# The sound of one foot falling: How do you measure the impact of recreational events within national parks and other reserves?

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**Abstract:**

As the general populace is encouraged to spend more time engaged in exercise and active participation in sports, the interest in large outdoors events continues to grow. For sports such as orienteering and rogaining, the natural environment is a very significant part of the total experience. As a result competing in near natural areas is highly desired. While such uses have been taking place in natural areas in Australia and New Zealand for several decades with no apparent significant impacts, the scale of some events (up to 1000 competitors) has raised concerns that reserved areas could be 'loved to death'.

The management of the environmental impacts from a major national orienteering event caused controversy and media interest due to the potential for impacts on natural ecosystems. In response to these concerns, a range of monitoring approaches was deployed to assess visitor impacts.

These monitoring methods consisted of:

- Landscape Function Analysis (LFA) – focused on soil and vegetation testing of impact and control zones
- Quantitative assessment of surface characteristics – using a range of photographic and direct measurement approaches based on circular quadrats at checkpoint sites.

While scientific studies in Europe have demonstrated a low environmental impact of orienteering, this was the first time that monitoring had been attempted at this scale in the Southern Hemisphere. The results from both methods were consistent in showing that there was an immediate detectable change, particularly where more than 300 competitors had passed through an area. After a year of recovery, however, the environmental conditions tended to return to the pre-event conditions, with no apparent long term effects.

These findings have supported adaptive management for both the area itself and for the planning of future events, demonstrating the linkage between strong science and better reserve policies.

**Keywords:** Landscape Function Analysis, monitoring, adaptive management, orienteering

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## Introduction

For bushland navigational sports such as orienteering and rogaining, the natural environment is a very significant part of the total experience. As a result, competing in near natural areas is highly desirable, and such areas have been used regularly for orienteering events and similar activities for over forty years. Over this period, major orienteering events in Australia have grown to attract of the order of typically 800 to 1,000 participants, and have raised concerns among some people that such areas could be 'loved to death'.

In an orienteering event, competitors are required to follow a course which consists of a series of checkpoints ('controls' in orienteering terminology), usually in a specified order, but are free to choose their own routes between checkpoints. This choice has the effect of dispersing competitors throughout the terrain, reducing the risk of concentrated impacts, except at the checkpoints where the competitors converge. Any impacts of orienteering therefore are likely to be concentrated mainly around the checkpoint sites. Other areas of high concentration are around the event assembly area and occasionally along compulsory routes which may be identified to channel competitors to the finish line or to avoid hazards or environmentally sensitive areas.

Areas within Namadgi National Park in the Australian Capital Territory have been used for major orienteering events (e.g. ACT and Australian Championships, as well as international competitions) every few years since 1973, well before the national park was declared. In addition, the park is used regularly for small local events which typically attract about 100 participants.

The Namadgi National Park Plan of Management 2010 states in relation to orienteering: 'Occasional large national or international events may be held in Namadgi. These should aim to showcase both the sport and a high standard of environmental management.'

The focus on Namadgi National Park for orienteering results from the fact that the park contains the highest quality orienteering terrain that is available within or close to the ACT. Consequently, it has been widely favoured for occasional large orienteering events which are essential to recoup the substantial costs involved in preparing the specialised maps that the sport requires, and which in turn are used in due course for local events.

In 2009 Orienteering ACT (OACT) sought permission to hold one day of the Australian Three-days competition in the areas surrounding Gudgenby Homestead, within Namadgi National Park on Saturday 3 April 2010 (over the Easter long weekend). This application caused significant concern within sections of the community and local media, particularly over the use of native grassland areas within the park. While the event was approved by the ACT Government, one of the conditions of the approval arising from the above concerns was a requirement for an independent monitoring study to be undertaken. Cormac Farrell of Aurecon Australia was appointed by the ACT Government to undertake this study, which was jointly funded by OACT and the ACT Government. This study was overseen by a Steering Committee consisting of representatives of ACT Parks Conservation and Lands, OACT and the National Parks Association of the ACT.

There were three main objectives to the Aurecon monitoring program:

- to determine if any environmental impact was observable, and to map the extent and severity of any impacts around checkpoint sites and in other high use areas;
- to determine the recovery time within sensitive environments should any impacts be detected; and
- to separate any impacts from the event from normal background processes.

As a parallel study, David Hogg and Frank Ingwersen, on behalf of OACT, undertook monitoring of checkpoint sites with a specific purpose of determining how many orienteers needed to visit a checkpoint to cause a level of immediate impact that critical observers may consider to be ‘significant’. It was assumed that there would be some immediate impact but the study documented the nature of this impact and correlated the level of impact with the number of visitors to each site.

While the environmental impacts of orienteering have been subject to numerous scientific research studies throughout the world (e.g. Parker 2005), there have been only limited studies of this nature in Australia. Within Namadgi National Park, there have been some selected observations of the effects of orienteering in areas of high concentration, but no rigorous scientific studies.

Both of the studies presented in this paper (Aurecon Australia 2012, Hogg and Ingwersen 2012) are available for reference on the OACT website. This paper presents a summary of the two studies and the relationship between them.

## Methodology

*Description of the study area*

The monitoring program was set within a section of Namadgi National Park, with the overall orienteering event area covering an area of the park 1.5km wide and 2.5km long to the north of the Gudgenby Homestead and west of the Boboyan Road (see Figure 1). The monitoring sites were located within the most intensively used part of that area. The project area is dominated by Temperate Montane Grassland and Subalpine Woodland, with the northern portions dominated by Southern Tablelands Dry Sclerophyll Forest (Keith 2004). As a result the project methodology was designed to capture both grassland and forested areas across the site.


**Figure 1: Overview of the study site**

The grassland areas in particular contain a mix of summer growing pastures such as Kangaroo Grass (*Themeda australis*) as well as winter growing pasture species such as Snow Grass (*Poa sieberiana*). These form the major pasture species across the site, and their growth rates are strongly influenced by the seasons. The area close to Gudgenby Homestead also contains a significant component of exotic pasture species and weeds.

The overall climate across the site is temperate, with four distinct seasons and a wide temperature range (ranging from thirty nine degrees in summer to minus ten degrees Celsius in winter) and a historic average rainfall evenly distributed throughout the year. This diversity in the growth response of grasslands across the seasons meant that the monitoring program needed to extend through a full year in order to capture an effective sample. The monitoring program coincided with the end of a major period of drought, and as a consequence the results should be seen in the context of recovering grassland that is growing strongly from stored soil seed banks.

This seasonal growth response is further complicated by the diverse species mix of grasses and forbs within the grassland areas, which includes both perennial tussock growing grasses (such as the ones noted above) as well as annual grasses such as Hairy Panic (*Panicum effusum*) which increased as a proportion of the pasture following abundant spring and summer rain.

The geology of the area is dominated by the volcanic rock, adamellite, loosely described among orienteers as 'granite'. The numerous boulders, outcrops, rock faces and bare rock slabs found in granite terrain are the main feature that makes this terrain highly valued for orienteering, not only in the ACT but throughout Australia, with a high proportion of large national or international events in Australia being held in such terrain.

### *Initial design of monitoring programs*

The high diversity and dynamic nature of grassland communities meant that a methodology that relied on species composition would run a high risk of encountering significant variation, and would require a high number of control sites in order to manage the variability or 'noise' in the data. This was a significant factor in the eventual choice of a sampling methodology based around physical soil processes and landscape function that are relatively independent of ecological changes.

The methodology selected for the Aurecon study utilised the Landscape Function Analysis (LFA) technique developed by CSIRO Sustainable Ecosystems (Tongway and Hindley 2004). This method is based on the initial categorisation of monitoring plots into 'patches' of vegetation that divert or absorb water and 'inter-patch' zones that nutrients and water flow over. Within these discrete zones a series of detailed soil surface assessments are carried out that are combined to provide indicators of stability, infiltration and nutrient cycling.

The strength of this method is that it focuses on fine-scale changes to the soil surface characteristics, including characteristics that are likely to be influenced by foot traffic, such as soil surface crusts, cryptogams (small surface lichens, algae etc) and fine-scale erosion effects.

The LFA technique was applied to locations within the orienteering competition area that were expected to experience relatively high levels of impact during the event. Orienteering requires competitors to navigate across a set course to a series of controls ('checkpoints'), where they record their visit electronically or by punching a card. The challenge of orienteering comes not only from running fast, but also from the need to navigate quickly and accurately using a map and compass, and selecting the fastest route between checkpoints. This route can vary for different competitors according to their physical fitness and navigational skills.

While runners are concentrated at the checkpoint sites, where any impacts are most likely to be detectable, they tend to disperse between checkpoints according to the route selected, unless there is an obvious feature such as a road or track which offers fast running or easy navigation. Orienteering events normally incorporate several different courses which may feature some common checkpoints but use these in different combinations, thus further dispersing competitors within the terrain. The number of competitors visiting a checkpoint can be predicted from the course design information and confirmed from electronic records. For purpose of the LFA assessment, six checkpoints (one with two transects) were selected, representing a range of environmental characteristics and a range of competitor numbers (between 136 and 827 competitors).

The area of highest people concentration at an orienteering event, however, is at the assembly area and associated parking area. This was of particular concern for this event as the proposed parking area was on grasslands immediately to the north of the Gudgenby Homestead. The event organisers had planned to have parking areas carefully controlled, and were able to nominate specific areas pre-event. This allowed the placement of a long transect for the LFA method through the parking area.

In addition, an area of rehabilitation which was identified as an environmentally sensitive area was fenced off with warning tape to exclude competitors. Competitors were diverted along a route outside the sensitive area which was policed by an OACT course marshal. This exclusion zone created an opportunity to create paired impact control sites for the LFA monitoring along the exclusion fence. Direct observation during the event confirmed that no runners entered the exclusion zone.

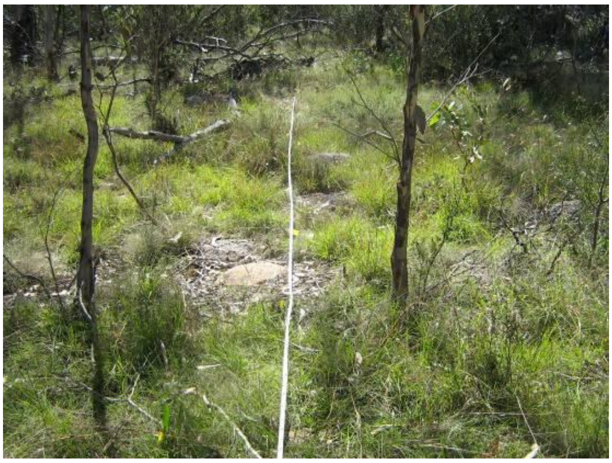
The main characteristics of the LFA monitoring sites, some of which are illustrated in Figure 2, are summarised in Table 1.

**Table 1: LFA site descriptions**

| Site | Site characteristics | No. of competitors |
|---|---|---|
| Checkpoint 140 | Southern Tablelands Dry Sclerophyll Forest with a sparse shrubby understorey. Groundcover dominated by leaf litter. Predominantly sandy decomposed granite soil. | 136 |
| Checkpoint 141 | Southern Tablelands Dry Sclerophyll Forest with a shrubby understorey. Ground cover dominated by leaf litter. Sandy decomposed granite soil with abundant populations of soil fungi. | 334 |
| Checkpoint 142 (2 transects) | Southern Tablelands Dry Sclerophyll Forest. Grassy understorey. In valley floor adjacent to creek line. | 270 |
| Checkpoint 129 | Subalpine Woodland. Groundcover of leaf and bark litter interspersed with Kangaroo Grass. Decomposed granite soil on steep slope. | 296 |
| Checkpoint 145 | Subalpine Woodland. Open grassy understorey (Kangaroo Grass) with scattered shrubs. | 390 |
| Checkpoint 200 (finish chute) | Temperate Montane Grassland dominated by Kangaroo Grass adjacent to drainage line. | 827 |
| Powerline site (paired impact and control) | Temperate Montane Grassland dominated by a dense swathe of Kangaroo Grass. | 500+ |
| Parking area (long transect) | Open grassed area with native and exotic grasses and clover. | NA<br>300 cars |

Checkpoint 141

Checkpoint 142



Checkpoint 145

Powerline site (paired control and impact)

**Figure 2: Examples of sites used in LFA method**

The Quadrat Analysis method focused on a quantitative assessment of surface characteristics, specifically groundcover, shrubs, litter, bare ground and rock.

A circular quadrat one metre in diameter, was placed at the checkpoint stand (see Figure 3), and an assessment was made of the relative proportions of each of the above surface characteristics. This record was backed up with both photographs and sketch records taken of the sampled area. The sketch records extended for a further 0.5 metre from the perimeter of the quadrat.

The focus on the areas immediately adjacent to control stands was based on the assumption that such areas which, in some cases, would be visited by several hundred orienteers during the course of the event, would be the areas most likely to show the impacts of high use levels within the course area. The main objective of monitoring these areas was to correlate the level of impact with the number of orienteers visiting the control site, with a view to applying this information to the planning of future events and minimising the risk of immediate impacts at a level which critical observers may consider to be ‘significant’. A further objective was to assess the extent to which affected sites would recover following a spring/ summer growing season.

**Figure 3: Example of site used in Quadrat Analysis**

The number of competitors visiting each checkpoint was determined using the SportIdent electronic checking system, a technique used routinely at all major orienteering events in Australia. Figure 4 shows the numbers through all of the checkpoints used for the event, with the points monitored by the LFA method highlighted. The numbers of competitors at the monitored sites ranged from 136 to 187. The number of competitors passing along the route adjacent to the exclusion site was determined by direct observation, with just over 500 competitors observed crossing the test transect, and none passing through the exclusion area.

For the Quadrat Analysis method, 25 checkpoints were monitored, with the number of visits ranging from 66 to 429.

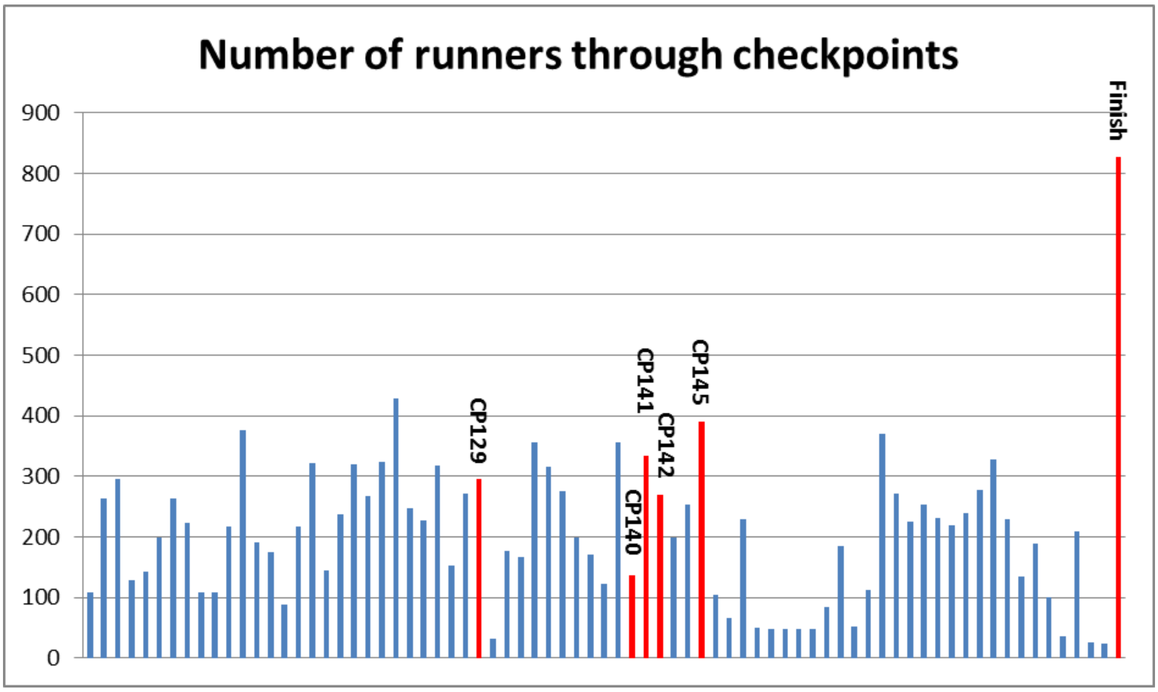



**Figure 4: Analysis of checkpoint visits with monitored plots highlighted**

Both methods involved sampling on three occasions, as listed in Table 2. The event was conducted on 3 April 2010.

**Table 2: Sampling dates**

| Occasion | Dates | |
|---|---|---|
| | **LFA method** | **Quadrat analysis** |
| Pre-event | 25-28 March 2010 | 31 March 2010 |
| Immediate post-event | 8 April 2010 | 6 April 2010 |
| One-year post-event | 28 January 2011<br>8 April 2011 | 30 March 2011 |

**Results – Landscape Function Analysis Method**

The study area included a diversity of soil types, aspects and slope positions, and as a result direct comparisons between the sites are difficult. Despite this, the availability of exact visitation data at checkpoints allows for some comparison to be made between similar points, as well as the use of paired sampling points at the Powerline site (impact and control) and Checkpoint 142 (separate transects, both monitoring impact sites).

The Landscape Function Analysis provides estimates of three aspects of landscape function, these being stability, infiltration/ runoff and nutrient cycling. The indicators most likely to be impacted by runners were the ones contributing towards the stability scores, however several of these tests also contribute towards the calculations for nutrient cycling and infiltration (such as litter cover). Therefore impacts can be expected to be detectable for all sites to varying degrees due to the inter-relationship between the landscape functions. These indicators are derived from a series of fine-scale soil surface tests, which are applied to patches (actively growing, accumulation zones) and inter-patch (transition zones) separately.

The individual soil tests are as follows:

**Soil cover** - testing the degree to which vegetation covers the soil from rain splash. Only the understorey layer is considered during this test.

**Perennial grass basal cover** - tests the proportion of the soil surface that is taken up by actively growing plants

**Litter cover** - includes two components, both the degree of soil coverage, as well as the source and degree of decomposition. This is also the only test that influences all three output areas (Stability, Infiltration, Nutrient Cycling) and is also significantly affected by foot traffic.

**Cryptogam cover** - measures the degree to which mosses, lichens and micro-ferns cover and stabilise the soil surface.

**Crust brokenness** - tests whether a stable crust has formed at the soil surface, and whether there are any breaks in this crust

**Erosion type and severity** - is relatively self-explanatory, classifying the type of erosion acting on the site and the severity

**Deposited materials** - tests whether the sampling site is actively collecting material washed or eroded from other parts of the landscape

**Surface roughness** - relates to how effectively the soil surface can capture and retain material

**Surface resistance to disturbance** - tests how easily the soil can be penetrated, indicating the level of porosity and stability

**Slake test** - tests how stable a small sample of soil is as it goes from a dry to wet state

**Soil texture** - classifies the soil into a broad grouping.

Each soil test is scored against a set of condition descriptors, and this forms the basis of the analysis. It should be noted that the slake test relies on obtaining a dry soil sample, and as a result rain can significantly disrupt the monitoring program.

The relationship between the soil tests and the three indicators is summarised in Table 3.

While the three indicators can be calculated manually, for simplicity Excel calculation sheets that form part of the LFA Procedures Manual cited above were used to derive these values. These data sheets also assign weightings to the ‘patch’ and ‘inter-patch’ zones within each monitoring plot. While the patch and inter-patch areas are generally grassy swaths and litter scatter areas, in the case of the car parking area the original long transect was later re-classified into high/ medium/ low traffic zones following the event.

**Table 3: Relationships between soil tests and indicators**

| | Indicator | | |
|---|---|---|---|
| **Soil test** | **Stability** | **Infiltration/ runoff** | **Nutrient cycling** |
| Soil cover | + | | |
| Perennial grass basal cover | | + | + |
| Litter cover | + | + | + |
| Cryptogam cover | + | | + |
| Crust brokenness | + | | |
| Erosion type and severity | + | | |
| Deposited materials | + | | |
| Surface roughness | | + | + |
| Surface resistance to disturbance | + | + | |
| Slake test | + | + | |
| Soil texture | | + | |

*Stability*

Stability is a measure of how resistant the landscape is to erosion, as well as the ability to reform after a disturbance event. Significant instability can result in the landscape losing nutrients and biological reserves such as seed stocks at a faster rate than they are replaced, resulting in a degradation over time.

Of the eight soil tests affecting stability, soil cover, litter cover and cryptogam cover were anticipated to be the most disturbed by excessive foot and vehicle traffic, and were likely to show the most direct impacts. As it turned out, soil cover and litter cover in particular showed a distinct impact from the runners immediately post event.

Figure 5 presents the results for the aggregated stability index for each of the monitoring points at the checkpoint sites and exclusion area.

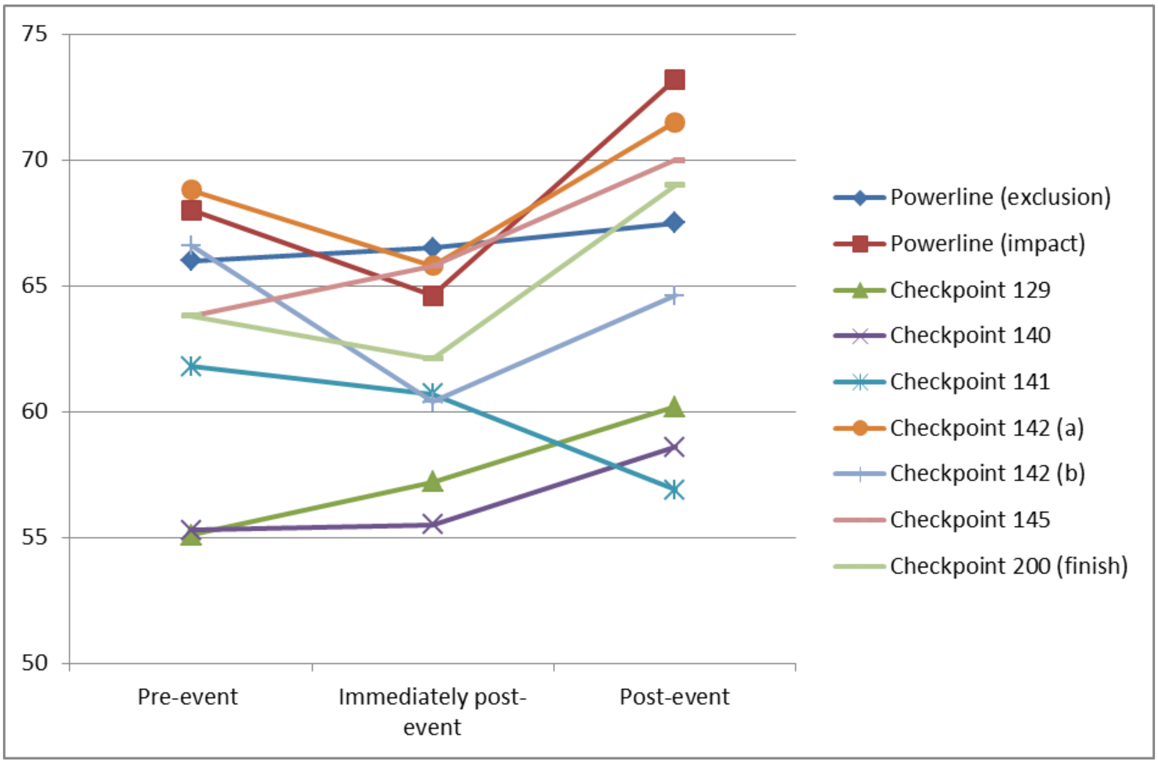



**Figure 5: LFA Stability results (%) for checkpoints**

There was a distinct difference over time between the indicators for Stability for the Powerline exclusion area and many of the other sites. The Powerline exclusion zone showed a slow increase in the overall stability index, which fitted with the observed increase in vegetation as the grassland responded to the wet summer. In contrast, most of the checkpoint zones showed a distinct 'dip' in stability immediately post event, which then recovered to above pre-event levels. This again fitted with the observed conditions at the sites, where the distinct tracks produced by runners disappeared as the spring and summer growth took hold.

The one point to move away from this trend was Checkpoint 141. In this instance the stability index continued to reduce as the year progressed. One explanation for this result could be that the substrate at this site is dominated by leaf litter, and would not have any significant vegetative growth that could regenerate following disturbance. The heavy spring and summer rains could be expected to increase the movement and overall instability at this site, and that fits with the observed data. It should be noted that stability at this site was impacted by a range of factors, including background water movement of litter, as well as intermittent disturbance by foraging fauna, particularly lyrebirds.

It should be noted that Checkpoints 129, 140 and 145 only showed a very weak indication of impact immediately post event, and both checkpoints 129 and 145 had less than 300 runners through them. In contrast, the remaining checkpoints that had more than 300 runners appeared to show a clear impact signal in the data.

Checkpoint 145 had a much higher number of runners passing through (390) and yet showed no significant loss of stability as a result, despite a clear path being apparent. As noted previously, the transect was at right angles to the paths and it is likely that the transect only partially captured the impact zones entering and exiting this checkpoint, resulting in a poor efficiency of detection.

The results for the parking area (Figure 6) were similar to those of the checkpoints with a higher visitation rate, with a distinct 'dip' in stability condition detected immediately post-event, and then a recovery. The original long transect data from the pre-event monitoring was re-classified immediately post-event to capture the observed traffic areas, with the high traffic zone (wheel ruts) identified as the highest traffic zone, followed by the upper parking bays and lower parking bays. The results show that the high traffic zone had the highest impact signal, as well as the lowest recovery, followed by the upper parking bays and lower parking bays.

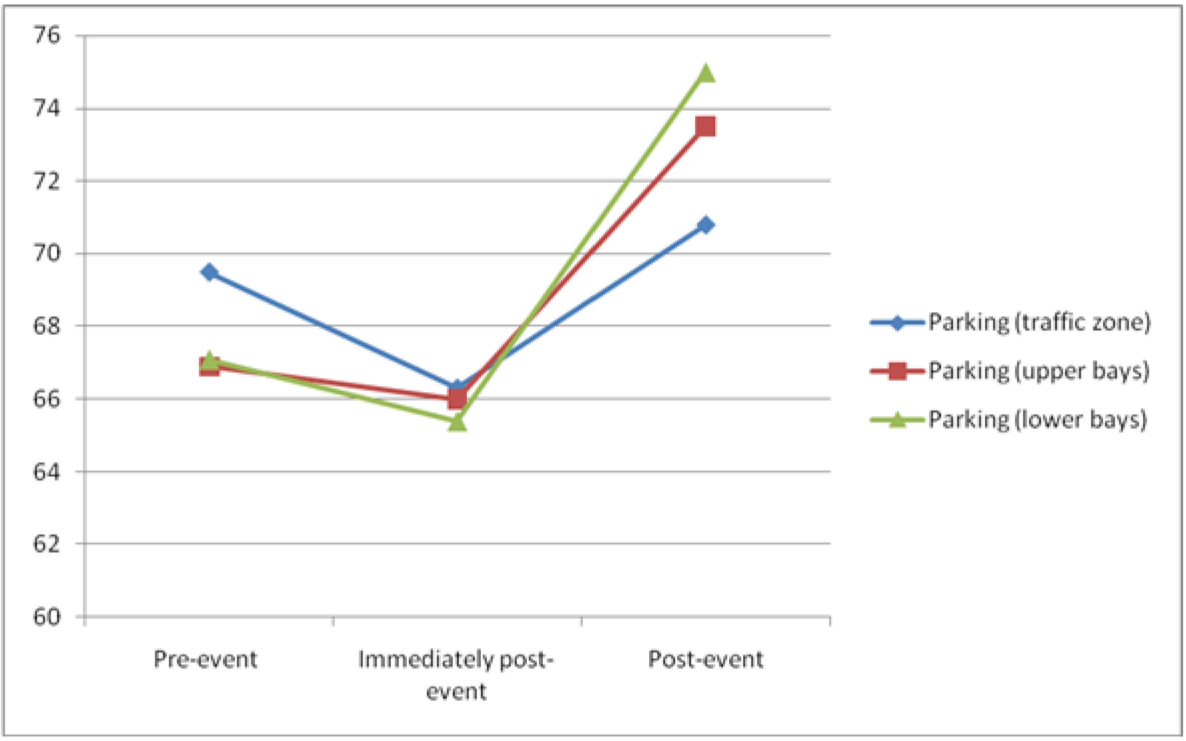



**Figure 6: LFA Stability results (%) for the parking area**

While all areas recovered to above their pre-event levels after a year, these results did demonstrate a clear impact signal from intensive wheel traffic that was distinct from occasional parking of cars. One interesting observation in the field during sampling was that the native perennial tussocks were relatively unaffected by the wheel traffic and re-sprouted post-event, whereas the exotic clovers suffered significant crush damage at their soft lower stems, and were generally killed outright and did not re-sprout, although this may also have been influenced by seasonal effects.

*Infiltration/ Runoff*

The infiltration and runoff index is a measure of how effectively the soil is able to retain moisture within the root zone, as well as the potential to capture runoff. Soil infiltration in a native pasture can often be highly variable and is affected by seasonal effects (particularly frost), fire and storm events. Soils within many grassland and woodland areas readily become hydrophobic, and several of the adaptations found in native grass seeds (such as the mechanical drilling action of Themeda seeds) appear to be in response to impermeable soils.

The tests affecting infiltration/ runoff are more heavily influenced by the natural properties of the soil, as well as long term conditions such as perennial plant cover. These tests are unlikely to be strongly influenced by the impact of footfalls, and as a result it was predicted that these would not be as effective as the stability indicators at monitoring the impact in this study.

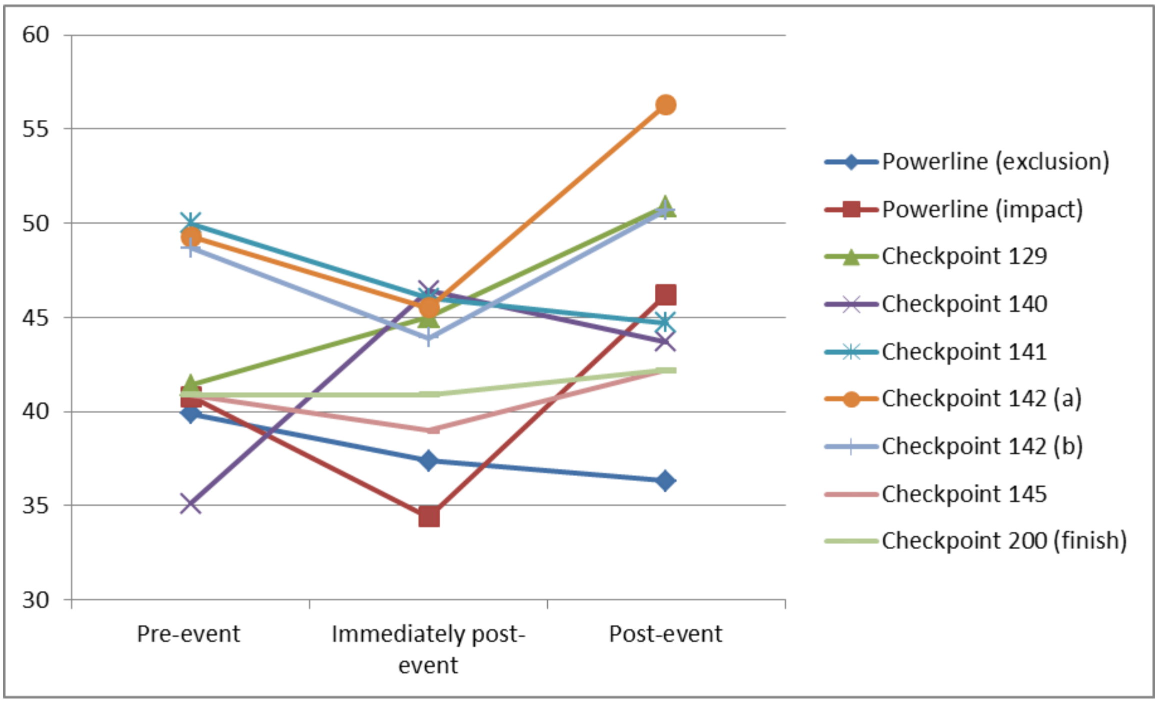



**Figure 7: LFA Infiltration results (%) for checkpoints**

The infiltration/ runoff results for the checkpoints and exclusion area are illustrated in Figure 7. As a general comment there was more 'noise' in the data for this indicator, with greater disparity between the number of sites showing a detectable impact and those showing little or no effect. As noted above this can be explained by the input indicators into the infiltration/ runoff index being more strongly influenced by long-term soil and surface characteristics. Even with high numbers of runners, there was not enough damage to cause permanent loss of tussocks. There were several checkpoint results that either did not show any impact effects from the event, or where these were not statistically significant.

For those that did show this impact, particularly the Powerline impact transect and Checkpoint 142(a), this was associated with the transect running along a distinct pathway that had formed following runners taking a consistent path. This was not always consistent, however – the finish checkpoint (200) had the highest number of runners and yet did not show any significant impact on the infiltration/ runoff function.

In contrast to the results for checkpoints, there was a distinct and detectable impact within the parking area (see Figure 8). The results for the Parking Bays show a strong impact trend for the trafficked areas, a lesser but still detectable impact for the upper bays and no detectable impact for the lower bays. These results are in line with the observed on-ground evidence of traffic use, and fits with the observed loss of exotic clovers within the wheel ruts. There was also a consistent recovery trend in the post-event data, however more data points (a minimum of six time series samples) are required to determine if this area has returned to baseline conditions (Tongway and Hindley, p. 62).

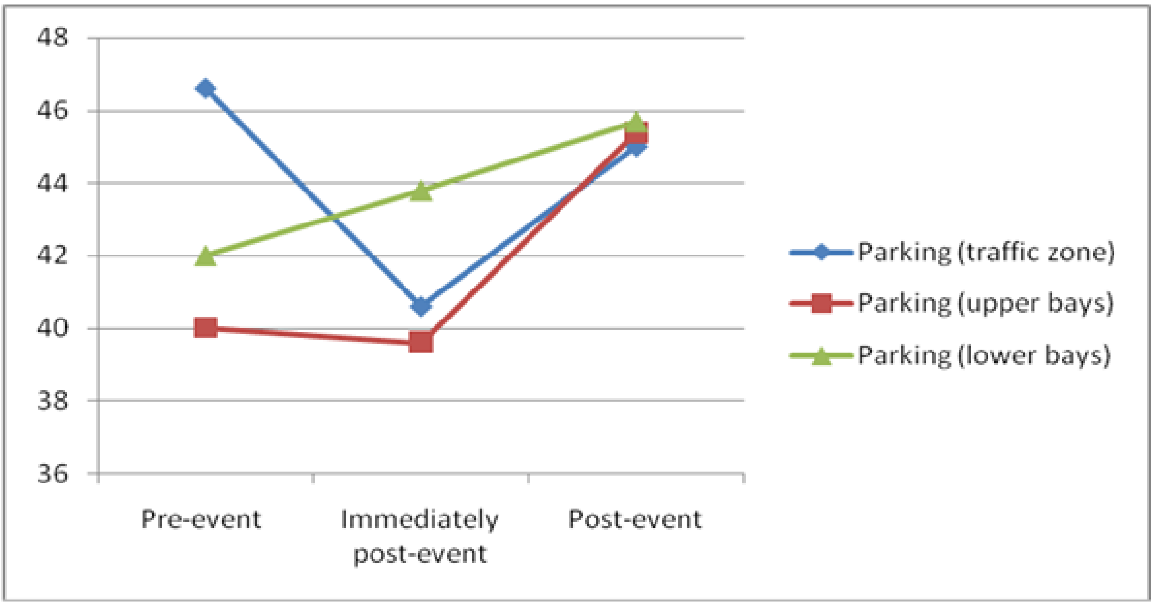



**Figure 8: LFA Infiltration results (%) for the parking area**

*Nutrient Cycling*

The nutrient cycling component of LFA measures how efficiently organic matter is cycled back into the soil. There is a clear relationship with the other indices, as some degree of stability and water retention is required for these biological processes.

As with the infiltration/ runoff index, several of the relevant indicators are based around long term environmental conditions, however during the field testing it was noted that the cryptogam cover test was a particularly important indicator. The soil level under the native grassland areas had a surprisingly rich and diverse cohort of soil microflora, including algae, lichens, mosses and miniature ferns. These appeared to play an important part in the maintenance of soil integrity and moisture, and were sensitive to disturbance.

As noted above for infiltration/ runoff, this index is based on attributes in the soil that are subject to longer term effects (excepting litter cover), and as a result are unlikely to be as effective in detecting impacts. This is borne out in the data shown in Figure 9, with only sites with a strongly defined path showing any detectable effect, and again the site with the highest number of runners through it not showing a strong impact trend.

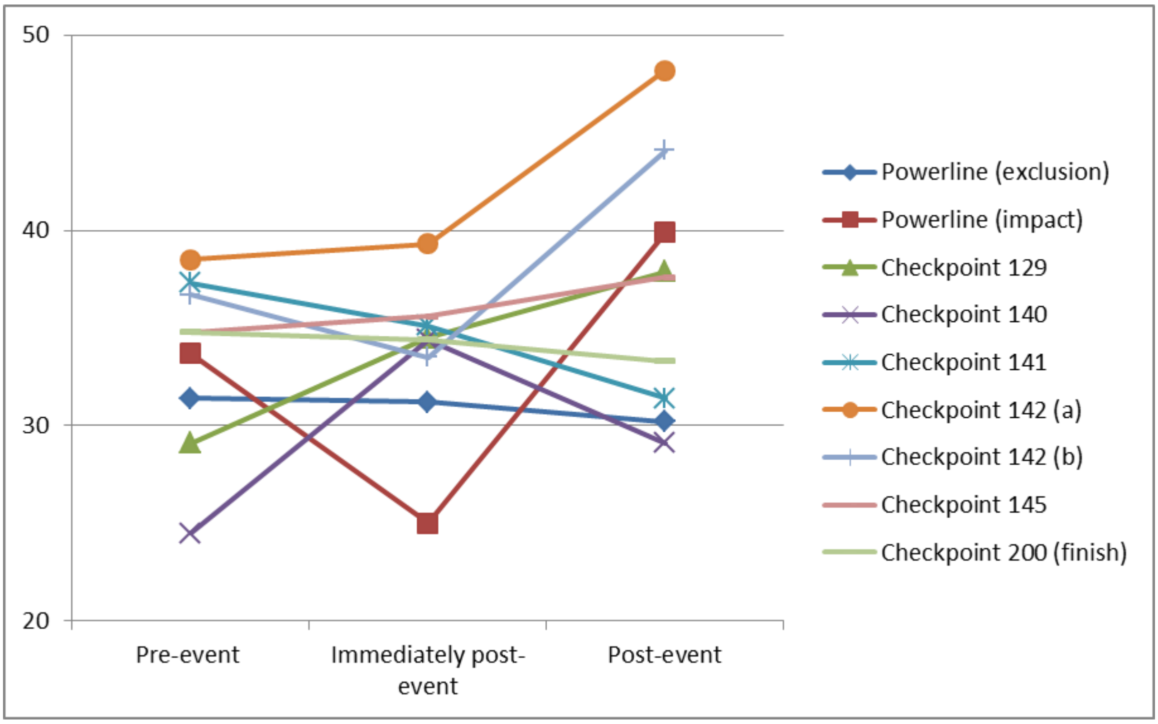



**Figure 9: LFA nutrient cycling results (%) for checkpoints**

The results above show the indicators for the Powerline exclusion area (control) staying essentially constant during the monitoring program. In contrast the adjacent Powerline impact area showed a significant dip in nutrient cycling function, followed by a rapid recovery. The most surprising result was for the finishing checkpoint, which had the highest number of runners and a clear visual impact. This did not show any significant change in the nutrient cycling indicator.

The nutrient cycling results from the parking area (Figure 10) show a distinct impact signal for areas subjected to regular traffic sufficient to leave visible wheel ruts. As with the data for infiltration/ runoff, there was also a clear recovery in the grassland areas that appeared to converge at a particular level of condition, however there is not enough data to confirm whether this has reached a baseline level that is maintained in the long term. The methodology requires at least six time series point to establish this.

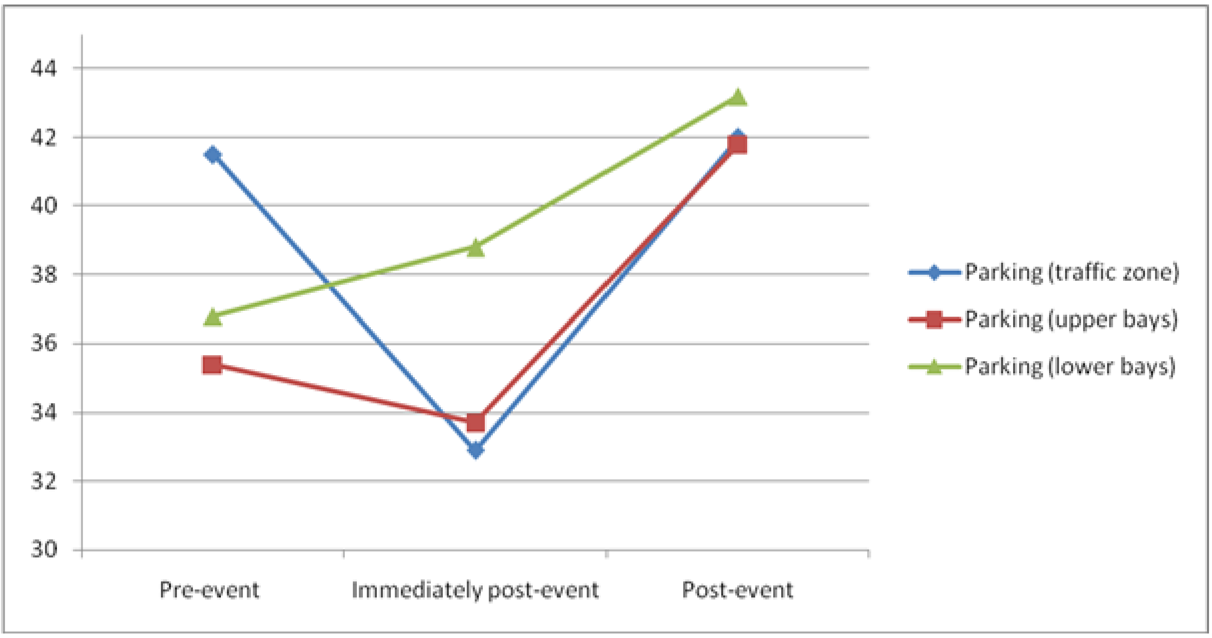



**Figure 10: LFA nutrient cycling results (%) for the parking area**

### Results – Quadrat Analysis Method

From each of the checkpoints the results were summarised in terms of a subjective assessment of the overall post-event and one-year impact using the descriptor scale of 'negligible' to 'major'. This assessment was based on both the quantitative data and the sketches, the relative impacts at each control site compared with the pre-event situation being estimated subjectively according to the following descriptions and criteria:

**Negligible**

- No apparent sign of disturbance

**Minimal**

- No significant changes in areas of bare ground

**Minor**

- Small areas of bare ground due to litter disturbance
- Minor changes to the relative areas of the various types of cover

**Moderate**

- Moderate areas of bare ground due to litter disturbance
- Minor damage to groundcover or low shrubs
- Major changes to the relative areas of the various types of cover

**Major**

- Large areas of bare ground
- Groundcover disturbed at base, giving rise to bare ground
- Extensive damage to low shrubs
- Movement of loose rocks.

Disturbance in the ‘major’ category was considered likely to be obvious to anyone who was critically concerned about the impact of the event, while the other categories of disturbance are probably unlikely to be noticed or to cause concern.

Table 4 presents a summary of the overall post-event and one-year impact assessments, while Table 5 identifies the nature and extent of the post-event impacts in further detail. Both tables list the controls in increasing order of the number of competitors passing through them.

**Table 4: Summary of impacts in relation to competitor numbers**

| | | Impact assessment | |
|---|---|---|---|
| **Control no.** | **No. of competitors** | **Post-event** | **One-year** |
| 147 | 66 | Minimal | Not monitored |
| 170 | 100 | Minimal | Not monitored |
| 146 | 105 | Minor | Negligible |
| 157 | 112 | Moderate | Negligible |
| 138 | 123 | Minor | Not monitored |
| 168 | 135 | Minimal | Not monitored |
| 132 | 167 | Moderate | Negligible |
| 114 | 175 | Moderate | Minor |
| 155 | 184 | Moderate | Negligible |
| 106 | 198 | Minimal | Not monitored |
| 116 | 216 | Moderate | Minor |
| 160 | 226 | Minor | Negligible |
| 148 | 230 | Moderate | Negligible |
| 144 | 253 | Minor | Negligible |
| 161 | 254 | Minor | Not monitored |
| 128 | 271 | Minor | Negligible |
| 129 | 295 | Moderate | Negligible |
| 134 | 315 | Moderate | Negligible |
| 120 | 320 | Major | Minor |
| 117 | 321 | Major | Negligible |
| 122 | 324 | Major | Minor |
| 166 | 328 | Moderate | Negligible |
| 133 | 356 | Major | Minor |
| 145 | 390 | Moderate | Negligible |
| 123 | 429 | Moderate | Minor |

**Table 5: Nature of impacts directly post-event**

| Control no. | No of competitors | Flattening of grass | Litter disturbance/ exposure of bare ground | Damage to groundcover | Damage to low shrubs | Movement of loose rocks or sticks | Lichen damage |
|---|---|---|---|---|---|---|---|
| 147 | 66 | + | | | | | |
| 170 | 100 | + | + | | | | |
| 146 | 105 | | + | | | | |
| 157 | 112 | | ++ | | ++ | | |
| 138 | 123 | | + | | | | |
| 168 | 135 | | + | | | | |
| 132 | 167 | ++ | + | | | ++ | |
| 114 | 175 | ++ | ++ | # | | | |
| 155 | 184 | | | | ++ | | |
| 106 | 198 | + | | # | | | |
| 116 | 216 | | ++ | # | + | | |
| 160 | 226 | + | + | + | | | |
| 148 | 230 | | ++ | | | | o |
| 144 | 253 | | + | +/ # | + | | |
| 161 | 254 | + | + | | | | o |
| 128 | 271 | | + | | | | + |
| 129 | 295 | ++ | + | ++ | | | + |
| 134 | 315 | ++ | ++ | | | | |
| 120 | 320 | | | | +++ | | o |
| 117 | 321 | | ++ | # | # | ++ | o |
| 122 | 324 | | +++ | | | | |
| 166 | 328 | | ++ | | | | o |
| 133 | 356 | | +++ | ++ | | ++ | |
| 145 | 390 | ++ | | | | | o |
| 123 | 429 | | ++ | | | | |

| | |
|---|---|
| +++ | Major impact |
| ++ | Moderate impact |
| + | Minor/ minimal impact |
| # | Change but not adverse (e.g. due to litter being spread over groundcover) |
| o | No impact on lichen |

Some general observations with regard to the post-event impacts are as follows:

- In the immediate post-event observations, all controls showed some evidence of having been visited by people, although in some cases the only such evidence was flattening of grass around the control.
- The most common impact, which was observed at most of the controls, was disturbance to litter. This commonly resulted in a reduced litter cover and exposure of bare ground, although in some cases litter was pushed into the quadrat, increasing the litter cover or covering rocks.

- Where grass was present at the control, this was generally flattened, but groundcover was generally not damaged.
- In a few cases, there was some damage to low shrub vegetation, although shrubs were absent from many of the sites.
- While it was not recorded systematically, minor damage to lichen on rocks was noted at some controls, although at other controls, no such damage was evident.

Because of the very low level of post-event impact, no further monitoring was considered to be warranted at six on the controls (see Table 4). The one-year monitoring of the remaining 19 controls resulted in the following observations:

- At 13 of the 19 controls, the vegetation and litter cover had recovered to the point where no impacts were evident (i.e. the impact was assessed as negligible).
- At the remaining six controls, the residual impacts were assessed as minor. This assessment reflected a noticeable change in percentage cover for some attributes although, in all cases, the main change was a substantial increase in the area of either groundcover or litter. In one case (control 120), damaged heath had not fully recovered and in another (control 122), the exposure of bare ground during the event was still evident, but to a reduced extent.

In no case, however, was the extent of residual disturbance so great that a casual observer would consider it to be unnatural.

**Discussion**

*Limitations of the methodologies*

*Sample size*

The sampled points for the LFA method were a good representation of the checkpoints used during the event, and were agreed with the Steering Committee prior to the commencement of the monitoring program. In contrast, the sample points for the Quadrat Analysis method were directly chosen to provide a spread of terrain conditions and runner visitation, but to compensate for this a larger number of points were sampled. Both the LFA and Quadrat analysis method sampled points that were well distributed in terms of visitation by runners.

Under the LFA analysis method the recommended sampling frequency for determining a long term trend is a minimum of six time series data points (Tongway and Hindley, p.62), however this was not possible within the time and budget for the monitoring project. As a result the findings for the LFA in isolation should be viewed as indicative of the initial response to disturbance. However, when combined with the results of the Quadrat Analysis method, we can have more confidence in the results as they were substantially consistent.

One of the most significant limitations is that the monitoring program was not designed to detect long term cumulative effects across the landscape, but was designed to separate these effects from impacts caused by the event through a comparison of impact and control sites. It is understood that a longer term set of monitoring points throughout the ACT is due to be established by others as a separate exercise. This would have the potential to provide a better baseline to assess long term changes in condition.

Increasing the number of points included in the monitoring program was considered by the Steering Committee, but was rejected as this would have reduced the ability to collect data within a single day, and increasing the number of points significantly would have resulted in a subsequent risk that the monitoring program could not be completed in a timely manner. One of the key weaknesses of the LFA method is that it can only be conducted if there has been no recent rain. For wetter years (such as 2011), this can be problematic.

*Sampling frequency*

In addition to the sampling size, the frequency of sampling throughout the year is another area of uncertainty due to the considerable change in the landscape over the course of the monitoring program. When the monitoring program commenced, the native pastures and forests had been in drought for approximately ten years. Over the course of the monitoring program there was significant rainfall, particularly over summer months, resulting in the rapid recovery and re-establishment of grassland areas. While this has the potential to cause significant 'noise' in the data, this has also provided a significant opportunity, as impacts on grassland regeneration was a significant concern.

This is not expected to have had a major impact on the results due to the sampling of both control and impact sites, as well as sampling across a range of points with different levels of visitation by runners.

*Detection of species change, weed expansion*

Under these assessment methods the main focus of monitoring is on trampling and litter disturbance. As a result potentially a heavily weed infested patch of grassland could still receive a high landscape function, provided that the weed cover is able to provide similar ecological services to prevent soil erosion and maintain soil porosity. In practice, the monitoring sites had a generally low level of weed infestation, with notable exceptions being the Powerline exclusion zone (Serrated Tussock) and the Parking Area (introduced pasture species, particularly Clovers). Both approaches allow for notes to be added to the results. This is more explicit under the Quadrat Analysis method, although weeds were not a significant factor at any of the sites assessed using that method.

It should also be noted that native grasslands are dynamic in their nature, and include a range of species that are favoured by different conditions. To give a specific example, it was noted that the Parking area monitoring sites experienced a strong dominance of Hairy Panic (*Panicum effusum*) during the later stages of the monitoring program. This species is heavily favoured by reliable summer soil moisture, and is able to rapidly produce a profusion of seed heads that break off and blow across the landscape (Eddy et al p.28). The summer conditions were wet and warm, and provided ideal growth conditions for this species across the landscape. The visual inspections confirmed that this change was not confined to the impacted zones.

*Thresholds of recreational impacts*

The general results of both methodologies were consistent with previous (mainly overseas) studies in demonstrating that:

(a) following a large orienteering event, the impacts of human activity around control sites are evident; and

b) following a reasonable period of time (i.e. one growing season), the evidence of those impacts are obliterated by natural processes.

An important outcome of the monitoring program was the consistency between both methods in demonstrating an immediate change in the environment. The observations from both methods suggest that a checkpoint in the type of terrain studied needs to have more than 300 orienteers pass through to register a short-term change in the environment that would be considered significant according to the criteria used. These conclusions were reached quite independently in the two studies, as the results were not compared until both studies had been completed.

The results can be explained only partially by similarities in the measures used. The disturbance of litter and trampling of vegetation is an important metric under both systems, however the Quadrat Analysis method was focused on visual signs of tramping, whereas the LFA method is more focused on soil characteristics. As noted above, each monitoring program had limitations that, when taken in isolation, would severely limit the strength of the findings. For example, under the LFA method generally six data points are required in order to provide an accurate estimate of landscape function over time (Tongway & Hindley, p.62). When combined however, there is a much higher degree of confidence that this observed threshold is the true one.

This finding has important ramifications for adaptive management. Most club or State level orienteering events in Australia attract less than 300 participants, and these are usually spread over several different courses of widely different standards to cater for young children as well as experienced adult orienteers. The need to disperse competitors to avoid concentrated impacts would therefore not arise at most Australian events. Numbers in excess of 300 are usually experienced only at some State Championships or events held as part of a national carnival. It is when setting courses at these events that the case for deliberately avoiding high numbers at individual checkpoints becomes most relevant.

In practice, course planners for large events tend to distribute competitors among different courses to reduce crowding at checkpoints and following on common legs. This is done primarily for technical reasons but is consistent also with reducing environmental impacts. The figure of 300 competitors per checkpoint is therefore recommended as an upper limit guideline and, at most events, may be well above the figure that a course planner would desire in terms of the technical quality of the courses. If there is any concern about the sensitivity of the terrain (or parts of it), it would be prudent for environmental reasons to apply a lower figure.

The type of terrain used in the present study is typical of much of the orienteering terrain in Australia in having a cover of eucalypt forest or woodland with an understorey of scattered shrubs, a variable groundcover with bare patches and significant accumulation of leaf and bark litter. The impacts commonly observed immediately after events in other areas include flattening of grass, scattering of litter and minor damage to low woody shrubs. This is the case whether events are held in granite terrain, which is present throughout Namadgi National Park, or in areas of different geology, as occur in the Canberra Nature Park areas close to Canberra.

It is considered that the results of this study can reasonably be applied to the majority of orienteering areas throughout Australia, where the broad environmental characteristics are similar. It may not be valid, however, to apply the results to some specialised terrains such as coastal sand dunes, alpine areas or arid areas where environmental conditions are significantly different. As conditions affecting vegetation recovery in these environments are relatively stringent, it would be appropriate to adopt more conservative figures in absence of better knowledge.

Irrespective of the above discussion, the environmental code of conduct adopted by Orienteering Australia (2006) places an obligation on course planners to avoid areas of particular sensitivity as far as practicable. This is a consideration in the siting of controls and the assessment of likely routes between controls. In some situations, areas may be declared out of bounds and be marked accordingly in the terrain. Such areas would not contain control sites or be traversed by orienteers.

The only site to see a significant reduction in its final (post-event) condition according to the LFA method was Checkpoint 141, which showed a reduction in its stability index. This checkpoint had almost no vegetation growing within the transect, and was essentially a long litter collection zone between boulders. The increased rainfall can be expected to increase overall movement of litter material, and the lack of vegetation to respond to the additional moisture meant that there was nothing to mitigate this movement. It is difficult to determine if this was a natural process or a result of the event.

The weather conditions under which the current study was undertaken were generally favourable from the viewpoint of limiting impacts on the competition day and encouraging recovery over the year following the event. While more extreme weather conditions (e.g. heavy rain on the day or severe drought during the following year) may have resulted in somewhat greater impacts or slower recovery, it is considered unlikely that these would have altered the main conclusions of the study, namely that large numbers of orienteers passing through a control site on one occasion do not lead to significant long term damage.

The return of most sites to their pre-event condition within one year of the event also confirms that the current impact management practice of OACT, using each area in Namadgi National Park infrequently (typically about once every two years) and choosing different checkpoint locations, is an effective approach to controlling impacts.

*Parking areas*

For the car parking areas where only the LFA method was applied, there is a much more definitive result, with a strong immediate impact signal present in the data for the areas subjected to continual traffic. This was apparent also from the presence of visually distinct wheel marks in the grassland. Within these areas of direct car traffic there was a significant reduction in stability, infiltration and nutrient cycling, however it should be noted that this was within a very small area of the overall landscape, and was generally parallel to the contour, minimising the risk of erosion. The upper parking bays, which were used for the majority of cars, also showed a detectable impact, and the lower parking bays (least used) showed only a relatively weak impact signal. While there was some impact detected it is probable that the parking bays may have experienced only a single vehicle being driven in and out, and the vehicle tracks may not even have encroached on the transect line (i.e. the line was beneath the middle of the car or between two cars).

*Exclusion zone as a control site*

An alternative approach to monitoring the baseline condition was through the use of a control site (the Powerline exclusion zone) to provide an estimate of landscape function for areas that were not visited by runners during the event. The results from the powerline control have been included on the graphs in the results section, and show a stable condition over time, as expected from high quality native grassland that had not been subjected to disturbance. Two of the indicators for the powerline control show a slight decline while the other shows a slight increase. Within the limitations of the method, these changes may not be significant, and the variation over time is much less than for most of the test sites. When compared to the impacted sites, the condition of the latter can be seen to reduce immediately post-event, before returning to pre-event condition levels. Based on both of the approaches used, there is a strong indication that most monitoring points had fully recovered to their pre-event condition, although this should be confirmed with ongoing monitoring if possible.

*Indirect Impacts*

The direct impacts of foot and vehicle traffic on grassland areas were the primary focus of the investigation, however there was also a need to separate out other impacts, particularly traffic from kangaroos. This was achieved through the use of a control site within the exclusion zone, however during the sampling program one interesting observation was made. For many of the sites where runners numbered higher than 300, a visually distinct path formed in grassland areas. For most of the sites, this path had progressively disappeared in the spring flush of growth, however at Checkpoint 200 (finish chute) this pathway persisted (see Figure 11).

**Figure 11: Condition photographs at Checkpoint 200 immediately post-event (left, April 2010) and the following summer (right, January 2011). Note the positions of the rock and the bush for perspective.**

This particular checkpoint was strongly confined and policed, as it was the crossing through a small ephemeral creek line, and as a result a single pathway was formed through the grass at this point. As can be seen from the photos above this pathway persisted, even when the LFA indicators had shown a return to baseline condition in this particular piece of grassland. Closer examination of this pathway noted abundant kangaroo prints in the mud areas. There remains a high population of kangaroos within this section of the park, with three distinct ‘mobs’ of kangaroos observed during the monitoring.

While the event did not in itself create a long-term impact, the formation of a pathway at this site appears to have encouraged kangaroos to cross the creek line at this point, rather than dispersing their paths through the landscape. This has had the effect of creating an indirect visual impact on the landscape, however as noted above this has not translated into a loss of landscape function.

In future it may be prudent to fence off these defined pathways until the next growing season to prevent the co-opting of these informal paths by kangaroos.

## Comparison of Methodologies

While the study area and time frame for the two studies were the same, the two studies described in this paper were undertaken essentially independently. They proved to be complementary, however, in using somewhat different approaches to arrive at consistent conclusions. Both methodologies have their inherent strengths and weaknesses, which are summarised as follows.

The Quadrat Analysis technique was designed to sample as many sites as practicable with the available resources and is a relatively fast and simple method which is easy to implement and reflects how most interested people tend to view the impacts of orienteering. It provides a permanent graphic record (both photographs and sketches) which can be readily used as a basis for comparing future changes, but is limited to visually detectable changes.

The LFA method explores more deeply the environmental factors, particularly those related to the soil, that can influence the environmental function of a site. This more extensive scientific analysis, however, is more demanding on skills and resources, and hence is slower, limiting the number of sites that can be assessed with a given level of resources. The data that it generates, however, can provide a more quantitative basis for assessing change, particularly on a long-term basis. One of its practical limitations is that certain tests can be undertaken only during dry weather, which is not a limitation of the Quadrat Analysis method.

A common feature of both methodologies is the significant role of litter cover in influencing the results. Disturbance to litter cover appears to be the most obvious impact of high concentrations of orienteers in typical Australian terrain, and may explain the high degree of consistency in the conclusions of the two studies.

## Conclusions

The results from the study support the following broad conclusions in terms of potential future monitoring programs, as well as the management of recreational impacts of this type in the future:

- Both the Quadrat Analysis and LFA methods are effective in detecting changes in the environment from recreational use, although both methods have their strengths and weaknesses.
- For some vegetation types, particularly for those that included significant litter cover, there was an immediate detectable change which was most evident where more than 300 competitors had passed through an area.
- Areas of undisturbed perennial native tussock appear to require a higher level of usage before changes can be detected.
- The one year post event monitoring shows that all but one of the LFA sites had returned to their pre-event condition. Most sites assessed by Quadrat Analysis also showed no significant difference from their pre-event condition after one year.
- The LFA site that did experience a small decline in condition had a number of other factors impacting on it, particularly movement of material due to rainfall and extensive foraging by lyrebirds. Recreational use is unlikely to have contributed to this change in environmental condition.

In terms of future orienteering events in areas with high natural values, it is recommended that event managers ensure that control points do not have more than 300 runners passing through them, which should be easily manageable. Such areas should not be used for large scale events more than once per year, and a longer time period between large events would further reduce any risk of impacts. Taken in combination, these measures are likely to reduce the risk of long term impact on reserve areas down to an acceptable level, while still allowing recreational use.

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