problem areas in a form useful for management planning (e.g. Fig. 3).

Data can also be presented as a simple chart illustrating a snapshot in time, useful for managers to gain an overall impression of trail conditions. Such charts illustrate the extent and condition of tread surfacing techniques on the Overland Track (Fig. 4), and highlight which side tracks might be the highest priority for future works (Fig. 5), clearly illustrating the extent of the problem of derelict cordwood (Photo 4). Fig. 4 also clearly illustrates the range and extent of tread hardening techniques used on the Overland Track (including 13.3 km of planking, 7.2 km of duckboard and 2.6 km of cordwood) but the majority of the track (38 km, or 60%) still comprises a natural surface (this includes sections of old benching, the tread of which remains essentially natural), much of which remains in acceptable condition.

Nine major destination side tracks, with a total length of 16.6 km, are associated with the Overland Track. About 20% of the total length these tracks were in *poor* or *very poor* condition in 2015 (Fig. 5), a slightly higher proportion than in 2012, despite some works in the interim. The major extent of problems lay on the Mt Pelion East and Mt Oakleigh tracks.

Changes in track conditions contemporaneous with the introduction of the walker booking system-funded works program have been observed in this study. Spatial data was only logged from Marions Lookout to Narcissus during the initial 2007 survey, so comparisons with subsequent surveys have been restricted to this part of the Overland Track (however this comprises most of the track - 59 of 63 total km - and most sections with identified problems).

Between the 2007 and 2009 surveys, some track upgrade works (mostly planking or duckboard) were undertaken on sections of the Overland Track but only totalled about 0.6 km. Much more extensive works were undertaken during 2009–2015, and are ongoing. New works on the Overland Track during this latter period totalled more than 8.6 km (including 1.1 km duckboard and 7.3 km of planking), a mean rate of construction of 1.4 km/year.

As illustrated in Fig. 6, in an overall sense, while works during 2007-09 did not fully balance ongoing deterioration elsewhere, a dramatic improvement has been observed since 2009. By April 2015, only 2.7 km of the Overland Track (and about 4% of its total length) remained in *poor* or *very poor* condition (see Table 3), compared to 7.2 km in March 2007 and 9.3 km in 2009. About half of the problem areas that remained to be addressed (in April 2015) were deteriorating unimproved track sections that still require hardening with the remainder mostly comprising decrepit old surfacing (mostly cordwood).

4.2. Campsites

More than 150 campsites have been recorded in the Overland Track corridor during repeated surveys undertaken from 1999 to 2015. Despite the aim of inventorying all campsites (see Section 3.2) some obscure sites were missed during the earliest surveys, and some new, developing campsites were noted and recorded in later surveys; hence the total number of campsites recorded has not been exactly the same throughout this study. Campsite sizes on the Overland Track vary, but the majority are small (1–3 two-person tent capacity). In April 2015, 60% of recorded campsites were considered 'minor', 23 campsites had been formally closed and another 65 were considered disused.

Notwithstanding some issues with photographic techniques (see Section 3.2), photographic records of some campsites on the Overland Track clearly illustrate surface changes over time (e.g. Photo 7), although not always as graphically as this photographic series.

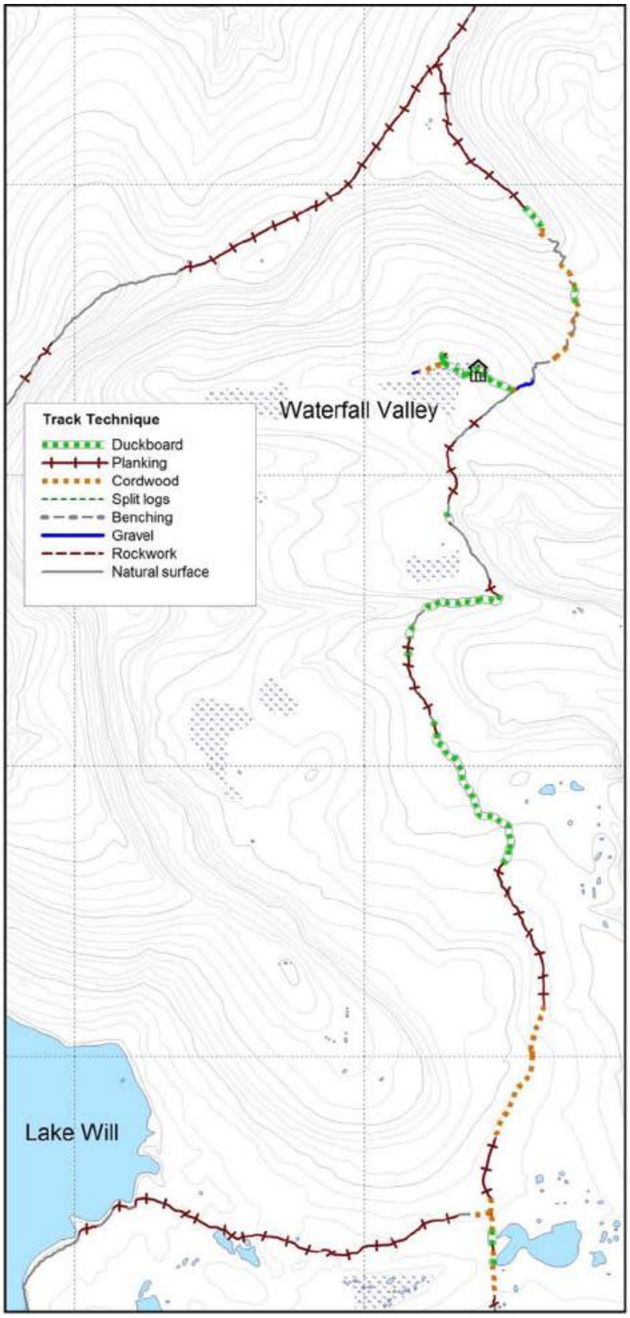
Historical data, obtained by seasonal track rangers between 1988 and 1995, is only available for 52 of the campsites recorded in the first comprehensive inventory of Overland Track campsites undertaken in 1999. Nevertheless, there is sufficient information in the early photographs, sketches and other census data for qualitative conclusions to be made regarding changes at these campsites. During the four to eleven years prior to 1999, more than 62% of the campsites monitored (i.e. surveyed on at least one occasion prior to 1999) displayed some deterioration. Less than 36% were considered stable and only a single campsite had improved. In addition, 7 campsites inferred to be newly-established (informally, by users) were recorded in 1999.

Since 1999, Overland Track campsite surveys have been comprehensive, inventorying virtually all sites. During 1999–2005, 21% of the campsites monitored displayed some deterioration, 53% were considered stable and 26% had improved. 'Improved' sites included those where campsite hardening (timber tent platform construction) had been undertaken.

Only 5% of campsites displayed some deterioration during 2005-09, and the condition of 27% improved, although most only slightly due to incipient revegetation. However, several of the deteriorating campsites were located in sensitive environments with limited resilience.

The situation was similar during the 2009-12 and 2012-15 monitoring periods. Since 2009, only 4% of unimproved campsites displayed any discernible deterioration (and mostly only slight), with 31% improving (again, mostly only slightly). The condition of the remaining unimproved sites was unchanged, although a number of old campsites remained significantly-impacted albeit little-used. Hence, unimproved campsites throughout the Overland Track now appear generally stable although many remain significantly impacted. Many formerly active campsites now appear disused and a number of minor sites have improved, at least slightly, since 2005.

An improving trend in Overland Track campsite condition is evident from several indicators; amongst many overnight node campsite clusters (e.g. Fig. 7), but is particularly clear when considering the change in median or mean condition class of all Overland Track campsites over the last 10–15 years, and comparison with a sub-set of these sites some 25 years ago (Fig. 8).



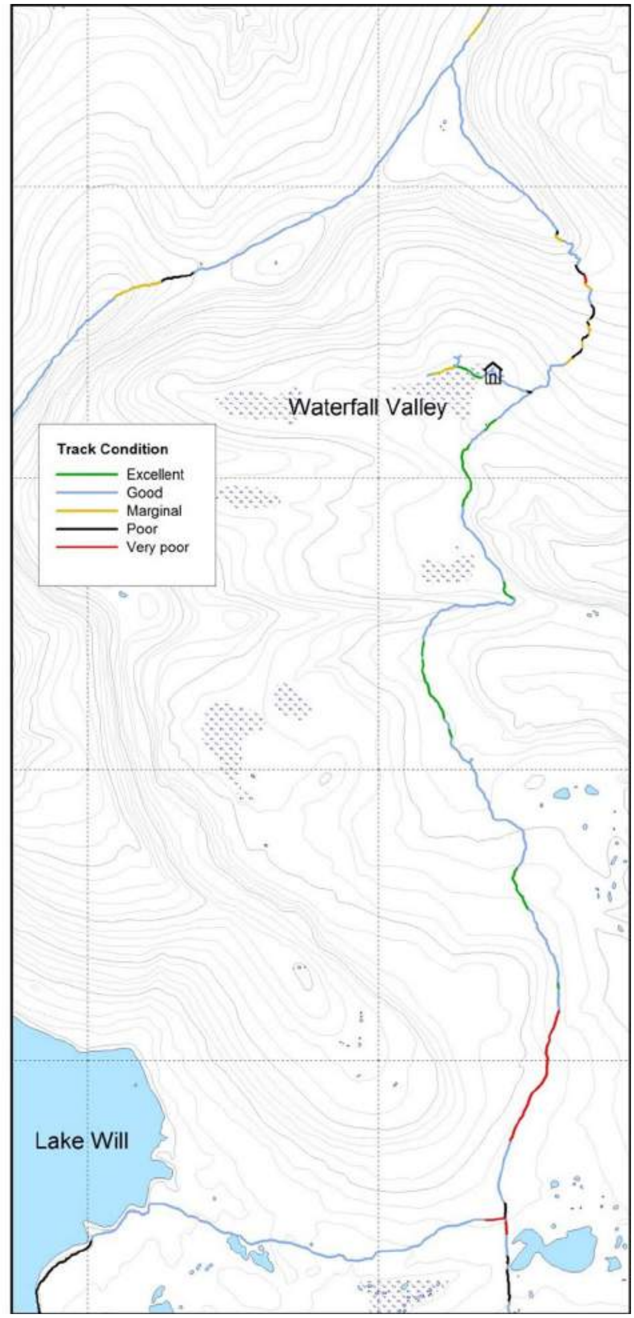


Fig. 3. Example maps of the location of tread surface infrastructure and condition for a section of the Overland Track in 2012. See Table 3 for condition category definitions.

5. Discussion and conclusions

This longitudinal study demonstrates that the application of relatively simple monitoring techniques over a reasonable time period can be successful at illustrating and evaluating user- and management-related changes on a backcountry walking track.

Problems associated with recreation use on the Overland Track were recognised by the 1970s. Calais and Kirkpatrick (1986) argued the key to minimising the extent of trampling damage associated with the Overland Track was to make the track more comfortable to traverse than the adjacent natural vegetation, a message echoed in various forms by others since (e.g. Marion, Leung, Eagleston & Burroughs, 2016). Marion and Wimpey (2017) emphasise the need to extensively harden moderate to high use tracks particularly if not originally designed for sustainability.

One question rarely considered in this approach, and not addressed in this study but nevertheless worth noting, is the impact of such hardening on wild character. The Overland Track and its associated infrastructure have a measurable impact on the wilderness value (character) of the adjacent country (Hawes, Ling & Dixon, 2015, map 3). Hardening tends to increase this impact as it increases the ease and speed of access, even when it is undertaken primarily for environmental reasons. Hardening also affects the visual and surface character of the track and hence the walking experience, especially when undertaken extensively (more than 25 km of the Overland Track is now artificially surfaced in some way). Vannini and Vannini (in prep.) reflect on how boardwalks on the Overland Track impact the relationship between walker and environment.

Managers often do not have free reign to choose between the full range of options for addressing recreational impact problems on tracks and campsites (see Section 1.4). In the case of the Overland Track, there was a general preference to address problems in situ rather than disturb yet-more sensitive alpine country. Furthermore, until after the start of

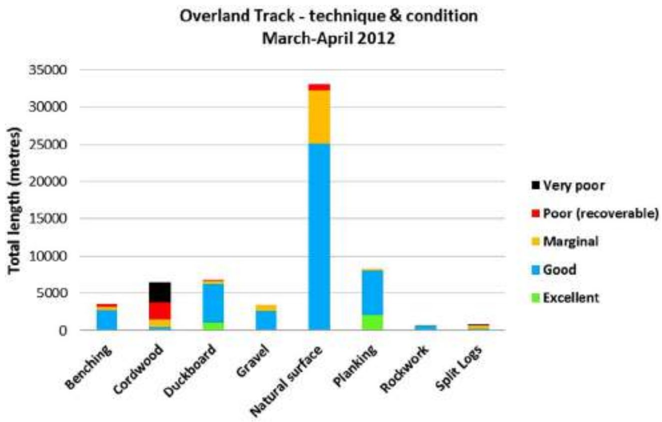


Fig. 4. Total lengths and condition of tread hardening techniques on the Overland Track; example from 2012. Duckboard = boardwalk; rockwork = paving or pitching; natural surface = generally unimproved surface but may have scattered steps or water-bars; planking = photo 6; split logs = locally-sourced fallen logs longitudinally-split and laid like planking. See Table 3 for condition category definitions.

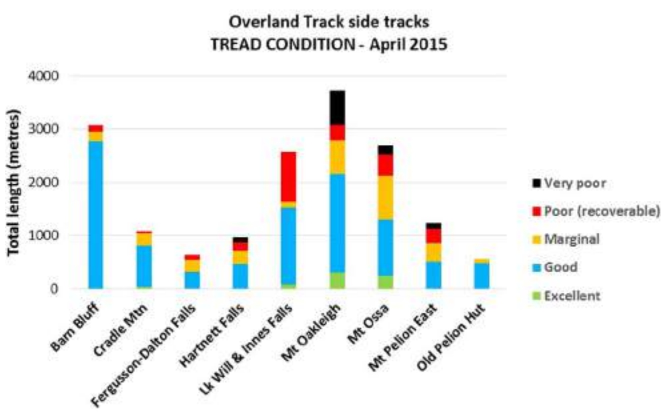


Fig. 5. Total lengths of various tread condition classes on the Overland Track side tracks; 2015. See Table 3 for condition category definitions.

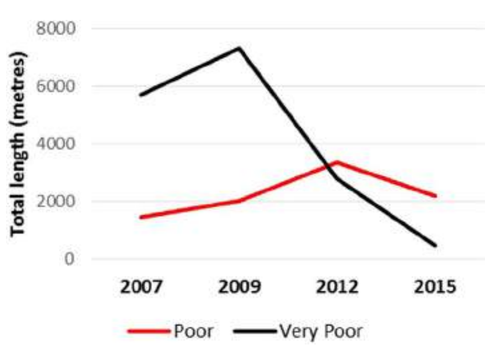


Fig. 6. Change in total length of the Overland Track in "poor" or "very poor" condition (see Table 3), 2007–2015.

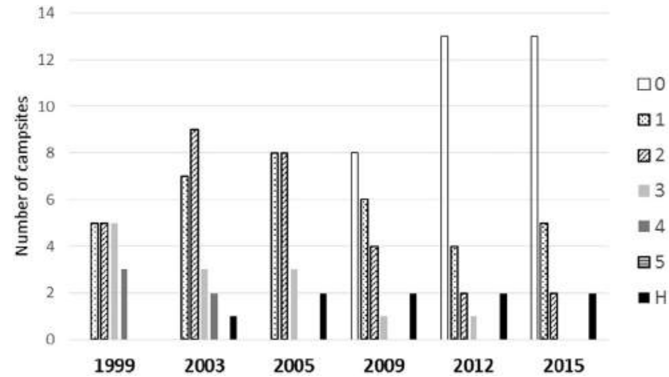


Fig. 7. Change in number of campsites, in different condition classes (see Table 4), at New Pelion overnight node, 1999–2015. H = hardened campsite.

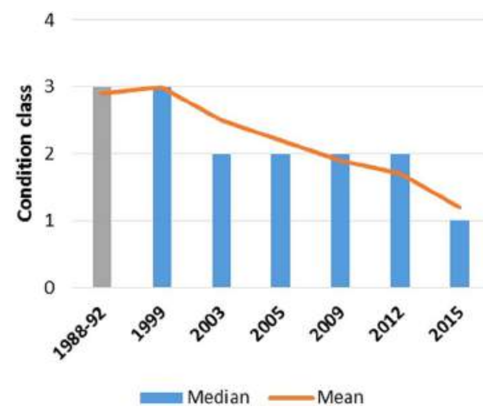


Fig. 8. Median and mean condition class (see Table 4) for campsites on the Overland Track, 1999–2015. Sites hardened by the construction of timber platforms (Photo 5) post-2000 have been considered class 2 for this exercise. Data includes all campsites since 1999 but only a sub-set of 42 campsites for 1988-92, but the latter is included here for comparison purposes.

the fee-based booking system in 2005, the availability of resources to undertake works was often limited and intermittent hence constraining the capacity for the longer-term planning necessary to consider major rerouting or relocation of tracks or campsites. Similarly, the selection of material to be used for hardening (mostly dimensional timber rather than more natural materials) was mostly about minimising the cost and maximising the extent of works that could be undertaken with the resources available.

Despite several hiccups due to the intermittent availability of resources for track repair and upgrade works in the late 1990s and early 2000s (with track and campsite conditions deteriorating when resources for repair were scarce), overlain with the progressive deterioration of 1980s era cordwood tread surfacing, the condition of the Overland Track improved notably during the 2009–2015 period. This was due to an ongoing, planned works program involving extensive tread hardening, guided by data collected during this study, and adequately funded by fees from a walker booking system introduced in

Photo 7. Evolution of a campsite near Waterfall Valley hut; 1995 (left, condition class 1), 2003 (centre, class 3–4) and 2015 (right, recovery to class 2). This campsite was closed in 2005.

2005. A mere 4% (2.7 km) of the Overland Track is now (2015) considered to be in poor condition and this is likely to be addressed within 2–3 years. Serious problems remain on some mostly-unimproved side tracks, but the spatial data collected during this study has the capacity to assist planning for repair works on those tracks also.

Campsite impacts also escalated through the 1990s but Overland Track campsite conditions have displayed an overall improving trend since 1999. This pre-dates the 2005 introduction of the Overland Track walker booking system (which regulates and limits peak-season daily departures on the Overland Track) and is probably associated with changed campsite use due to the campsite hardening program, which commenced at Kia Ora in 2000, and Windermere and Windy Ridge soon after. Robust (either timber platforms or hardy ground) campsites now exist at all major overnight nodes on the Overland Track. No data on any changes in overall campsite use patterns has been collected but track ranger observations suggest a greater concentration of camping use at hardened sites co-located with huts. Certainly walkers are now encouraged to use such sites, although they are not formally designated (for non-commercial users) and unrestricted informal camping is still permitted, but perhaps this is not surprising given they are dry and flat (compared to many unimproved sites they replaced), and located near roofed shelter (attractive if the weather is bad) and toilet facilities.

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