Project: Environmental Monitoring Report

Australian Three-days Orienteering 2010
Prepared for Orienteering ACT Inc. and ACT Parks, Conservation and Lands

Reference: 204763
Revision: 2
7 September 2012

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Document Control Record

Document prepared by:

Aurecon Australia Pty Ltd
ABN 54 005 139 873
Level 1, 15 Barry Drive
Turner ACT 2612
GPO Box 320
Canberra City ACT 2601
Australia

T +61 2 6112 0100
F +61 2 6112 0106
E canberra@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Report Title		Australian Three-days Orienteering 2010 Prepared for Orienteering ACT Inc. and ACT Parks, Conservation and Lands				
Document ID			**Project Number**		204763	
File Path		Document2				
Client		Client	**Client Contact**			
Rev	**Date**	**Revision Details/Status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	30 June 2011	Draft	CF	CF		
1	22 February 2012	Draft	CF	CF	DH	CF
2	7 September 2012	Final	CF	CF	DH	CF
Current Revision		**2**				

Aurecon would like to acknowledge the significant time and effort of the OACT Monitoring Steering Committee chaired by Mr Brett McNamara, in designing the study and reviewing the results. In particular we would like to acknowledge the input of Dr Sarah Sharp in the design of the survey methodology, and Dr David Hogg and Mr Clive Hurlstone in the data collection and report review phases.

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ABN 54 005 139 873
Level 1, 15 Barry Drive
Turner ACT 2612
GPO Box 320
Canberra City ACT 2601
Australia

T +61 2 6112 0100
F +61 2 6112 0106
E canberra@aurecongroup.com
W aurecongroup.com

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Executive Summary

As the general populace is encouraged to spend more time engaged in exercise and active participation in sports, the interest in large outdoor 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 Australian Three-days Orienteering event held in the Canberra area over the Easter weekend 2010 was an internationally recognised event and provided a relatively rare opportunity for Australian runners to accrue points towards a world ranking. The hosting of events in a near natural environment is an important part of the challenge of the sport, and the area of Namadgi National Park around the Gudgenby Homestead was chosen as the venue for one day of this event.

The use of reserve areas for large scale events has proved to be a contentious one, with significant concerns raised within the community over the potential impacts, as well as a concern that this could be the 'thin edge of the wedge' for broader use of national parks. Equally, there was a concern that existing impacts on the environment from the prolonged drought could be attributed to the event, with recreational use unfairly blamed for impacts.

As an independent company, Aurecon was engaged to undertake environmental monitoring that could detect changes to the environment from overuse (such as soil compaction, trampling of vegetation and erosion) as well as separating pre-event impacts from recreational use. Aurecon had previously managed major environmental assessments within Namadgi National Park, and was able to provide staff specialised in the grassland and woodland ecology of the area.

After some initial discussions between the National Parks Association (NPA), event organisers and ACT Parks Conservation and Lands, a steering committee was established to oversee the impact monitoring by Aurecon. The steering committee considered a wide range of monitoring approaches, eventually settling on the Landscape Function Analysis (LFA) approach developed by CSIRO as having the best chance of providing useful data on impacts. 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, and the first time that the LFA method had been applied to recreational impacts.

The next step was to develop an effective sample of impact zones to measure the range of environments and level of usage within the various areas covered by the event. The steering committee also provided oversight of this process, to ensure agreement of all stakeholders to the eventual outcomes. A total of eight sampling points were chosen, covering parking areas, checkpoints (with between approximately 140 to 830 runners passing through) as well as exclusion areas. Sampling was undertaken by Aurecon, with support from NPA and Orienteering ACT members, with this sampling taking place immediately before and after the event, and up to one year later after a full growing season.

The results from the study support the following conclusions:

- The LFA method is effective in detecting changes in the environment from recreational use.
- There was an immediate detectable change, particularly where more than 300 competitors had passed through an area, although this was not consistent across all vegetation types, with areas

of undisturbed perennial native tussock appearing to require a higher level of usage before changes could be detected.
- The one year post event monitoring showed that all but one of the sites had returned to their pre-event condition, indicating that observed changes in environmental condition resulting from orienteering are temporary only. One site had experienced a small decline in condition, but this was unlikely to have been as a result of recreational use, with abundant foraging by lyrebirds noted at this site.

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. In terms of future events, it is recommended that event managers ensure that control points in typical Australian orienteering terrain do not have more than 300 runners passing through them. This measure, together with continuing the practice of using each area in Namadgi National Park infrequently (typically about once every two years and less frequently for large scale events) and choosing different checkpoint locations for each event, can be expected to reduce the risk of environmental impacts to an acceptable level.

1 Introduction

1.1 Background

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'.

Areas within Namadgi National Park 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. Aurecon Australia Pty Ltd was appointed by the ACT Government to undertake this study, which was jointly funded by Orienteering ACT Inc. and the ACT Government.

Native grassland areas were still suffering the effects of drought at the time the event was planned, and concerns were raised both over direct trampling of sensitive areas, as well as management of event parking. Despite these concerns, effectively defining and measuring impacts from events has proved to be a significant challenge, and measuring impacts in general is an area of ongoing research.

Larger scale events provide a range of experiences that are not as available for smaller groups including better safety and services, team based challenges and the opportunity for sponsorship and are essential to recoup the substantial costs in preparing the specialised maps that the sport requires. These in turn are used in due course for local events. In the specific case of the Australian Three-day competition, this was an internationally recognised event, and was a relatively rare opportunity for Australian based runners to accrue points towards their world ranking, and thus qualify for international competitions.

After some initial discussions between the National Parks Association, event organisers and ACT Parks Conservation and Lands a steering committee was established to oversee impact monitoring by Aurecon in its role as an independent consultant. The steering committee considered a wide range of monitoring approaches, eventually settling on the Landscape Function Analysis (LFA) approach developed by CSIRO as having the best chance of providing useful data. This was the first time that monitoring of an orienteering event had been attempted at this scale in the Southern Hemisphere, and there was a genuine interest in the application of the results to produce a wider adaptive management system for similar events not only within Namadgi National Park but elsewhere in Australia.

There were three main objectives to the monitoring program:

- to determine if any environmental impact was observable, and to map the extent and severity of any impacts
- 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.

While the environmental impacts of orienteering have been subject to numerous scientific research studies throughout the world, 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. In order to assist in understanding the impacts of orienteering in the Namadgi environment, ACT Parks Conservation and Lands (PCL) commissioned Aurecon to develop and deliver an environmental monitoring program that was sensitive enough to detect impacts from a large national orienteering event.

1.2 Description of the project area

The monitoring program is set within a section of Namadgi National Park, with the main 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. The monitoring sites were located within the most intensively used part of that area. The project area is dominated by Temperate Montane Grassland, 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. A satellite image of the project area is shown below at Figure 1 and a detailed map of all sampling points is at Appendix A.

Figure 1: Overview of the project area (See Appendix A for map of sampling points).

The impact of climate on the monitoring program was also a key area of concern, with the response/recovery in the spring growth period seen as a key area of interest. 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 (see Figure 2 below). 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. It should be noted that 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 a 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 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.

Sampling was undertaken in January, March and April, representing the summer/autumn growing period for the grasslands.

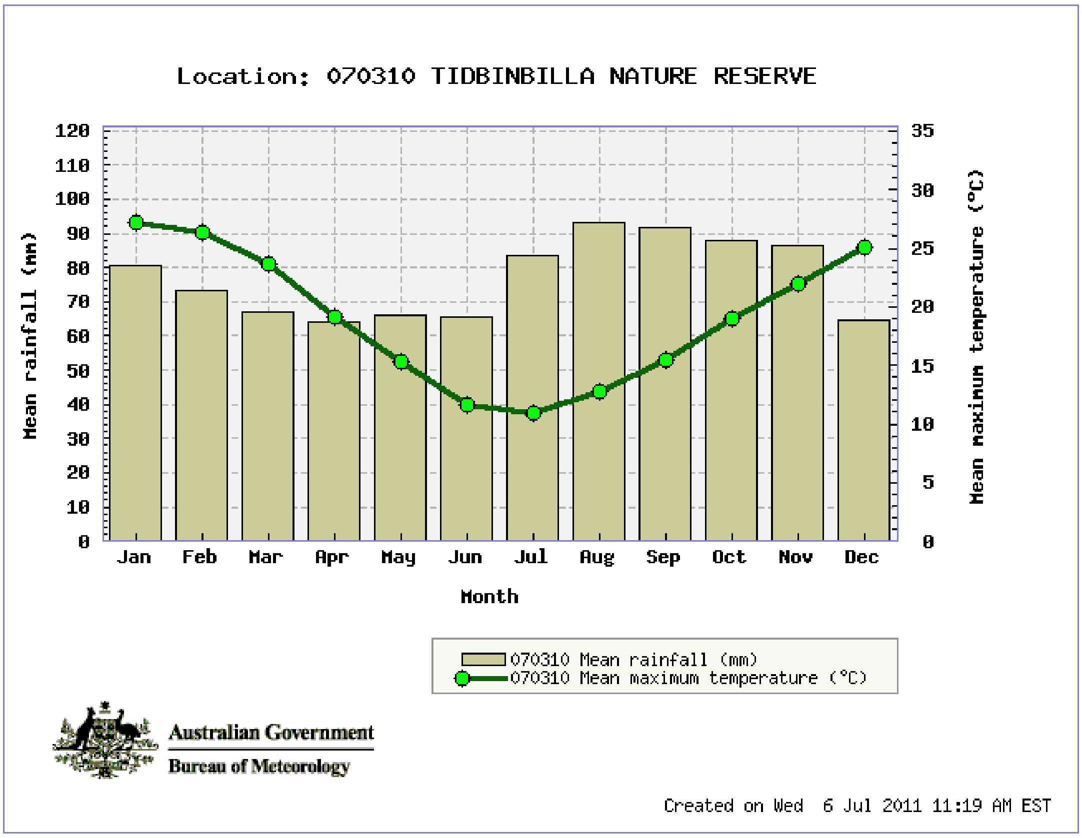


Figure 2: Average rainfall and mean maximum temperature for the closest weather station (Tidbinbilla Nature Reserve) Source: Bureau of Meteorology (http://www.bom.gov.au/jsp/ncc/cdio/cvg/av)

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. The results of the study therefore could have broad implications for orienteering throughout Australia.

2 Methodology

2.1 Initial design of monitoring programs

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. The fact that runners are concentrated in particular points of the landscape is both an issue of concern for stakeholders and an opportunity for monitoring.

The area of highest people concentration at an orienteering event 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 through the parking area.

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

The environmental monitoring program utilised LFA methods as described in *Landscape Function Analysis – Procedures for Monitoring and Assessing Landscapes* by D J Tongway and N L Hindley of CSIRO Sustainable Ecosystems. 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 indications 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.

2.2 Description of individual sample sites

The next step in developing the methodology was to identify an effective sample of impact zones to measure the range of environments and level of usage within the various areas covered by the event. A shortlist of ten potential sample locations were investigated and checked in the field and recommendations were presented to the steering committee. After discussions within the steering committee, a total of eight sampling points were chosen, covering parking areas, checkpoints (with between 136 – 827 runners passing through) as well as exclusion areas.

A summary of the sampling locations is provided in Table 1 below, providing an overview of the dominant vegetation type, position in the landscape and the number of runners that were recorded through each sampling area. **Appendix A** shows a map of the sample points locations

Table 1: Sampling sites

Site identifier and photograph	Description
Checkpoint 140 	This checkpoint is set within Southern Tablelands Dry Sclerophyll Forest with a predominantly shrubby understorey. The understorey is dominated by leaf litter and sparse shrubs, intermixed with granite boulders. The soil is predominantly sandy decomposed granite. The dominant tree species are Broad Leaved Peppermint (*Eucalyptus dives*) and Mountain Gum (*Eucalyptus dalrympleana*) over a diverse shrubby understorey. The ground layer is dominated by leaf litter, with relatively little contribution to stability from vegetation. This checkpoint logged 136 runners passing through it during the event, and was chosen due to the location of the granite boulder which would funnel runners through the investigation zone, the scattering of leaf litter and that the creation of erosion zones near boulders was a key area of concern.
Checkpoint 141  \	The checkpoint is similar to number 140 above, and is set mid-slope within a field of large boulders. As a result runners were funnelled down a discrete path; the investigation zone was set within this area. This area was also dominated by Southern Tablelands Dry Sclerophyll Forest with a shrubby understorey, and leaf litter again the dominant ground cover, with only a minor contribution to stability from vegetation. It was noted that there was significant disturbance of leaf litter due to Lyrebird foraging at this site. Soils at this site were sandy decomposed granite, and it was noted that there were abundant populations of soil fungi, and fungal hyphae which were observed to have a strong binding action on sampled clumps of soil. The checkpoint recorded 334 runners during the event, which was at the higher end of the expected number of visits per checkpoint.

Checkpoint 142

This monitoring site is set on the valley floor of Rendezvous Creek, and two transects were established at this point to cover different approach routes. The two transects radiate out from the large boulder that was used to mark the checkpoint itself.

In contrast to the previous two monitoring plots, this area had a much higher stability and nutrient cycling contribution from vegetative cover. The vegetation community is Southern Tablelands Grassy Woodland. The understorey is dominated by Kangaroo Grass (*Themeda australis*), but with a significant proportion of both Weeping Grass (*Microlaena stipoides*) and Snow Grass (*Poa sieberiana*). This valley floor adjacent to the creek line represents a transition zone between the denser forest communities and the open grasslands that dominate the southern portion of the study area.

The checkpoint logged 270 runners through the area during the event, and it was noted that the path through the grassland taken by runners could be easily discerned immediately post event and aligned well with the layout of the monitoring transects.

Powerline Site (paired control & impact)

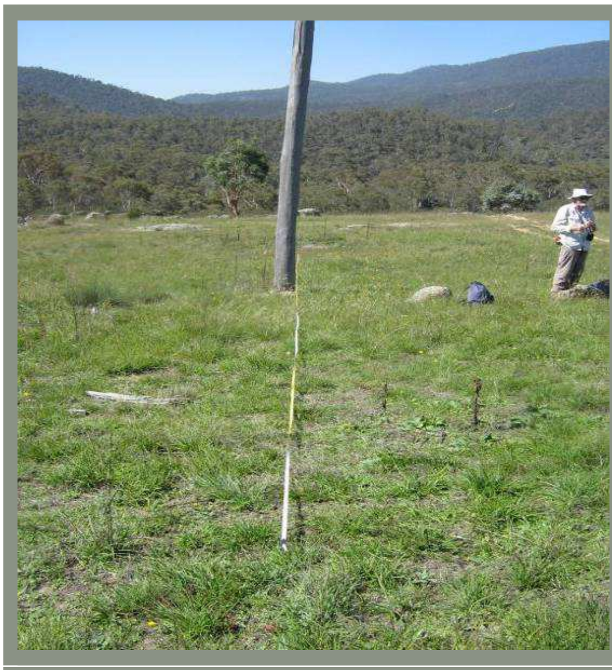
There was a significant exclusion area during the event to protect the most sensitive portion of the native grasslands rehabilitation area. This monitoring site included a paired impact/control site transecting the temporary boundary tape that was erected to mark the edge of the exclusion zone.

The dominant vegetation type in this section was Temperate Montane Grasslands dominated by a dense swath of Kangaroo Grass (*Themeda australis*). It was noted that some sections of the grassland had a minor infestation of Serrated Tussock (*Nassella trichotoma*).

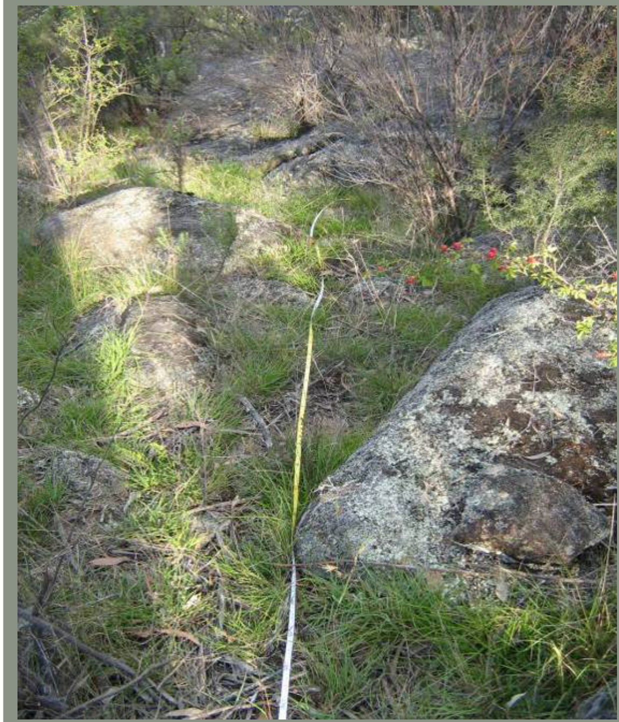
The transect was set up using a power pole as the central marker, as this was a major feature in the landscape that could not be readily disturbed or removed by runners.

There were no formal checkpoints established at this site, however approximately 500 runners were counted passing along the outside of the boundary tape separating the exclusion and impact sections and across the test transect. A clearly discernible path through the grassland was apparent immediately post-event, but this was not visually discernible during later monitoring events.

Some small patches of Serrated Tussock (*Nassella trichotoma*) were noted during the pre-event monitoring phases, but these did not colonise the disturbed areas or change their extent of coverage during the monitoring program.



Checkpoint 129



This checkpoint was on a slope against large boulders within Subalpine Woodland dominated by Snow Gum (*Eucalyptus pauciflora*) and Mountain Gum (*E. dalrympleana*). The actual checkpoint at this site also contained a drinks station, and was set on a flat section of sheet rock that was unlikely to show any detectable disturbance.

The approaches to the checkpoint however, would likely show disturbance, and included sections of leaf and bark litter interspersed with Kangaroo Grass (*Themeda australis*). The runners were effectively 'funnelled' down a narrow patch of grass and leaf litter between large boulders, and this provided a good site for the placement of the transect.

It was considered highly likely in the pre-event inspections of this monitoring site that this area would show disturbance from runners, and a total of 295 runners were recorded passing through the site, making this one of the more frequently visited sites.

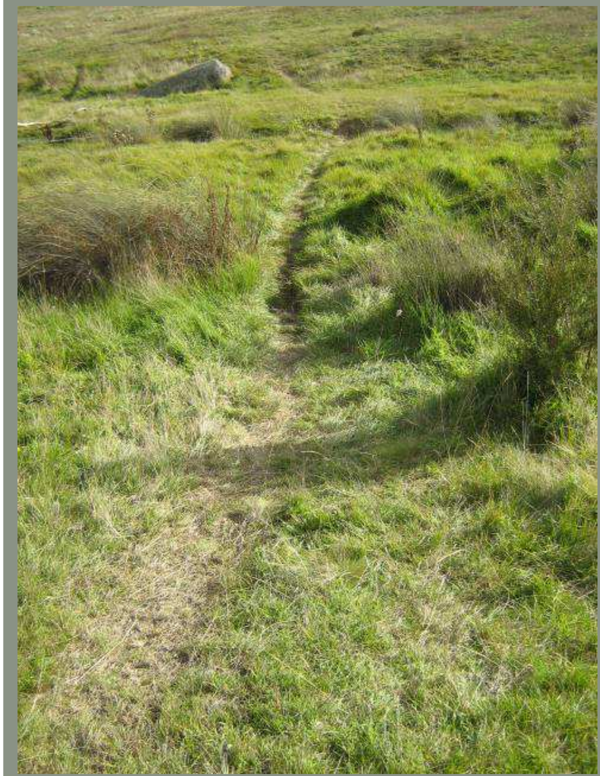
The steep slope and soils derived from decomposed granite also placed this in a higher risk category for erosion, making this a priority for monitoring.

Checkpoint 145

Checkpoint 145 is set mid-slope within an open, grassy section of Subalpine Woodland amongst large boulders. The dominant species in the grass layer is Kangaroo Grass (*Themeda australis*) interspersed with scattered shrubs. The checkpoint itself was situated within a group of boulders requiring runners to pass over an open patch of grassland, with the transect run across this open patch.

A total of 390 runners passed through this zone during the event. The competitors approached the checkpoint from a variety of directions, but all left along the same route which was perpendicular to the transect. As a result this transect is likely to have only partially captured the impacts of the foot traffic.

Checkpoint 200 (Finish chute)



The final checkpoint was the same for all courses with the transect located at the beginning of the finish chute. This transect had the highest number of competitors passing through it. The area is an open section of Temperate Montane Grasslands dominated by Kangaroo Grass (*Themeda australis*) with Sedges (*Carex* sp.) becoming more prominent within the drainage line itself.

The LFA methodology used for the monitoring requires dry soil for the slake test component (where water infiltration into a soil sample is tested) and as a result it was not appropriate to locate the transect within the drainage line itself, but the Kangaroo Grass pasture on the approaches provided a good alternative.

Runners approached the final checkpoint from several different directions, however they then all crossed an ephemeral drainage line along a set path. As a result the runners were funnelled through the area where the transect was located. Immediately following the event, a clear path through the vegetation was apparent, which persisted for the duration of the monitoring program. Visual inspections were regularly carried out at this site between monitoring events and are discussed in the results section.

A total of 827 runners were recorded passing through this checkpoint, making this the most visited site.

Parking area (long transect)

The proposed parking area was another key area of concern for stakeholders, with an estimated 300 cars to be parked on native grassland areas immediately to the north of Gudgenby Homestead. The parking was on an open grassed area, however the dominant grass cover changed several times during the monitoring program, with this change not confined to the parking areas. During the initial monitoring phases, the pasture was a mixture of exotic Clover (*Trifolium* sp.) and native Red Grass (*Bothriocloa macra*), however this changed during the following spring to become strongly dominated by Panic Grasses (*Panicum* sp.) with Weeping Grass (*Microlaena stipoides*).

Potential causes of this change could either be natural seasonal changes in the grassland, or an ongoing progression of the grassland from grazed pasture to native grassland.

This area did not have control points or estimates of usage in the same manner as the runners' checkpoints, but there were three distinct parking areas marked out on the grass. The parking area was to be within a clearly defined area, and as a result a long (30m) transect was run from the top of the slope down to the bottom of the expected car bays.

Following the event two sets of wheel ruts were apparent to the naked eye, and this allowed the transect to be re-classified into parking and track zones to give a better resolution in the results.

The analysis of the chip data logging the number of visits to each checkpoint was also undertaken to determine if the sample points were representative of the overall visitation pressure on checkpoints within the course. As shown on the figure below, the checkpoints monitored do capture the spread of visitation pressure on the checkpoints, with the sampling zones skewed towards the more visited sites that are expected to have the highest level of impact.

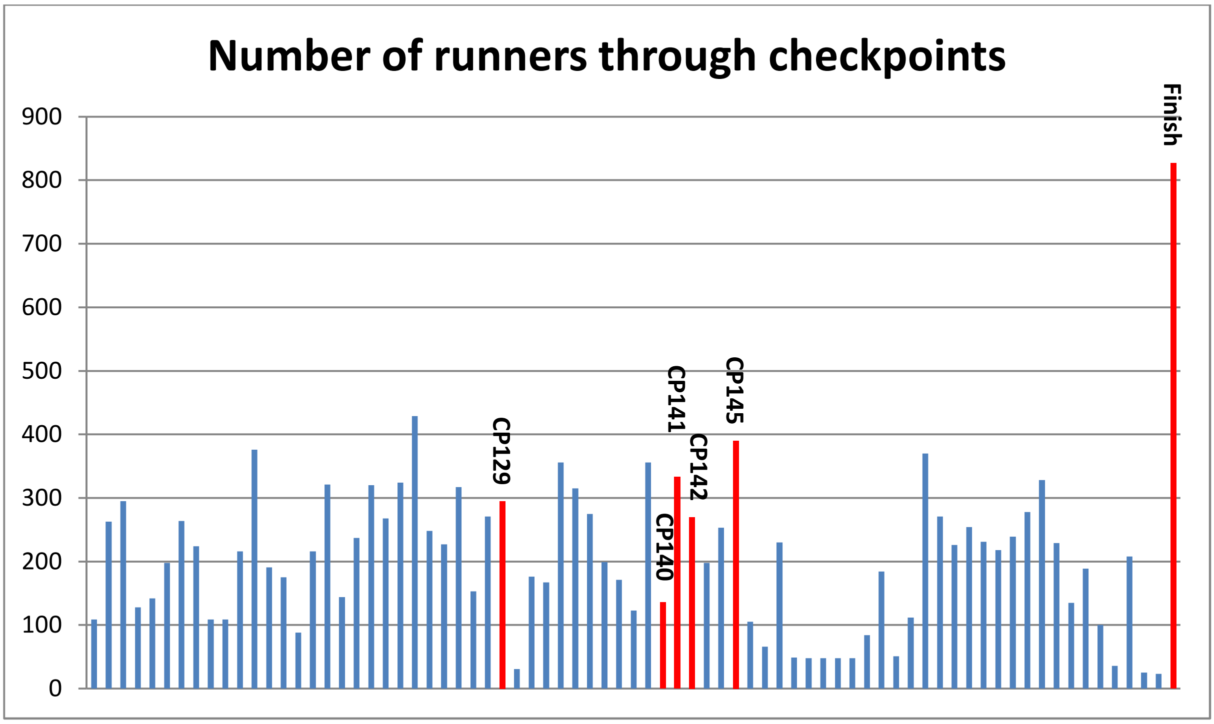


Figure 3: Analysis of checkpoint visits with monitored plots highlighted

2.3 Field data collection

The next step was to develop an effective sample of impact zones to measure the range of environments and level of usage within the various areas covered by the event. A total of eight sampling points were chosen, covering parking areas, checkpoints (with between 136 – 827 runners passing through) as well as exclusion areas. Sampling was undertaken by Aurecon, with support from NPA and Orienteering ACT members, with this taking place immediately pre and post-event and again following a full growing season after the event. The pre and post-event sampling was intended to assess the immediate impacts of the event with the later monitoring intended to assess the extent of recovery from the immediate impacts. The analysis of sampled checkpoints shown in Figure 3 above demonstrates that the sampled points are a good representation of the frequency of runners visiting, and also captured the most heavily utilised checkpoint (finishing chute).

Each monitoring point was sampled on three occasions, with sampling taking place during the following dates:

- 25-28 March 2010 (pre-event monitoring)
- 8 April 2010 (immediately post-event)
- 28 January 2011 (post event, covering points 140, 141, 142 and Powerline sites)
- 8 April 2011 (post event, remainder of the points)

Due to inclement weather, the final monitoring event was split, with roughly half of the sampling points sampled in January 2011, with the final set of monitoring points completed in April 2011.

2.4 Limitations of the methodology

Sample size

The sampled points 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. The analysis shown in Figure 3 above demonstrates that the sampled points were well distributed in terms of visitation by runners. The recommended sampling frequency for determining a long term trend is a minimum of six (6) time series data points (Tongway and Hindley, p.62), however this was not possible within the time and budget for the project. As a result the findings should be viewed as indicative of the initial response to disturbance. 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.

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.

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

The LFA method focuses on the stability and nutrient cycling processes of a landscape, and there is no specific input to track changes in species or weed infestations. To mitigate this potential blind spot, visual checks and reference photographs were taken at each of the monitoring plots. Under the LFA method, 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).

It should also be noted that native grasslands are by their nature dynamic, 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.

3 Results and Discussion

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.

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.

3.1 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. The stability calculations incorporate the results of the following soil surface assessments:

- Soil cover
- Litter cover
- Cryptogam cover
- Crust brokenness
- Erosion type and severity
- Deposited materials
- Surface resistance to disturbance
- Slake test

These soil tests, particularly the first three, were anticipated to be the most disturbed by excessive foot and vehicle traffic, and were likely to show the most direct impacts. Several of the indicators of impact, particularly Soil Cover and Litter Cover, showed a distinct impact from the runners immediately post event.

The following table provides an overview of the results for the aggregated stability index for each of the monitoring points, with the subsequent figures displaying this in a graphical form for analysis.

Table 2: Stability indicators (%) (Checkpoints sorted by numbers of runners, low to high)

Monitoring point	# runners	Pre-event	Immediate post-event	Post - event
Powerline (exclusion)	0	66	66.5	67.5
Powerline (impact)	~500	68	64.6	73.2
Checkpoint 129	295	55.1	57.2	60.2
Checkpoint 140	136	55.3	55.5	58.6
Checkpoint 141	334	61.8	60.7	56.9
Checkpoint 142 (a)	270	68.8	65.8	71.5
Checkpoint 142 (b)	270	66.6	60.4	64.6
Checkpoint 145	390	63.8	65.8	70
Checkpoint 200 (finish)	827	63.8	62.1	69
Parking (traffic zone)	N/A	69.5	66.3	70.8
Parking (upper bays)	N/A	66.9	66	73.5
Parking (lower bays)	N/A	67.1	65.4	75

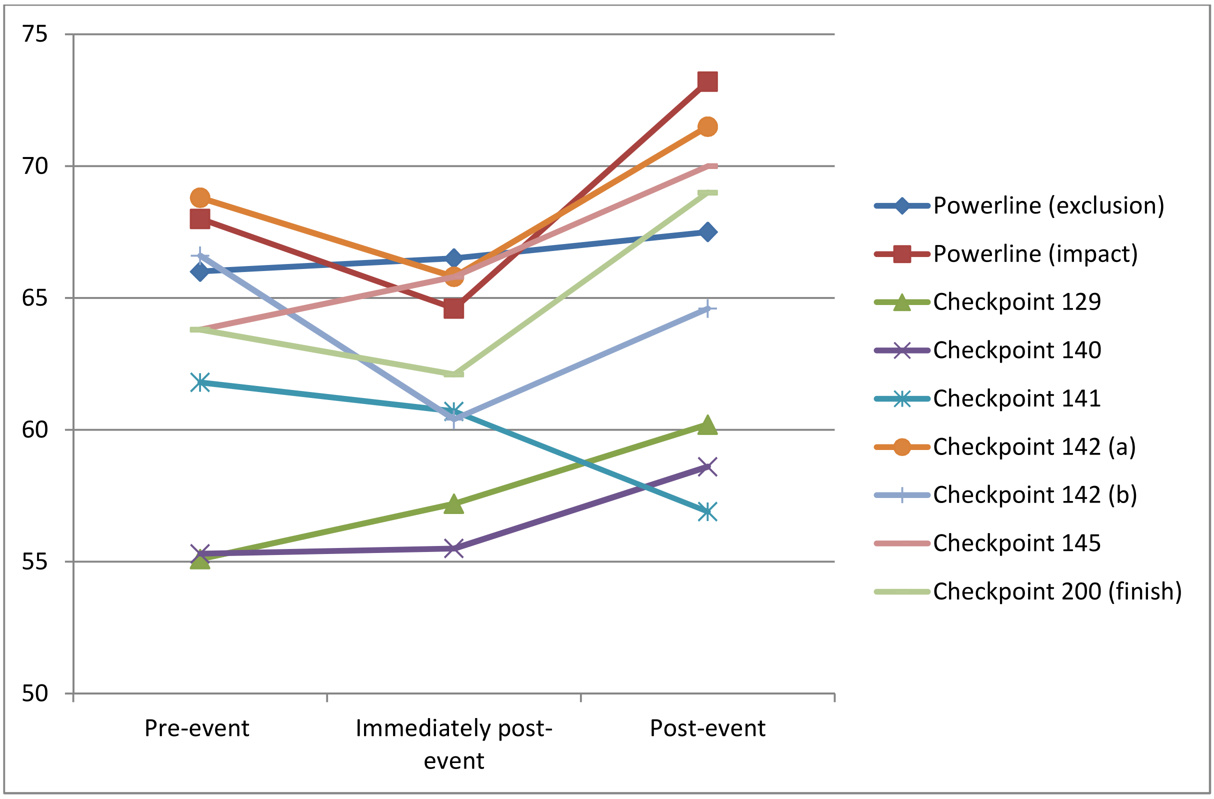


Figure 4: LFA Stability results (%) for Checkpoints

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.

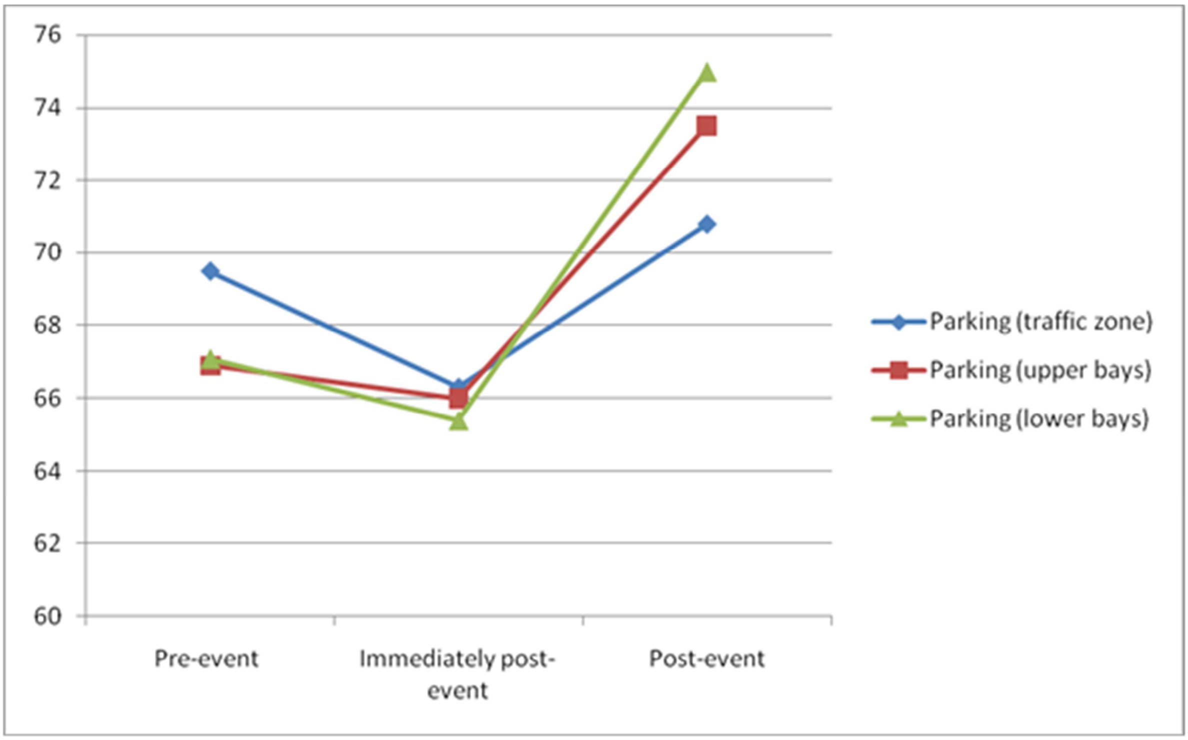


Figure 5: Landscape Function Analysis Stability results (%) for parking area, broken down by impact type

The results for the parking area are 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.

While all areas did recover to above their pre-event levels, these results did demonstrate a clear impact signal from continual 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.

3.2 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 infiltration/runoff incorporates the results of the following soil tests:

- Perennial grass basal cover
- Litter cover, origin and degree of decomposition
- Surface roughness

- Surface resistance to disturbance
- Slake test
- Soil texture

These tests 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.

Table 3: Infiltration/runoff indicators (Checkpoints sorted by number of runners)

Monitoring point	# runners	Pre-event	Immediate post-event	Post - event
Powerline (exclusion)	0	39.9	37.4	36.3
Powerline (impact)	~500	40.8	34.4	46.2
Checkpoint 129	296	41.4	45	50.9
Checkpoint 140	136	35.1	46.4	43.7
Checkpoint 141	334	50	46	44.7
Checkpoint 142 (a)	270	49.3	45.5	56.3
Checkpoint 142 (b)	270	48.7	43.9	50.7
Checkpoint 145	390	40.9	39	42.2
Checkpoint 200 (finish)	827	40.9	40.9	42.2
Parking (traffic zone)	N/A	46.6	40.6	45
Parking (upper bays)	N/A	40	39.6	45.4
Parking (lower bays)	N/A	42	43.8	45.7

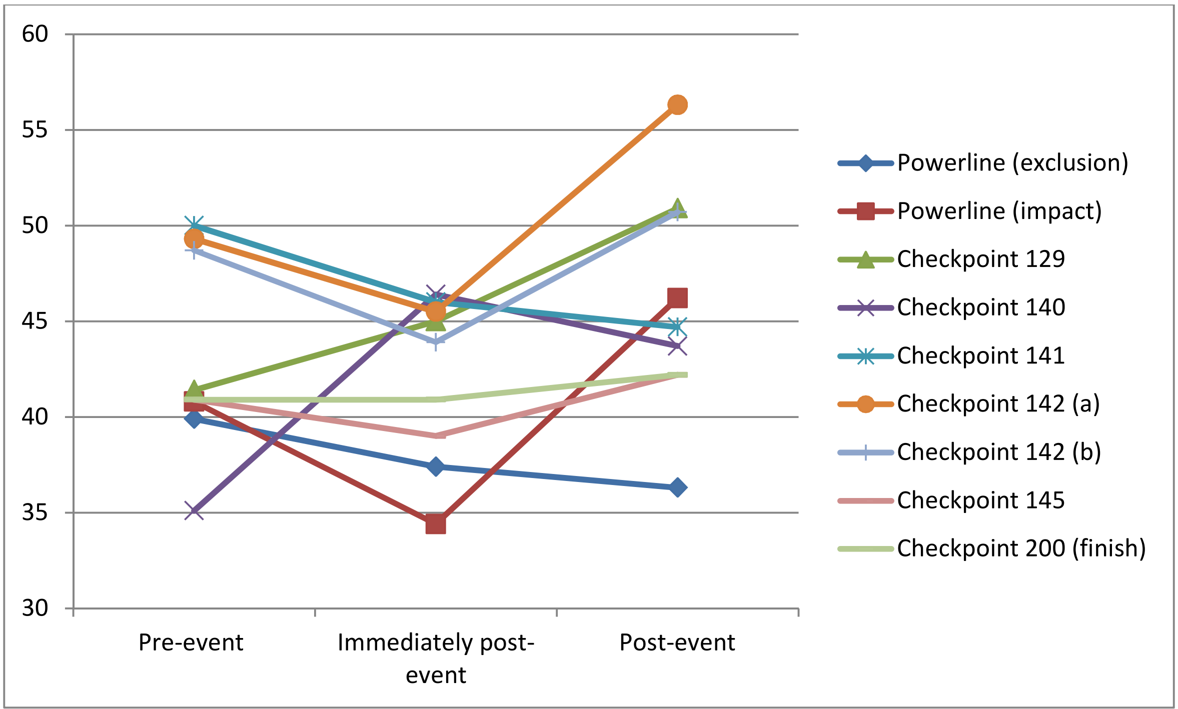


Figure 6: Landscape Function Analysis Infiltration (%) results for checkpoints.

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 to infiltration/runoff function.

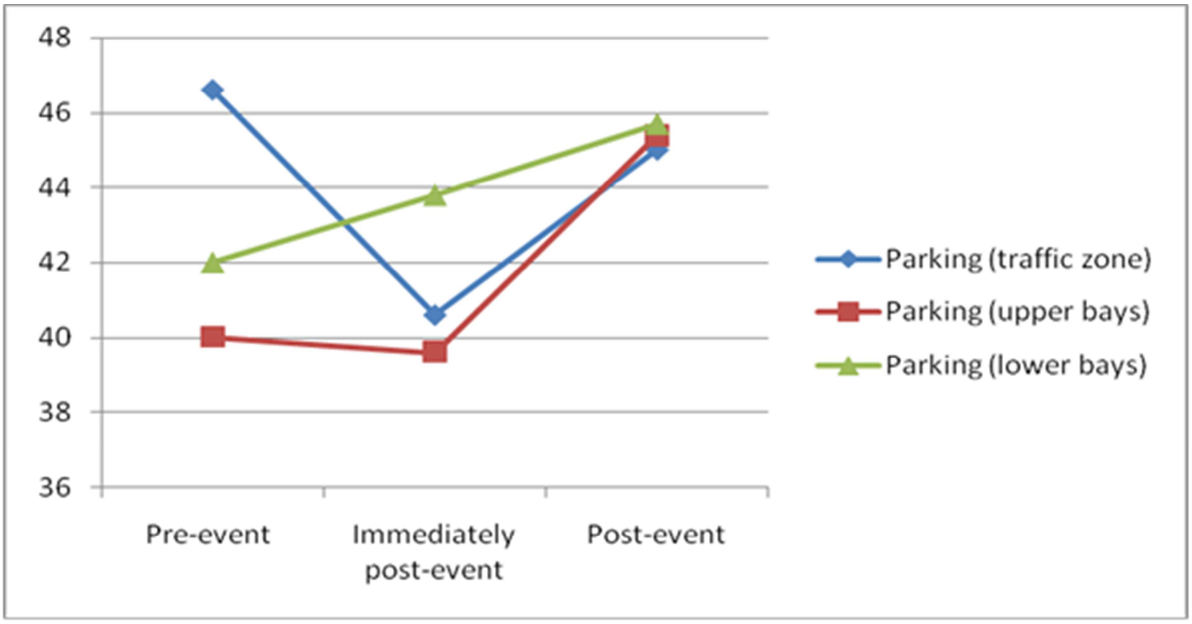


Figure 7: Landscape Function Analysis Infiltration (%) results for the parking area

In contrast to the results against checkpoints, there was a distinct and detectable impact within the parking area. 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 6 time series samples) are required to determine if this area has returned to baseline conditions (Tongway and Hindley, p.62).

3.3 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.

Nutrient cycling incorporates the results of the following indicators:

- Perennial grass basal cover
- Litter cover, origin and degree of decomposition
- Cryptogam cover

- Surface roughness

As with the infiltration/runoff index, several of these 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.

Table 4: Nutrient cycling indicators (Checkpoints sorted by number of runners)

Monitoring point	# runners	Pre-event	Immediate post-event	Post - event
Powerline (exclusion)	0	31.4	31.2	30.2
Powerline (impact)	~500	33.7	25.0	39.9
Checkpoint 129	296	29.1	34.5	37.9
Checkpoint 140	136	24.5	34.4	29.1
Checkpoint 141	334	37.3	35.1	31.4
Checkpoint 142 (a)	270	38.5	39.3	48.2
Checkpoint 142 (b)	270	36.7	33.5	44.1
Checkpoint 145	390	34.8	35.6	37.6
Checkpoint 200 (finish)	827	34.8	34.4	33.3
Parking (traffic zone)	N/A	41.5	32.9	42.0
Parking (upper bays)	N/A	35.4	33.7	41.8
Parking (lower bays)	N/A	36.8	38.8	43.2

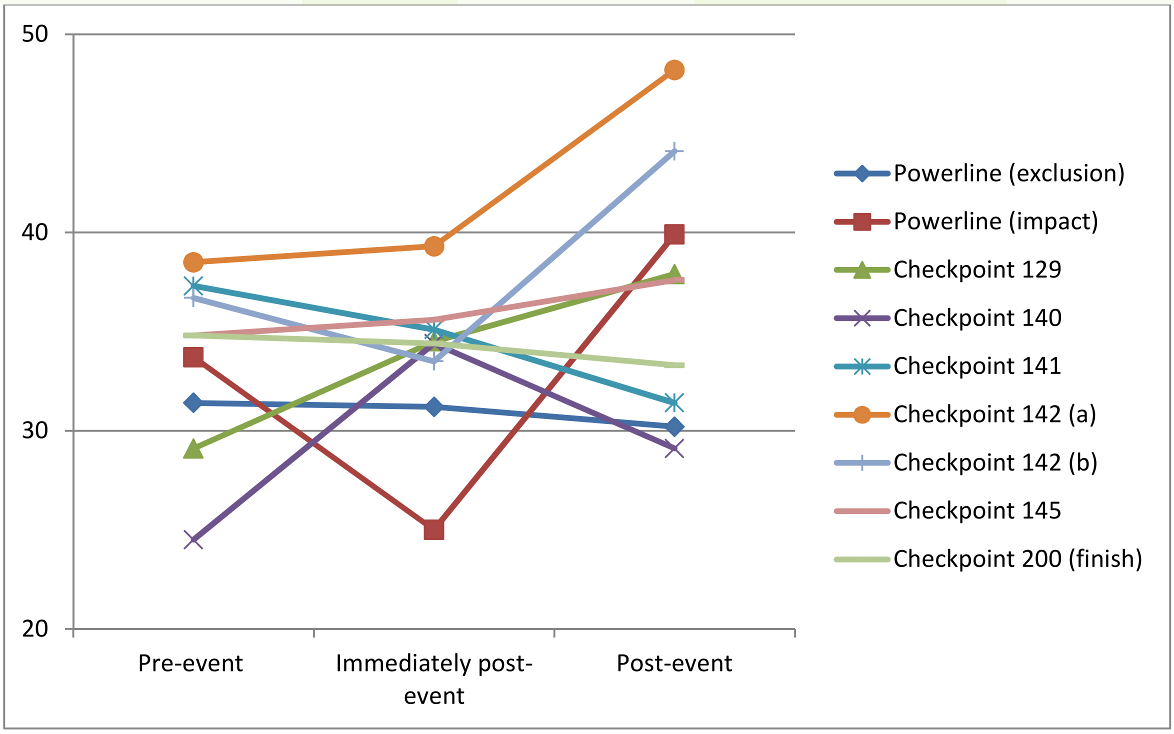


Figure 8: Landscape Function Analysis for nutrient cycling (%) for the checkpoint areas.

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 the table above and the figure below, with only sites with a strongly defined path showing any detectable effect, and again the site with the highest runners through it not showing a strong impact trend.

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

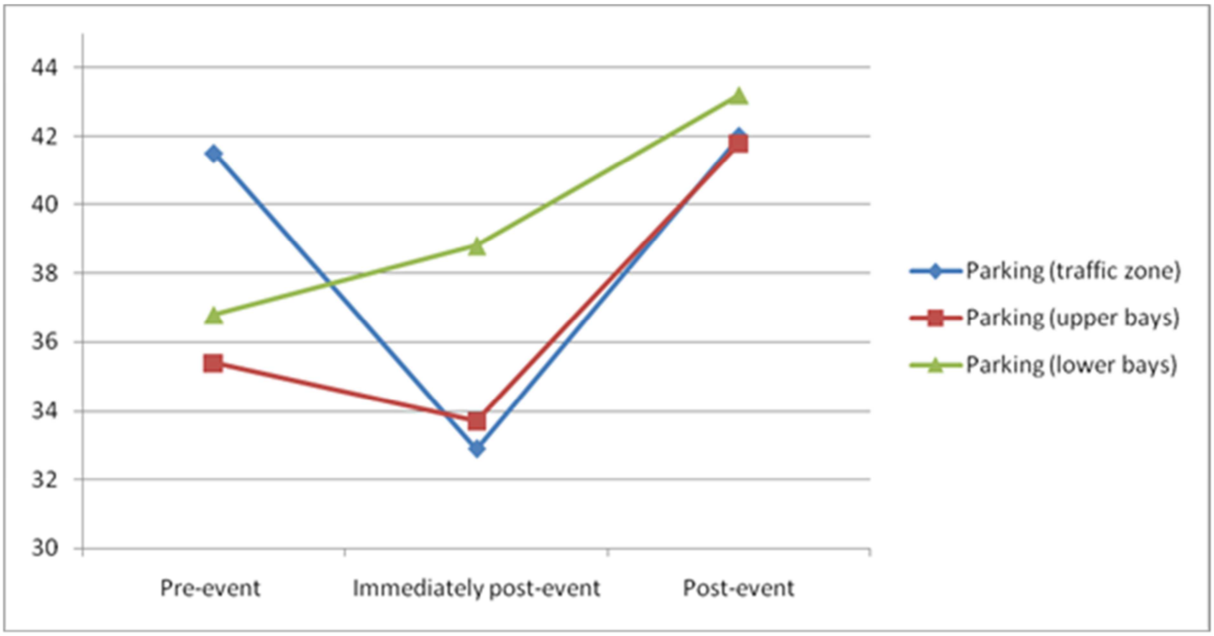


Figure 9: Landscape Function Analysis for nutrient cycling (%) for the parking areas.

The nutrient cycling results from the parking area does 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.

4 Conclusions

4.1 Direct Impacts

The monitoring program for the national orienteering event was spread over a diverse range of landscapes within the study area, and each of these had highly variable degrees of use during the event. There were several objectives to this monitoring program, including:

- the detection of any impacts
- determining the severity and persistence of impacts
- identifying a threshold for impacts to guide the management of future events

The results presented above were split into the areas subjected to foot traffic, where the ability to detect impacts may be expected to be quite marginal, and areas subjected to vehicle traffic, where more severe impacts may be expected.

The results to date should be considered indicative only, as there are not enough data points to determine if a stable state in the landscape has been reached. It is stated in the LFA Procedures handbook that generally six data points are required in order to provide an accurate estimate of landscape function over time (Tongway & Hindley, p.62). At present only three data points have been collected for all of the sites; however these are enough to provide indicative results and to prove the utility of the LFA method.

In terms of the original objectives of the project, there is a strong indication that immediate impacts are detectable from foot traffic once the number of runners through a site exceeds 300, particularly for sites where there is a grassy substrate. This is indicative only, but does demonstrate that a level of impact was detectable, and that this could potentially be applied to other environments. There are stronger indicative results from the stability index compared to the indices for infiltration/runoff and nutrient cycling, however some impacts were still detected against all three facets of landscape function for some sites. It should be noted that all sites showed a return to pre-event levels within one year of the event.

For the car parking areas, there is a much more definitive result, with a strong immediate impact signal present in the data for the areas subjected to continual traffic, with this being apparent by 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).

For the determination of the severity and persistence of impacts, there are two approaches that are available within the LFA framework. Firstly, the original reference condition of the landscape pre-event can be used to determine the target condition for the site. In the case of the study area, the condition of the grassland areas had been compromised by a long drought and a past history of cattle grazing near the homestead and nearby checkpoints. During the monitoring program almost all indicators exceeded their original condition indices, however this can largely be explained by the higher than average summer rains creating ideal growing and breeding conditions for grassland flora.

The second approach to determining the baseline condition is 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 availability of detailed checkpoint chip data (provided by event organisers) also allows for the ranking of sites based on visitation. 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 these can be seen to reduce immediately post-event, before returning to pre-event condition levels. Based on both of these approaches, 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.

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.

The only site to see a significant reduction in its final (post-event) condition 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.

4.2 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 reference site, 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.

Table 5: Condition photographs immediately post-event (left, Apr 2010) and the following summer (right January 2011). Note the position of the rock and bush for perspective.

This particular checkpoint was strongly confined and policed, as it was the crossing through a small semi-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.

4.3 General 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:

- The LFA method is effective in detecting changes in the environment from recreational use.
- There was an immediate detectable change, particularly where more than 300 competitors had passed through an area for some vegetation types, particularly for those that included significant litter cover.
- 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 sites had returned to their pre-event condition.
- The 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 events, 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. Areas should not be used for large scale events more than once per annum, and a longer time period between large events will further reduce the 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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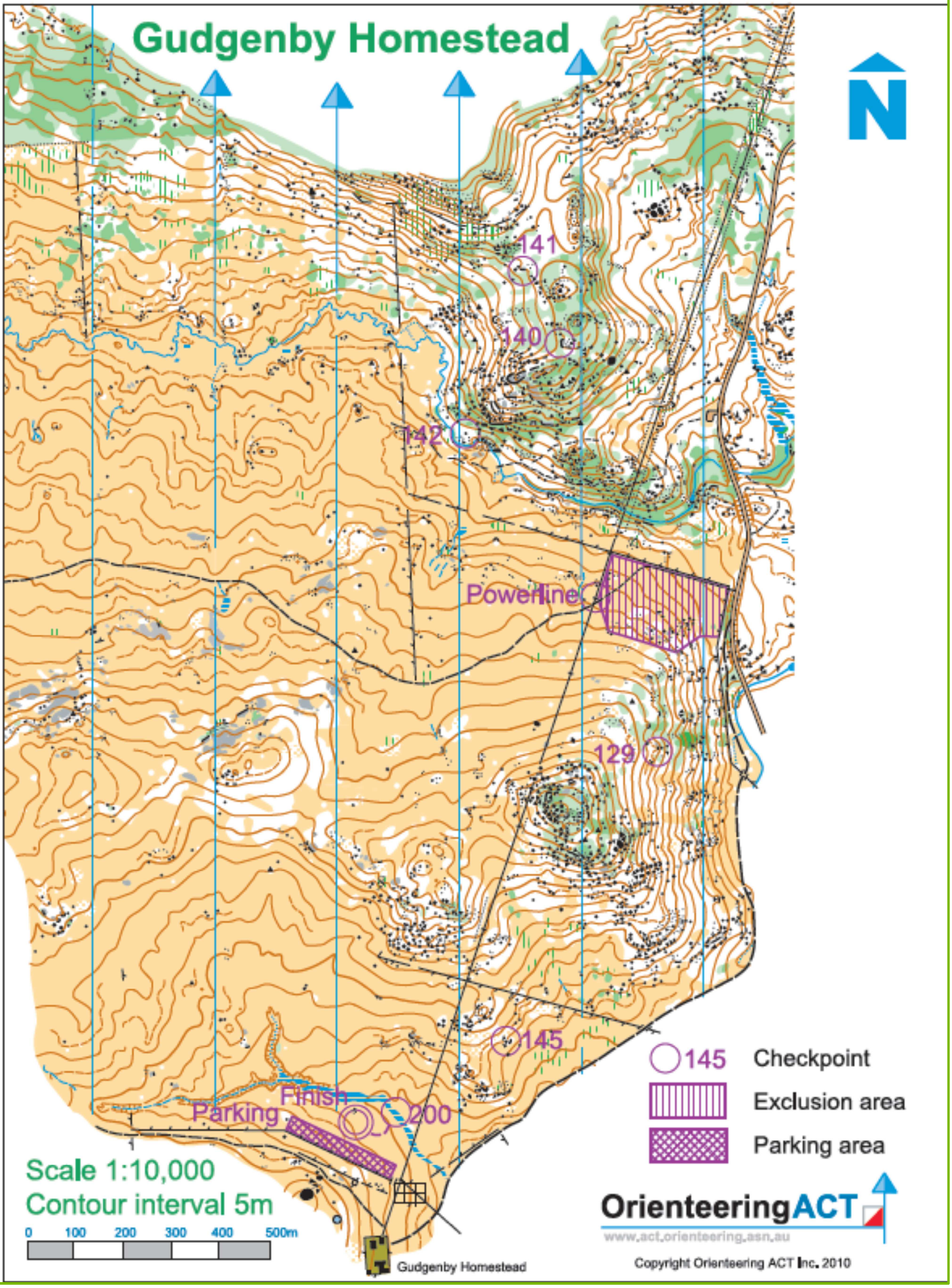
Appendix A
Sample Points Map

Appendix A. Sample Points Map



Aurecon Australia Pty Ltd
ABN 54 005 139 873
Level 1, 15 Barry Drive
Turner ACT 2612
GPO Box 320
Canberra City ACT 2601
Australia
T +61 2 6112 0100
F +61 2 6112 0106
E canberra@aurecongroup.com
W aurecongroup.com