Developing a Walking Track Monitoring Program

for the

Tasmanian Wilderness World Heritage Area

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Abstract

The Tasmanian Parks and Wildlife Service has developed a program for monitoring track conditions throughout the Tasmanian Wilderness World Heritage Area (WHA).

The monitoring technique involves the measurement of a small number of impact variables at widely spaced and permanently marked sites, each site consisting of a cluster of transects spaced at two metre intervals along the track.

Sites are classified into types, each type corresponding to a defined range of environmental and siting variables and exhibiting a characteristic range of impact levels. Typing can be used to group and compare changes at monitoring sites.

The distribution of impacts within each type can be expressed as a function of environmental variables, siting variables and usage levels by means of regression equations. Once the typing system has been further refined part of the monitoring program will consist of classifying tracks into sections of specified types. It may then be possible to predict track conditions within using the regression equations corresponding to the various types, backed up by further sampling if necessary.

1 Introduction

1.1 Importance of monitoring

Monitoring is an essential component of effective wilderness management. Only by monitoring environmental and social impacts in wilderness areas can managers make informed decisions and assess the effectiveness of management actions and policies (Lucas 1985, Price 1985, Cole 1987). In particular, monitoring plays a central role in the "limits of acceptable change" (LAC) approach to wilderness management which involves the implementation of management strategies designed to maintain the values of specified impact variables within specified limits (Stankey, Cole & Lucas 1985).

1.2 World Heritage Area Track Management Strategy

The *Walking Track Management Strategy for the Tasmanian Wilderness World Heritage Area* (Parks and Wildlife Service 1994) states that the Park and Wildlife Service will undertake a comprehensive program of walking-track monitoring throughout the World Heritage Area (WHA). The monitoring program will encompass track impacts, campsite impacts and usage levels and will be undertaken in conjunction with ongoing surveys of visitor characteristics and attitudes.

The *Walking Track Management Strategy* recommended the implementation of a number of previously untried (by us) management strategies. These include the short-term channelling of resources into "first aid" measures to stabilise rapidly eroding tracks (Priority Erosion Control, or PEC), and the implementation of an education program which encouraged users to "fan out" in some areas.

The *Strategy* also recommended that walking tracks be managed in the context of a track classification scheme which specifies acceptable levels of track development for different categories of tracks.

Track monitoring is therefore an essential component of the *Walking Track Management Strategy* because it allows the effectiveness of management policies to be assessed and the extent to which track conditions conform to the levels specified by the track classification scheme to be determined.

1.3 The purpose of this document

The purpose of this document is to describe the program currently being used to monitor track impacts on unimproved tracks and pads in the Tasmanian Wilderness World Heritage Area, and to highlight key issues that must be taken into account when developing similar programs for other areas.

2 Nature and extent of track impacts in the WHA

2.1 The WHA track system

The Tasmanian Wilderness World Heritage Area (WHA) encompasses an area of nearly 1.4 million hectares and includes more than 1000 km of walking tracks varying from high-grade nature trails to unmarked pads.

The policy of the Parks and Wildlife Service is to continue stabilising and upgrading major tracks in the WHA, using intensive track "hardening" techniques such as duckboarding, cording and graveling where appropriate.

Management inputs on tracks which are rated lower in the track classification scheme will be limited to works, including track relocation where appropriate, designed to stabilise erosion and minimise environmental damage with minimal expenditure of resources.

It is therefore envisaged that a large proportion of the tracks in the WHA, especially tracks which are rated lower in the track classification scheme, will and should remain largely unimproved in the medium to long term.

2.2 Types of impacts

The main types of deterioration affecting unimproved tracks in the WHA are:

- track erosion - mainly rill formation due to water flow and gouging due to trampling impacts on steeper gradients;
- quagmire formation on poorly drained sites;
- track widening; and
- track braiding.

These problems are exacerbated by the inherent fragility of much of the western Tasmanian environment, and by the fact that many of the existing tracks in the region are too steep, poorly drained or located in highly sensitive areas.

Other common problems occurring in the WHA include the unplanned formation or extension of new tracks and pads in previously trackless areas, and the deterioration of pads into full-blown tracks through loss of vegetation.

2.3 Extent of impacts

A comprehensive inventory of tracks and track conditions in the WHA was undertaken during the period 1990-91 to provide an information base for the *Walking Track Management Strategy.* Analysis of the inventory data revealed that roughly 120 km of tracks were already subject to erosion greater than 25 cm deep, and that this figure is likely to increase to an estimated 200 km if no preventive action is taken and if usage continues at current levels.

3 Aims and priorities of the monitoring program

At the outset of any monitoring program it is important to clarify the aims and priorities of the program and the type of information that the program is required to produce. The aims and priorities of the WHA track monitoring program are as follows:

3.1 Primary aims

The primary aim of the track monitoring program is to provide managers with data on the basis of which track conditions and trampling impacts in the WHA can be assessed and predicted. The program should:

- Provide the basis for a systematic assessment of the levels, rates of change and distribution of track impacts throughout the WHA and the major regions which are visited by recreational walkers;
- Provide detailed information on the levels, rates of change and distribution of track impacts in local areas where necessary.
- Facilitate the prediction of future track conditions.
- Identify existing and potential trouble spots, especially places where damage is likely to be irreversible or expensive to stabilise/repair unless preventive action is taken in the short term.

3.2 Secondary aims

The track monitoring program should also enable managers to:

- Gain a better understanding of the mechanisms of track deterioration and the relationships between environmental and usage variables and impacts.
- Assess the effectiveness of management actions.
- Monitor rehabilitation.

3.3 Main priorities

Priority is generally given to:

- Sites where environmental damage is occurring, including unplanned track development. (The program gives lower priority to assessing user comfort.)
- Sites judged to be susceptible to unacceptably high levels of impact.
- Sites where conditions are close to exceeding acceptable levels as specified by the track classification scheme.
- Sites where rates of change are highest or are considered likely to increase rapidly in the near future.
- Sites where recent changes have taken place (eg increased ease of access) which may affect usage or impact levels.
- Sites where new management policies have been implemented, eg a fanout policy.

The monitoring program focuses mainly on unimproved tracks, ie tracks where no stabilisation works have been undertaken. However, impacts are also monitored at some sites where priority erosion control (PEC) has been undertaken.

Techniques for monitoring the condition of track infrastructure such as duckboard may be developed in the near future, but are beyond the scope of this paper.

3.4 Secondary priorities

Priority may also be given to:

- Sites where the quality of existing data on track impacts is poorest.
- Sites where our understanding of the effects of management is poorest.
- Sites where impacts are judged to pose a substantial threat to ecological and other values, eg trampling of rare plant communities and cultural sites.
- Sites representing a broad spectrum of environmental and impact types (including impacts resulting from low usage levels).
- Where practical, preference will be given to sites in relatively accessible locations to facilitate ease of data collection.

Note: In practical terms the above priorities will determine the density of sites installed in a particular area, the frequency with which sites are measured and the level of precision with which track sections are classified into types (see sections 5 and 10.4).

3.5 Information output

At this stage, information derived from the monitoring program is summarised in internal reports, usually focusing on various walking areas within the WHA. Information concerning the extent of track impacts in the WHA as a whole may be of particular interest to policy planners, whereas information on local impacts is more likely to be of interest to district ranger staff.

4 Track monitoring strategies: the options

4.1 Detailed measurements vs the "big picture" approach

When undertaking an inventory or monitoring program of walking track conditions, managers are faced with the choice of making a large number of fast and relatively inaccurate measurements or a smaller number of more accurate measurements (Cole 1983). The choice must depend upon the type and accuracy of the information required and on statistical considerations such as the variance of the indicators being measured.

4.2 WHA walking track inventory

The walking track inventory which formed the basis of the *Walking Track Management Strategy* was a census-type inventory in which the extent of specified track conditions was estimated as a percentage (by length) of identified track sections. For each section of track an estimate was made of the percentage of the section eroded to a depth of more than 25cm, the percentage subject to mud more than 10 cm deep and so forth. The track sections in question were chosen so as to exhibit reasonably homogeneous environmental and siting conditions, and varied in length from a few hundred metres to several kilometres.

The inventory was completed in about 18 months and provided an overall picture of track conditions in the WHA. However, the data obtained using this technique were considered insufficiently accurate for use as the basis of an ongoing track monitoring program.

4.3 Transect-based monitoring of extended sections of track

A more accurate monitoring technique involves the sampling of a small number of variables at a relatively large number of localised sites. For example, estimates may be made of track width and erosion depth at 500m intervals along an entire track system (eg Bratton et al 1977).

Lance et al (1989) described a study of walking tracks in the Cairngorm area of Scotland in which three indicators (width of bare ground, width of damaged vegetation and total width) were measured at permanently marked, evenly spaced sites and remeasured after a lapse of time. By assessing the variances of each of the three indicators the authors were able to determine how many sites were needed on each track to detect changes in impacts with the degree of sensitivity that they required. The sensitivity of the technique was enhanced by taking measurements at fixed (ie relocatable) sites instead of selecting a new set of sites each time track conditions were measured.

4.4 Detailed transects

Still more accurate data can be obtained by undertaking detailed transect measurements, for example by measuring track depth at 10cm intervals across transects (see for example Leonard and Whitney 1977, Whinam et al 1994). Such techniques provide accurate information on impacts at specific sites, but because they are time-consuming it would be impractical to use them as a means of monitoring track conditions over an extensive track system.

4.5 Choice of technique for the WHA monitoring program

For the purposes of monitoring track impacts in the WHA a technique similar to that employed by Lance et al has been adopted, but with several important differences. The technique involves the measurement of a relatively small number of variables at fixed, widely dispersed sites, each site consisting of ten transects spaced at two metre intervals along the track. The statistical aspects of the program are outlined in section 5 below and the details of the technique are described in section 7.

5 The statistical framework

5.1 The concept of track "types"

The long-term aim of the WHA track monitoring program is to classify tracks into types on a section-by-section basis, each type corresponding to a defined range of environmental and siting variables and exhibiting a characteristic range of impact levels and rates of change of impact levels.

For example, the type designated "boggy" is associated with the following environmental conditions and impact characteristics:

Environmental conditions:	Flat sites, poor drainage
Impact levels:	Deep mud, minor erosion
Rates of change of impact:	Slowly increasing width and mud; static or slow erosion

Providing the types are well defined it should be possible to derive predictive equations which express impact levels and rates of change as a function of a relatively small number of explanatory variables within each type. For example for the track type "boggy", track width may be a function primarily of usage and be largely independent of other variables.

5.2 Classifying tracks into types

Once sufficient information has been obtained to identify types and to derive reliable predictive equations, the main task will be to classify tracks throughout the WHA into sections of particular types. On the basis of this classification it will then be possible to:

(a) derive a statistical summary of the levels, rates of change and distribution of track impacts throughout the WHA and its major regions; and

(b) provide more detailed information on track impacts in local areas using the track "typing" supplemented with further sampling where necessary.

It should be noted that, at the time of writing (April 2001) this long term aim has not yet been achieved. The typing scheme currently serves only as a basis to group and compare changes at monitoring sites.

6 Indicators

6.1 The concept of indicators

An indicator is a measurable variable whose value indicates the severity of a particular impact. For example the maximum depth of a track as measured across a transect is an indicator of the amount of erosion occurring at that transect.

The choice of indicators to be measured in a particular monitoring program will depend upon the aims and priorities of the program, the impacts and impact-levels of greatest concern, the relative ease with which indicators can be measured and other factors such as the resources available for data analysis.

6.2 Choice of indicators

Lists of possible indicators have been published in various papers (eg Kuss, Graefe & Vaske 1990).

In the current monitoring program in the WHA the following indicators are measured at each of the ten transects at a given site:

- Maximum depth below (estimated) original ground surface;
- Width free of vegetation; and,
- Width of visibly trampled ground and/or vegetation;

In addition, the following indicators are estimated for each site:

- Presence or absence of litter over at least 90% of the trampled ground within the limits of the site.
- Evidence of frequent water flow along the track at the site in question.

A number of additional indicators were also measured at each site earlier in the monitoring program but statistical analysis of the data revealed that no additional information was being gained. These superfluous indicators were:

- Width of bare ground;

- Width of transect eroded to a depth of more than 10cm relative to the (estimated) original ground surface;
- Number of braids;
- Presence or absence of mud at least 10cm deep; and,
- Presence or absence of mud at least 20cm deep.

7 Measurement technique and data storage

7.1 Transect measurements

Transects are imaginary lines situated at right-angles to a track, or at right-angles to the main branch of a track if the track is braided.

The indicators listed in section 6 above are measured at each transect, a tape measure being used to measure widths and depths. Each of the variables and the techniques required to measure them are described in detail in a reference notesheet (*Guide to the WHA track monitoring form and track monitoring database*), which is printed on water-strength paper for on-site reference. Monitoring is undertaken by experienced and trained staff.

When measuring the variables "erosion depth" the original soil level is estimated by stretching an extendable metal rod (a car radio aerial is ideal) between the edges of undisturbed soil on either side of the track.

Experience suggests that monitoring field-trips are best undertaken by two people; apart from the safety factor it is far easier for one person to be recording data while the other is taking measurements.

7.2 Site measurements

7.2.1 Definition of a site

A site is a cluster of transects (usually ten) spaced at two-metre intervals along a track in a specified direction from a fixed starting-point. Sites are identified by numbered stainless steel tags attached with stainless steel cable either to aluminium pegs or to vegetation. The first transect at each site is located at the point on the track nearest the marker tag, unless otherwise specified. The remaining transects are located at two-metre intervals along a 20-metre tape.

7.2.2 Use of tape to locate transects

For many sites, the results obtained by using a 20-metre tape to locate the transects are statistically indistinguishable from those obtained by pacing out the two-metre intervals between transects. However on steeper sites it is difficult to measure distances by pacing, and when transects coincide with eroded steps it is often difficult to decide exactly where to take the transect measurements. For these reasons a 20-metre tape is used on all sites to minimise the risk of bias in the location of transects and to maximise the precision with which measurements can be reproduced.

The sensitivity with which changes in impacts can be measured by this technique could be improved if the locations of all ten transects at each site were permanently marked (eg with additional aluminium pins). However, this would increase the risk of marker pegs being trodden on or pulled out by walkers. Furthermore, the gain in accuracy would be outweighed by the additional time and cost associated with putting in ten times as many markers at each site.

7.2.3 Type of data recorded

When a site is first established, data are recorded on a wide range of environmental and siting variables including geological type, soil profiles, drainage, vegetation type and track and terrain gradients.

On subsequent visits to established sites, modified forms are used with the relevant location data already printed on them, and only time-dependant data such as the date and track impacts are recorded.

It is possible some of the environmental data collected may eventually prove to be redundant once the typing system has been finalised and further information is available about the relationships between environmental and siting variables and track impacts.

7.2.4 Site location photographs

To assist the relocation of sites photographs are taken and carried into the field on subsequent visits in the form of postcard-sized prints.

These photographs have proven to be extremely useful, enabling relocation of sites even when marker pins have been lost.

7.2.5 Time needed to undertake site measurements

It takes a team of two experienced field-workers about fifteen to twenty minutes to establish a new site and record all the relevant data. Subsequent measurements at established sites take about ten to fifteen minutes per site.

7.3 Data storage

7.3.1 Field forms

All the data recorded at a site including location data, environmental data, recording data (date, recording officer, photo numbers etc), transect data and other relevant data such as notes on track improvements are initially recorded on forms printed on A4 sheets of water-proof paper.

As mentioned in 7.2.3, on subsequent visits to established sites modified forms are used with the relevant location data already printed on them, and only time-dependant data such as the date and track impacts are recorded.

The Parks and Wildlife Service is currently investigating the feasibility of using a weatherproof palmtop computer for data storage in the field, but these would have some disadvantages - not least the risk that they could break down three days out from the nearest road.

7.3.2 Calculation of means

To speed up data entry the means and standard deviations of the track-impact variables at each site are calculated in the field using a pocket calculator. This provides a pleasant form of occupational therapy for those long nights in the tent! Means were chosen in preference to medians so as to take outlying values into account. For example, the presence of intermittent mudbowls on a track section may be indicated by the occurrence of a few exceptionally high values of width at sites located in that section. This information would be lost if only median values were recorded.

Some of the indicators listed in 6.2 are undefined in some environments: for example "width free of vegetation" is undefined in some forest environments where ground vegetation is sparse. If a variable is undefined at more than four transects at a particular site, the data are discarded to avoid giving undue weight to under-sampled data. Because the incidence of undersampling is relatively rare, no attempt has been made to give a reduced weighting to mean values calculated from fewer than ten transects.

7.3.3 Monitoring database

At the conclusion of field trips data are transferred to a Microsoft Access97 database on DOS-compatible computers, using a data-entry format which closely mirrors the format of the field forms.

8 Program development: pilot study and preliminary analysis

8.1 Aims of the pilot study

In developing the track monitoring program a pilot study was undertaken with the following aims:

(i) To assess the validity of an initial classification of types (basically an informed guess) and to modify that classification as necessary;

(ii) To assess the variability of impacts both within sites and within types;

(iii) To assess the reliability of the monitoring technique (as described in 7 above) and to determine if it is necessary (and if necessary, possible) to adjust data to make allowance for human bias in the measurement process;

(iv) To assess the relationship between track conditions and causative variables, ie environmental variables, siting variables, track age and usage.

The typing system developed to date is based only on information about environmental conditions and *current* impact levels. The long term aim is to develop a system which takes into account not only current impact levels but also the rates of change of the impact variables.

Twelve types were initially selected based on the variables track slope, vegetation height and drainage. These variables were judged to have the greatest influence on track conditions, the judgment being based on information gained from (a) the WHA tracks inventory (see 4.2 above), (b) the findings of recreational-impact research both within Australia and overseas and (c) personal experience and anecdotal information about track deterioration in the WHA.

It was recognised that track impacts, and especially track width, are generally dependent on usage levels. However, rather than defining types in terms of usage it was felt that usage should be treated as a separate variable whose influence will be taken into account in predictive equations.

Vegetation height was chosen as a criterion for distinguishing types because it provides an easily measured indicator of the extent of woody root-systems which tend to resist erosion.

8.3 Sampling strategy

8.3.1 Initial assessment of type frequency

Using the data obtained in the WHA track inventory an assessment was made of the relative frequency with which the types described in 8.2 occurred on tracks in the WHA. The areas in which the pilot study was undertaken were selected so as to ensure that frequently occurring types were well represented in the study (see 8.4.1).

Had information been available on the variability of impacts within each type, this factor would also have been taken into account in determining sampling frequencies, higher within-type variability requiring greater sampling frequencies. However before the pilot study was undertaken no data on within-type variabilities was available.

8.3.2 Criteria for selecting the location of sites

In the field the aim was to identify track sections of a given type and to sample track conditions within those sections according to the following criteria:

(i) Sites were selected on the basis of environmental/siting variables and usage levels, not on the basis of impact variables.

(ii) Sites were selected so as to represent a wide range of environmental conditions within each section.

(iii) Where possible sites were chosen close to distinguishing features to facilitate easy relocation, providing the choice of such sites was unlikely to introduce a sampling bias.

(iv) Sites were chosen so that each site spanned a segment of track with fairly homogeneous environmental and siting conditions. For example, an effort was made to ensure that track gradient was fairly constant over the length of every site.

(v) Sites were located away from fanout points and the ends of sections of a given type.

(vii) Otherwise sites were distributed at approximately evenly spaced intervals within each section.

8.4 Description of the pilot study

8.4.1 Selection of areas

The pilot study involved the sampling of 191 sites on two extended field-trips. The areas chosen for the study were (a) the Southern Ranges traverse and the eastern half of the South Coast Track and (b) the Arthur Range/Arthur Plains area. These areas were selected because:

(i) They exhibit a wide range of environmental conditions representative of environments through much of the WHA;

(ii) Types which occur frequently in the WHA were well represented in these areas;

(iii) Most of the tracks in these areas were unimproved, ie no stabilisation works have been done on them;

(iv) Detailed transect sites had already been established on the Southern Ranges traverse, and could be remeasured in the course of the pilot study;

(v) The areas contain sections of track where rapid deterioration was (and is) occurring.

8.4.2 Technique reliability trial

During the pilot study a trial was undertaken in which a particular site (judged to be typical of track conditions throughout much of the WHA) was measured independently by three field staff, each of whom located transects both by pacing and by using a 20-metre tape measure. For the results of this trial see 8.5.1.

8.5 Analysis of pilot study data

8.5.1 Technique reliability trial

Analysis of the data obtained in the technique reliability trial (described in 8.4.2) revealed no significant difference between the results obtained by the three field staff; hence human bias does not appear to be an issue.

Note, however, that by the time the sampling trial was undertaken all three members of staff were well versed in the measurement techniques.

Subsequent experience revealed that the technique initially developed for measuring track depth was fairly inaccurate and that the accuracy could be greatly improved by using a telescopic radio aerial to indicate the original soil level.

The sampling trial also indicated that the results obtained by using a 20-metre tape measure were statistically indistinguishable from those obtained by pacing out the transects. However, as mentioned in 7.2.2 a 20-metre tape measure is always used to minimise the risk of human bias when choosing the transect locations, especially on steep sites.

8.5.2 Assessment of initial typing system

The validity of the initial choice of types (see 8.2) was tested by performing a canonical variate analysis of the data obtained during the pilot study. Only the site values (ie the mean values at each site) of track depth and the track-width variables were included in the analysis. Three distinct types were identified corresponding to boggy sites, sites subject to high erosion and "normal" sites.

8.5.3 Identification of explanatory variables and derivation of predictive equations

For each of the impact variables mentioned in 8.5.2 (ie depth and the three width variables) a logistic regression was undertaken with the following aims:

(a) to identify environmental variables which account for variations in impact levels over and above those accounted for by the typing, and

(b) to provide a probability-based prediction of whether a given site will have a "high" or "low" value, based on the values of the variables referred to in (a).

8.5.4 Interpretation of results of logistic regression

On the basis of the results of the logistic regression the following conclusions could be drawn:

(i) Width of visibly trampled ground is strongly influenced by usage;

(ii) Track depth is partially dependent on terrain slope (and track slope);

(iii) The width of track eroded to a depth greater than 10cm is influenced by track gradient;

(iv) Track conditions are strongly dependent on siting variables such as track slope and on local environmental conditions such as drainage.

The conclusion to be drawn from (iv) is that it is not possible to predict track conditions from data derived from maps and aerial photos (eg altitude, geology etc). Tracks must be inspected on the ground in order to classify them into types.

8.5.5 Inspection of outliers

Data recorded at sites where impact variables were found to be poorly predicted by the logistic regression (ie sites with a "high" value of an impact variable for which a "low" value was predicted to be very likely, or vice versa) were subsequently re-examined to determine if any other factors could be identified which might account for the observed inconsistency.

On the basis of this inspection a number of changes were made to the typing criteria; these changes are described in the next section.

9 Introduction of new variables and revised typing criteria

9.1 Additional indicator

In the pilot study three types of width were measured: "width cleared", "width trampled" and "width eroded to a depth of more than 10cm". "Width cleared" was defined to be the width of track free of either litter or vegetation depending on which of these constituted the dominant ground cover. However due to the difficulty of defining "dominant ground cover" the indicator "width cleared" was subsequently dropped and replaced with "width of bare ground" and "width free of vegetation", with “width of bare ground later being found to be superfluous, as noted in 6.2.

9.2 New variables

After outliers were inspected the variable "drainage" was substantially redefined and the new variable "confinement" was introduced, confinement being defined as the extent to which walkers are constrained to walk on a track by vegetation and other obstacles (ranked on a scale of 1-3).

Values for these variables were assigned to the sites sampled in the pilot study using information already recorded in the monitoring database.

The analytical procedures described in 8.5 were then repeated.

9.3 Results of analysis using revised criteria

On the basis of the second analysis the following conclusions could be drawn:

(i) Four distinct types were identified, but substantial misclassification still occurred between some pairs of types. There is the possibility that a fifth type may be identified but at the time the analysis was undertaken there was insufficient data to verify that this type was significantly different from its neighbours.

The four types identified to date are:

Type 4: Sites with water flow and steep sites with low vegetation (characterised by moderate width and deep erosion);

Type 3: Boggy sites (characterised by wide tracks with shallow erosion);

Type 1: Stable sites corresponding to various categories of environmental and siting variables (characterised by narrow tracks with shallow erosion); and

Type 2: Other sites (characterised by moderate width and moderate erosion).

(ii) For the purposes of separating types the indicator track depth and all three of the original width indicators provide useful information - ie the classification is less successful if any of these variables are omitted. (Note: the width indicators have since been modified - see 9.1)

(iii) The new variables drainage and confinement added useful information and increased the predictive power of the regression equations.

Note:

The criteria used to define types include variables whose values may vary over time, and to some extent are themselves a function of the degree of deterioration of a track. In particular, the variable "drainage" and the percentage of litter cover on a track may change as impacts increase (eg drainage may change from "normal" to "water flow" as a track gets deeper). Hence the typing for some sections of track may have to be revised every few years.

An additional two types (N1 and N2)have subsequently been defined, corresponding to situations where the “erosion potential” is limited by the presence of a non-erodible surface (eg hard bedrock or non-erodible horizons derived from hard rocks) at a depth of <25cm. Criteria used to define these types also include the track gradient and presence of a high proportion naturally-occurring bare ground.

10 Development of the track monitoring system

10.1 Establishing new monitoring sites

Rather than waiting several years for the finalisation of the typing system the Parks and Wildlife Service proceeded with the establishment of new monitoring sites in a number of areas. The criteria for selecting these areas and sites include:

About 500 permanent track monitoring sites have now been established on more than 100 tracks in the World Heritage Area, with reliable data obtained from many areas since 1994. The data collected indicate that significant track deterioration is occurring in most areas being monitored. Of particular relevance and concern is that higher rates of change often tend to occur at relatively low-use sites.

Data on track conditions and rates of change at sites for which two or three sets of data had been collected by mid 1998 were analysed by statistician Glen McPherson of the University of Tasmania.

Key findings of these analyses are as follows:

- Confirmation that sites can be classified into types on the basis of usage levels and environmental and siting conditions. There are statistically significant variations between the impact distributions of these types.

- Statistically significant increases in depth occurred within most types, and statistically significant increases in width occurred within some types.

- Over all type/usage categories, during the 1994-98 period, depth increased at an average rate of 11% per year, width free of vegetation increased at an average rate of 4% per year and width trampled increased at an average rate of 3% per year.

- Impacts were highest within types defined as having high track gradients and/or low vegetation.

- For given classes of environmental and siting conditions, width tends to increase with usage. There is no obvious relationship between usage and depth.

- The rate of deterioration tends to decrease as the level of deterioration increases. For mature (ie long-established) tracks, deterioration occurred at similar rates for all type/usage categories.

Specifically the analysis indicated that Type 4 tracks (e.g. much of the northern end of the Western Arthurs) tend to show the worst state, but often low rates of deterioration. Type 2 (the most common type, occurring in all parts of the WHA) and type 1 tracks were in the relatively best state relatively but had the greatest rates of deterioration.

Since the completion of the above analyses, sites have been remeasured in a number of areas, including the Arthur Ranges, Southwest Cape, Anne Range, Southern Range, Walls of Jerusalem and upper Mersey-Pelion region. The information obtained from this more recent monitoring suggests that significant deterioration is continuing in these areas, and that impacts on certain tracks has exceeded or are likely to soon exceed the limits specified by that track classification.

10.2 Gathering data on usage levels

The collection of usage data is an essential component of the monitoring program because track impacts and rates of track deterioration are generally dependent on usage levels. Registration booths remain the main source of information on usage levels in the WHA, but the data obtained from registration booths is supplemented and correlated with data from pedestrian counters and a number of remote-area logbooks where possible. Nevertheless, in many areas the knowledge of usage levels amounts to little more than guesswork.

10.3 "Typing" of tracks

If the typing system becomes sufficiently refined the next step will be to begin "typing" tracks throughout the WHA, giving priority to tracks and areas where impacts are considered likely to be of concern in the foreseeable future. The task of track typing is one that with training could be undertaken by field staff, and could be made substantially easier if programmable pocket calculators or palmtop computers were used.

Track "typing" will involve classifying tracks into sections of specified types on the basis of environmental and siting variables. The accuracy with which tracks are classified will depend on the priority assigned to monitoring in the areas under study.

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