ENVIRONMENTAL BASELINE STUDY OF DAMAGED GROUND AT CAIRNGORM ESTATE

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SUMMARY

This report presents the results of a study of damaged ground at Cairngorm Estate, based on field work in 1990-93.

Most of the bared ground on the main ski grounds resulted from operations in the 1960s, especially the use of machines on the ground during construction works, but much of it has been caused by walkers. Ground alterations and new facilities carried out by the ski company in recent years have caused minimal and negligible impacts.

On the wider Estate, outside the main ski grounds, most of the damage has been caused by walkers. Ground damage by walkers is concentrated on paths, most of which have widened and deteriorated. However, repairs to the most seriously damaged paths in recent years have reversed this trend markedly in these cases. The path repair works have been on a larger scale than on any comparable hill area in Scotland. At high altitudes outside the main ski grounds, some slopes show widespread diffuse damage over a broad front, again due to walkers.

The main aim of the Study was to set up a monitoring scheme on some of the most seriously damaged paths and slopes, based on fixed sampling sites marked with metal pegs, as an objective baseline for comparison with future changes. As far as we are aware, this is the most rigorous quantitative scheme for monitoring damaged ground so far established on a mountain area in Britain and Ireland.

A second aim was to identify and describe the main problem sites which posed threats to the stability of hill ground or to amenity, and to recommend remedial action for them.

A third aim was to start annual monitoring on the ski area, of the kind already done for some years at the Lecht and Glenshee. The purpose was to inspect in early summer the fresh damage caused by skiing operations in the previous winter, agree a rectification programme with managers, and check its efficacy in autumn.

This report describes locations and methods used, and gives results covering all three of the above aims. Monitoring at fixed marked sites was done in eight different locations, chosen deliberately because they had much damaged ground, on paths and on slopes with widespread diffuse damage. Measurements were made in late summer 1991, 1992 and 1993, and the report presents the first data on change from year to year. There was little material change. So far, this indicates no trend towards deterioration in ground condition on the Estate from year to year.

Some paths show a trend towards widening and deteriorating in surface, some appear to be approximately stable in condition, with no material change, and most show signs of less use, narrowing, and colonisation by hill vegetation. Some of the most seriously damaged sections have been repaired. The repairs have markedly improved path surfaces and narrowed the paths, allowing colonisation by hill plants on formerly bared areas at the side. Some repaired parts could be further improved by minor changes, and suggestions for this are given. Recommendations are made on priorities

for new repair works and other management suggestions for paths so far untreated. Notes are presented covering all paths and their condition.

Inspections and monitoring on the ski area started in 1990 and have been carried out annually since. In each year, hardly any fresh damage was caused by the previous winter's skiing operations. The main damage was confined to small patches of bare peat in lower Coire Cas and a few in Coire na Ciste, which were already there in earlier years. The patches in Coire Cas have shown a marked increase in vegetative cover since 1990 due to reseeding and colonisation by native hill plants.

In 1990 there were minor bank slips at a steep corner on the gravel road up Cairn Gorm; suggestions for reinstatement are given. Each winter there has been short-term deterioration in the condition of the gravel vehicle track and its drains; this was rectified each summer, and suggestions have been made for longer-term improvement. For example, agreed changes in track surfaces and drains have reduced runoff and erosion. Suggested changes in the platform surface at the Ptarmigan Restaurant have made a better walking surface and reduced the rolling of stones on to vegetation. Other ground works near the Ptarmigan Restaurant have improved the appearance of the area. Alterations by the Chairlift Company to the upper part of the vehicle track to the Ptarmigan Restaurant and at the top of the new extended M1 Tow have reduced soil erosion markedly, increased vegetative cover, and produced better surfaces for walkers on the track and for skiers off the track.

Major problem sites with bare ground were identified. They are classified in terms of safeguarding the stability and condition of hill ground, and in terms of amenity in places visited by people. Recommended treatments, with priorities and an implementation table, are given. The only case recommended for urgent treatment from the viewpoint of safeguarding the stability of hill ground is the set of small landslips that took place in the headwall of Coire Cas in 1992.

This Study is a baseline, upon which rolling annual action plans and monitoring would rest in future. The action plan would be reviewed and brought up to date once a year. It would change in the light of fresh damage or other problems highlighted by future annual monitoring and recovery. The aim is to increase ground stability and amenity continually, wherever possible providing good conditions for recovery by natural processes.

1 INTRODUCTION

1.1 General

In 1989 the Highlands & Islands Development Board (now Highlands & Islands Enterprise), asked the writer to carry out an environmental baseline study on their Cairngorm Estate. I was then a member of staff of the Institute of Terrestrial Ecology at Banchory, and preliminary costs were paid to ITE. Since May 1990, the Board have commissioned the work from the writer as an independent environmental consultant. The Board's request for a baseline study followed the production of the Environmental Baseline Study at Glenshee Ski Centre (Watson 1988). Glenshee Chairlift Company commissioned this in response to requirements by Grampian Regional Council and other planning authorities, which were considering the Company's proposals for new developments and their Development and Management Plan (Glenshee Chairlift Company 1987).

As at Glenshee, the Cairngorm study was to concentrate on measuring ground damaged by human impact. The term "damaged ground" involves bare ground where all vegetation has gone, and associated soil erosion. Damage to vegetation, such as bruising, is often included in the term, is often associated with bare ground, and is often an early warning of likely impending bare ground. Below, "damaged ground" includes bare ground and vegetation damage, and the two are frequently distinguished and described separately (see Section 3 for a fuller account of the terms and meanings). However, it was decided by Mr K.S. Bryers of HIDB with my full agreement that the study should concentrate on bare ground. All were agreed that this was of key importance for the condition of the hill, including the vegetation and the skiing which both ultimately depend on maintaining the soil and thus on reducing the amount of bare ground as much as possible.

1.2 Study aims

The aims of this Study were:-

1. to produce an objective quantitative baseline of the state of ground conditions in the area now, against which future changes could be reliably compared. There has long been argument between conflicting interests, sometimes acrimonious, on whether ground conditions on Cairngorm Estate and on the nearby plateau are worse or not, and to what extent (e.g. evidence at the Lurcher's Gully Public Inquiry in 1981). The intention was to produce factual quantitative information that would stand up to cross-examination at a public or other inquiry, and should also be capable of being used in publications in refereed scientific journals. In this way the credibility of the monitoring and of the organisations associated with it would be strengthened.

2. to recommend measures for reinstatement of problem sites that were at risk, and to state priorities and responsibilities, with a view to reducing the amount and severity of damaged ground and to improving the appearance of the area.

3. to establish a monitoring scheme, which would be largely quantitative. Its purpose was to measure reliably the state of damaged ground in future, in particular to find whether there was a trend towards deterioration, or towards improvement, or whether there was no material

change. In turn the data would allow the monitoring results to be related to the baseline and to the reinstatement works. The intention was that this process would involve an action plan brought up to date each year, and re-assessed in the light of the monitoring. In consequence, ground management of the area should continually improve, given a commitment to this by the land managers, along with the necessary finance.

Field work for the first and third aims began in 1990 and was completed in early autumn 1993. This report gives an account of that field work, and covers the second aim above. It also collates descriptions on path repairs by those doing the work, and presents photographs showing changes in damaged ground over the years, and changes due to path repair works.

1.3 Differences from the Glenshee Environmental Study

A major difference from the Glenshee Study is that it was agreed that there was no need for the Cairngorm Estate Study to include a critical summary review of information on the area's past and present land use, land management, geology, geomorphology, climate, snow lie, water catchment, soils, vegetation, wild animals, and recreational uses and intensities. Unlike Cairngorm Estate, such information had not previously been collated and summarised for Glenshee, and indeed far less research had been done on these aspects at Glenshee than at Cairngorm Estate.

Available information on the Estate has often been made public and reviewed (e.g. Land Use Consultants 1972; Morris, Hammond & Kessler 1974; Watson 1976, 1979, 1982, 1988a, 1991; Pitkin 1979; Nethersole-Thompson & Watson 1981; Anderson Semens Houston 1981; Scottish Development Department 1982; Miller 1985, 1986, 1986a; Scottish Affairs Committee 1985; the HIDB's Estate Management Plan 1987; Wood 1987, 1987a; Bayfield et al. 1988; Mackay Consultants 1988; Whittome 1991; Watson 1993), and these refer to many other relevant papers and reports. This short list is selective, and is merely intended to help readers who wish to search further.

It was not an aim of this Study to review the literature on the Estate comprehensively and critically, but brief guidance may be useful. Some reports both pro-development and anti-development are largely works of advocacy and at times polemic rather than objective factual accounts, but nevertheless are of some use in helping understand the history of events on the Estate. Clearly, independently refereed scientific papers in internationally recognised journals are most likely to be impartial. Although there are exceptions, internal reports by scientific research organisations are likely to be more impartial than reports by public and private organisations where there is no scientific base or where there is such a base but where other aspects are more important.

As compared with the present Study, the Glenshee Environmental Baseline Study was also more comprehensive and wide-ranging on the amenity appearance of buildings, car parks and snow fences, the problems of car park surfaces, the occurrence of construction debris and other litter, a full account of the impacts of the developments on landscape, runoff, water pollution, soils, wild animals, sheep, and vegetation including changes in vegetation due to snow fencing, the assessment of future pistes and towlines, likely impacts of proposed developments, and suggested changes in the Company's Development and Management Plan. Again, it was

decided that enough information on these aspects had already been made public for Cairngorm ski area in the above papers, unlike Glenshee. In the Glenshee Study, Watson (1988) stated that collecting data on snow lie was of no material value for assessing the locations of future installations, and indeed was likely to be misleading, and the same comments apply with equal force to Cairngorm Estate. This issue is covered more fully in Section 12 and Appendix 10 below.

In Section 6 I do summarise the history and impacts of the Cairngorm ski developments and other changes in human use of the area, as background information to help readers understand the causes of the ground damage that is seen there. However, again there was no need to give detailed descriptions as in the Glenshee Environmental Baseline Study, as these aspects have been well covered in the papers mentioned above and in other papers cited by them.

Another difference is that annual independent monitoring began at Glenshee Ski Centre in 1986, before the Environmental Baseline Study, as a condition of planning permission by Kincardine & Deeside District Council for new tows. When the Highlands & Islands Development Board asked me in 1989 to do an environmental baseline study at their Cairngorm Estate, they had also decided that independent annual monitoring should be done at the Cairngorm ski area, similar to that carried out for several years at the Lecht and later Glenshee. They had reached agreement on this with the Cairngorm Chairlift Company, which leases the ski area. The Board asked me to do the monitoring at Cairngorm ski area, in cooperation with the Cairngorm Chairlift Company who would pay for the work.

1.4 Monitoring on the ski area and on the wider Estate

The monitoring at Cairngorm ski area was to differ from the general monitoring of damaged ground on the Estate, although the two would be related. The essential difference is that monitoring on the ski area would be confined, as at the Lecht and Glenshee, entirely to fresh damage caused by skiing operations in the previous winter, and rapid rectification of that damage. In contrast, most of the ground damage on the main Cairngorm ski grounds, as at Glenshee, was caused by construction operations many years ago, some by long-term heavy usage by walkers, and on the wider Cairngorm Estate as a whole mostly by long-term heavy usage by walkers. These longer-term problems were to be covered by the HIDB's monitoring, which would concentrate on (i) fixed marked transects on severely damaged sites involving paths and widespread diffused damage over larger areas up to entire slopes in some cases, and (ii) other problem sites with more localised bared ground.

2 LOCATION AND LAND DESIGNATIONS

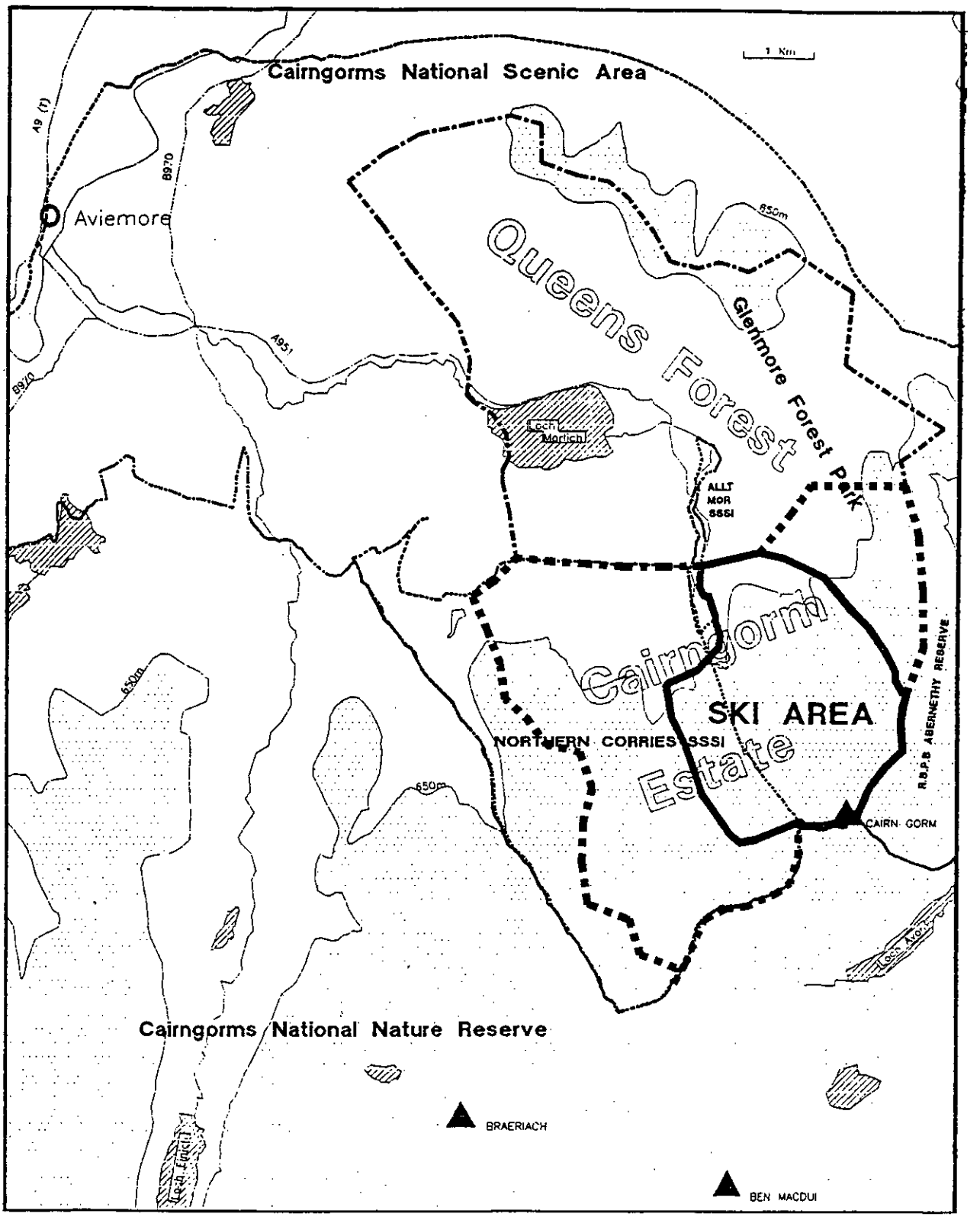
The general location of Cairngorm Estate and adjoining land is shown in the map in Fig. 1.

Fig. 1 also shows the area leased by Cairngorm Chairlift Company, which is entirely on Cairngorm Estate, and the Northern Corries Site of Special Scientific Interest, mostly on the Estate. The northern boundary of the Cairngorms National Nature Reserve runs south from the summits of Cairn Gorm and Cairn Lochan. The Cairn Gorm plateau is mostly on the NNR, but its north-west corner at Miadan Creag an Leth-choin and Creag an Leth-choin lies off the NNR but on the Estate and SSSI. Its north-east corner, north-east of Cairn Gorm, lies off the NNR and SSSI but on the Estate. The Forestry Commission's Glen More Forest runs south to the forest edge, at the Estate's northern boundary.

The entire Estate and all adjoining land in Fig. 1 lie within the Cairngorm Mountains National Scenic Area, as designated by the Countryside Commission of Scotland (1978).

The large-scale map of the Estate in Fig. 2 (at back of this report) shows roads, car parks, buildings, ski lifts, vehicle tracks, snow fences and footpaths. Arabic numerals show the locations of problem sites, and Roman numerals those being monitored at fixed transects. This will allow readers to refer quickly to the appropriate details in the text, and when reading the text to find quickly where the locations are on the map.

Fig. 1. General location map (Figure 1.1 in Cairngorm Chairlift Co 1993)



3 BACKGROUND AND MAIN RATIONALE

3.1 Background

Since the mid 1980s, four District Council planning authorities and two Regional Council ones have tightened their control of proposals for new ski tows and other downhill ski developments at the Lecht and Glenshee Ski Centres. A condition for planning permission has been that the ski company arrange for annual monitoring by an independent body, inspecting damaged ground and reinstatement measures. The writer has been in charge of monitoring at both ski areas. Planning authorities dealing with Glenshee Ski Centre decided that an Environmental Baseline Study for the ski area was required, and I produced the report in spring 1988. It served as a useful model for any similar study of Cairngorm Estate and ski area.

3.2 The meaning of "damaged ground"

The term "damaged ground" usually includes (i) vegetation damage such as breakage and bruising of foliage, and partial or complete uprooting of plants, and (ii) surface movements of soil including disturbance of soil layers or horizons, soil erosion by water either linearly by rills and gullies or laterally by sheet erosion, and soil erosion by wind. Either (i) or (ii) on its own can lead to more bare ground without a vegetative cover, and (i) and (ii) can combine to cause even more bare ground. Bare ground also includes places where water-borne or wind-borne sediment has buried plants underneath and has killed them or materially reduced their ground coverage. Bare ground occurs naturally due to exposure on poor soils at high altitudes, but the proportion of bare ground can be greatly increased by vegetation damage and soil movements.

The concept of "damage" to plants is easily perceived. Damage to soils is a more difficult concept, which can lead to argument. Even if a soil erodes or has its horizons disrupted and turned upside down, it is still there and will change inevitably towards a steady state depending on the array of climate, bedrock, drainage and vegetation on the site. Disturbance of soils is not a fully satisfactory term either, as it can mean different things to different people. In this Study I use "damaged ground" as an umbrella term covering all these problems.

As distinct from bare ground, "bared" ground is where partly or wholly vegetated ground becomes bare as a result of (i) or (ii) or both. Bared ground can be caused by severe climatic effects in the Cairngorms, but usually only on a small scale less than 1 square metre, except for sporadic events such as debris slides and floods. Bared ground over large areas of open hillside at low gradients, such as in Coire Cas, are a clear sign of human impact, generally resulting from the use of machines.

Vegetation damage usually goes along with soil movements. However, an area at low gradient with a good vegetation cover can withstand considerable vegetation damage without leading to more bare ground or soil erosion. Nevertheless, vegetation damage is a useful early warning sign that more bare ground and soil erosion may follow.

On high hills, vegetation damage and soil erosion can occur due to (a) the natural effects of gales, frost heave, and heavy rain, (b) grazing and trampling by deer, sheep and other animals, and (c) human-induced causes

such as bulldozing, use of piste machines and vehicles, and skiers and walkers. All three factors (a), (b) and (c) can interact and combine to produce greater effects than any one on its own.

In the present Study, "damaged ground" is mainly about bare ground from various causes, whether the soil is severely disturbed or not. If it is materially disturbed, involving erosion or other disturbing events, this is usually noted. Vegetation damage is not ignored, as it is so often a valuable portent and as its timely rectification can often prevent the onset and extent of bare ground.

3.3 Differences from the Glenshee Study: ground conditions

Amounts and kinds of ground damage are greater on Cairngorm Estate than on other mountain lands of broadly similar area in Scotland. This is associated with a combination of i) a high prevalence and intensity of natural damage due to factors of climate, bedrock, topography, soil and vegetation in this extreme subarctic-oceanic environment, and ii) unusually high levels of human impact in recent decades and currently.

Studying ground damage on the Estate was therefore much more difficult than at Glenshee Ski Centre, where the Environmental Baseline Study (Watson 1988) was the first carried out on a Scottish ski area. Public perceptions of problems at Cairngorm Estate have also been greater than at other hill estates, because such large numbers of people visit the area and because of major past conflicts between different interests. Hence it was particularly important to ensure that objectives, methods, and teamwork for the study were carefully appraised, practical in operation, and likely to produce reliable conclusions, and that relationships with key organisations were good. For example, I knew from experience with the Glenshee study that good cooperation with Cairngorm Chairlift Company was essential, in order to obtain frank information about historical events that help explain the pattern of ground damage we see today.

In my initial submission to HIDB I stated, "Monitoring of the ski grounds presents no obvious problems; the same methods that have proved useful at the Lecht and Glenshee should work at Cairngorm ski centre too, albeit the Cairngorm centre has a more complex array of problems than the other two centres and covers a bigger area than the Lecht centre ... Monitoring of the rest of the Estate is a much bigger problem, involving footpaths, sliding grit, higher altitudes, poorer soils, and other features that do not arise at the Lecht and Glenshee. Also, the kinds of impact are unusually varied and extensive, as are the kinds of recreational and other pressures. Indeed, the Estate is probably unique in Scotland in the range and extent of impacts and pressures upon it ... nobody has yet tackled a baseline study on such a complex area and problem in Scotland".

4 CHRONOLOGICAL ACCOUNT OF WORK DONE

4.1 Contact with Cairngorm Chairlift Company

In early summmer 1990 I spent a day on the ski grounds with Mr T. Paul and Mr T. Whittome. This was meant to be the first early-summer inspection of the ski area, as part of the new programme of monitoring as at the Lecht and Glenshee. In fact, the inspection was done but most of the time was taken up with viewing and discussing major problem sites shown by Mr Paul, mostly stemming from actions taken many years ago. We had a useful practical discussion on remedies for these problems and for several cases of fresh damage from the previous winter's ski operations. A few of these measures were implemented later in the summer and proved successful.

The differences between annual monitoring of the ski grounds as at the Lecht, Glenshee and now Cairngorm ski area, and annual monitoring of damaged ground on Cairngorm Estate as a whole, became clarified to all, in discussion.

At the outset I believed that good relations with Company managers were a pre-requisite for a successful study, especially for identifying causes and timing of past damage, and for the success of follow-up actions in future. Cooperation has been very good.

4.2 Colleagues who helped, and work proposals

I asked Dr G.R. Miller to accompany me to Cairn Gorm to discuss methods for measuring damaged ground, along with Mr K.S. Bryers of HIDB. Mr Bryers showed us the repairs on the Northern Corries path out to Allt Coire an t-Sneachda. Later I led a general discussion on the objectives and methods for the entire study. It was agreed that the main objective was to find whether bare ground is increasing, decreasing, or staying unchanged from year to year. Secondary objectives were to note the incidence and severity of soil erosion and other forms of ground disturbance, to suggest reinstatement measures, and to check how well they work.

Hence there was no need for quantitative data on which plant species were present and how much of the ground they covered. Earlier, it had been thought desirable to use the same methods as those envisaged for vegetation in the Nature Conservancy Council's Mountain Plateau Ecology Project, where plant species composition and ground cover were two features to be studied. I kept in close touch with Dr D.B.A. Thompson (MPEP Leader) on his progress in trying different methods and comparing them. Early hopes that the quick easy method of colour photographs would provide reliable data on the amount of bare ground and on plant species cover were dashed.

However, now that full discussion between Mr Bryers, Dr Miller and myself had made it clear that the objectives of the NCC study and the Cairngorm Estate study were not the same, even though related, there was now no point in trying to have common usage of exactly the same methods. In any study, the methods used should depend on the objectives set.

Dr Miller and I returned on another day to try out different methods, selecting footpaths and more widespread areas of diffuse damage as two very different types. We later went with Chief Ranger Mr N. Baxter to inspect in the field the methods for the monitoring that he had been doing, and to

try the proposed new methods with him. Later I had a number of discussions with him at Cairn Gorm and at his home. Dr Miller and I were impressed by his care in making the field observations and his foresight over how to overcome practical problems. I was therefore content to entrust the detailed field work in future to him, and to other Company staff with experience of such field work who were supervised by him.

I had several useful discussions with Mr A.D. Walker, formerly Principal Scientific Officer in charge of the Grantown office of the Macaulay Institute for Soil Research, about the general problems of measuring bare ground over the large area of the Estate. Mr Walker, Dr Miller and I agreed that measurements on aerial photographs were the most objective, most reliable and least expensive method for measuring damaged ground over the entire Estate, and the only method for doing so in past years.

An important drawback is that aerial photographs are not good enough to measure patches of less than about 1 square metre, yet much of the bare ground on the Estate, including most of the human-induced bare ground in cases with diffused widespread damage, is in patches below this size limit. For this reason it was decided by Mr Bryers that the Study in the first place should not involve detailed measurements from aerial photographs, although this might be considered as a possibility later.

4.3 Footpaths

In autumn and early winter 1990 I walked all paths except one from Coire na Ciste car park to Ryvoan and a small section on each of three others; I walked these in 1991-92. The plateau path round the rim of the Northern Corries was inspected, as some damaged ground on the Estate started at this path. I waited until autumn and early winter; walking on dry summer days tends to give an over-rosy picture, whereas it is easier to see problems when conditions are wet. I made descriptive notes, including comments on whether each path was showing evidence of improvement, deterioration, or no material change. Notes were made on all parts that had been repaired, including suggestions for further improvements.

I met Mr K. Wilson of Pathcraft Ltd at a meeting on path erosion convened by HRH The Prince of Wales on Balmoral Estate in November 1990. By then I had walked most paths on Cairngorm Estate, and we discussed the repair work. He said he would be glad to know my comments in due course. He made me aware of the constraints of working there, due to conditions laid down by NCC on repair works in the SSSI. I also met Dr R. Aitken at the Balmoral meeting, and had useful discussion with him about the Cairngorm Estate repairs and path problems there.

4.4 Monitoring footpaths and other damaged ground

As a result of the visits in 1990 with Dr Miller and Mr Baxter, practical methods were devised and tried in the field. The key method for monitoring at fixed sites involves using a metal tape to make measurements across a transect between two spots marked with permanent metal pegs, and then subsequent pairs of pegs for transects further on. The measurements were to be simpler and less subjective than those which Mr Baxter had been doing with his earlier work on path monitoring. The same new method was to be used for measuring footpaths and areas of diffuse damaged ground. Colour photographs would be taken of the transects. It was planned to set

up the monitoring scheme in summer 1991, and make the first measurements later that summer.

The approximate number of places to be monitored at fixed sites was agreed when I met Mr Bryers at Inverness in October 1990. By then I had done enough field work and had had enough discussions with Dr Miller and Mr Baxter to feel confident about the likely lines and depths that the Study should take. Mr Bryers and I agreed on the number of paths and other areas where monitoring at fixed sites should be done. I suggested that it would be best if Mr Baxter took the analysis of measurements as far as he was happy with, and similarly any comments on the observations; he was willing to do so. This was agreed. I would be responsible for final drafting.

The assessment and description of other problem sites was done by me in the field. I had already plotted much of this on 1: 10 000 maps during surveys of damaged ground in 1981, and I visited all these places in 1990-93 to inspect them in detail again.

4.5 Monitoring on the ski area

The objective here was to go with key Company staff on an early-summer inspection of the area to look at fresh damage caused during the previous skiing season, agree on reinstatement measures for that summer, and check their efficacy in autumn. I made the first summer inspection in 1990. However, quantitative monitoring using visual estimates as at the Lecht and Glenshee was not done in autumn 1990 at Cairn Gorm. The reason for this was that by then we had not decided fully on monitoring methods for the Estate in general.

After considerable discussion in 1990-91, it was agreed that visual estimates be made on substantial (over 1 sq. m) patches of fresh damaged ground affected by the previous winter's operations. Such estimates would be continued until patches were reinstated. Colour photographs were to be taken from the same positions at the same time of year.

4.6 Monitoring of people and other causal agents of damage

Any assessment of paths, damaged areas and repairs to them are more meaningful if there is information on the impacts that are causing the damaged ground or reducing its rate of recovery. Mr Baxter has been counting numbers of people, sheep and deer in certain areas for some years. Clearly it is best if a) count methods produce reliable data, and b) the data can be related to the measurements of paths and other damaged ground. If so, the two kinds of data complement one another and elucidate the general problem better. This was not part of the remit for this Study, but is relevant to it. It would be useful if Mr Baxter's counts and the other information that he collects on impacts could in future be of the fullest use for comparison with his new work programme on measuring paths and other damaged ground. Mr Bryers has asked me to help with this by reviewing the methods that Mr Baxter has been using.

Ideally, data from the past monitoring on the Estate should be collated and used for a short report, with Mr Baxter doing as much of the work as possible. I will help, and Mr T. Whittome has also agreed to help.

For the future, it is important that there is a follow-up to each year's

field work on the monitoring of anything, ao that staff doing the work understand fully why they are doing it, what new information or conclusion has come from the most recent season's work, and what the general importance of this is, in practical terms. It was my intention that this should be the case with the new monitoring.

5 GROUND DAMAGED NATURALLY, WITHOUT HUMAN IMPACT

5.1 Distinguishing human-induced and naturally caused ground damage

In the Glenshee Study, Watson (1988) wrote, "Before one can make any reliable statements about damage due to a specific development such as a ski development, one must first be able to distinguish human-induced from natural damage, or at any rate damage due to the development from damage due to all other causes". Watson (1985) listed and described a number of diagnostic features that distinguished natural from human-induced damage on Cairn Gorm plateau, including some of the higher parts of the Estate and leased ski area. In particular, signs such as dislodged soil and uprooted plants beside a boot mark are incontrovertible evidence of direct human impact. As this is very important for certain aspects of the present Study, especially for widepread areas of diffuse damage, a copy of Watson (1985) forms Appendix 1 of this report; the relevant pages are 365-367.

5.2 Ground damage by natural causes on the Estate

The commonest form of damage from natural causes on the Estate is the deposition of wind-blown grit on vegetation; this bruises plants and can in severe cases bury them partially or wholly. Gales tear foliage off, especially noticeable with woolly fringe moss in exposed places, and sometimes uproot plants. Freezing and thawing cause damage by exposing parts of plant roots and by making exposed soils more prone to subsequent movement by wind and water.

Heavy rain sometimes uproots plants. However, the main form of damage by rain is lateral movement of soil downhill by sheet erosion, and the more drastic linear concentration of erosion by the cutting of rills and gullies. Severe erosion causes poorer soil fertility by washing finer topsoil and organic matter downhill, leaving coarser, more infertile material behind. This was clear in soil samples on disturbed and undisturbed sites on the Estate and National Nature Reserve (Watson 1985).

Eroded soil in turn can bury plants under sediment. On the Estate, most vegetation buried by more than 5cm of sediment subsequently dies. A common form of natural damage is deposition of eroded infertile grit to bury fine topsoil underneath, which is then unavailable for plant colonisation, whereas the coarse grit now on the surface is too well drained to support good plant growth. In time, this changes naturally, as soil movements caused by freeze-thaw action frequently push underlying topsoil through to a patch on the surface, where it then becomes a good site for plants. In the short-term, however, the effect is to delay revegetation.

Trails used by red deer in the past caused a very small amount of bare ground, negligible in total extent, and similarly trails of hares.

Snow avalanches occur each year on the rock slab in Coire an Lochain and occasionally on the headwall of Coire Cas. Avalanches started by people have occurred on the west slope of Coire an Lochain, and naturally caused avalanches west of Fiacaill a' Choire Chais and Coire na Ciste. Most did no damage to ground, as the avalanche snow fell on ground already protected by deep snow. A few avalanches at Coire Cas headwall have torn small amounts of vegetation and soil. In total, the effects are minor.

A considerable amount of bare ground on the Estate consists of bare peat in peat hags. These were there for years before the developments, and this includes the peat hags below the Mid Station in Coire Cas. Such bare peat is widespread in the Cairngorms. Its cause is uncertain; Watson (1988) gave a brief review with references. One possibility is a drier climate now than in the past. Another is that the peat blanket's surface becomes unstable when peat builds up beyond a certain thickness. There is general agreement that high numbers of sheep and deer add to the amount of bare peat, and muirburn can do so. The animal effects and the muirburn probably hasten the process of peat erosion, as would heavy human pressures by vehicle and trampling, even if they do not start it.

5.3 Ground damage by sporadic, larger-scale events on the Estate

Sporadic, larger-scale damage to ground is caused by heavy rain leading to major debris slides, smaller landslips, and stream flooding. Flooding has done severe damage by causing large landslips on stream banks, by moving infertile gravel and boulders far downstream to bury vegetation thickly and damage trees, and by removing the sides of roads and bridges.

An old debris slide comes straight downhill on the steep face of Cairn Gorm above the big bend in the road up Coire Cas, above the top of Coire Cas Tow. It has been stable and well vegetated since I noticed it in 1946. Fresh debris slides occurred in Coire an Lochain and Coire an t-Sneachda during intense rain in a thunderstorm in July 1976, described in Section 11. Some of these originated in heavily trampled bare ground in places visited by many people, but other debris slides on Sron na Lairige and other hills in the Cairngorms during the same storm originated in places with no noticeable human impact, where very few people go. Hence, human impact was not necessary for the slides to occur, but it is likely that it made some slides on the Estate bigger than they would otherwise have been.

Landslips, debris slides and stream flooding are more frequent and more intense where there is extra bare ground as a result of human impact, and these are cases where natural and human-induced effects overlap and add to one another. Similarly, human-induced extra bare ground increases the likelihood of further natural damage from the causes mentioned above.

Stream flooding is a typical hazard in mountainous areas. A major flood occurred on the Allt Mor in 1956 during an intense thunderstorm, and severe damage was done in other parts of the Cairngorms (Baird & Lewis 1957). Another big flood on the Allt Mor took place in 1960, and others there in the 1970s and up to autumn 1981 (Hudson 1978; McEwen 1981; Watson 1981; House of Commons Scottish Affairs Committee 1985).

Watson (1981) noted that the greater frequency of major floods on the Allt Mor in the 1970s and up to autumn 1981 than in earlier decades was highly significant statistically (using the Poisson distribution, the standard method for studying infrequent events such as floods). He noted that the increase of flooding was associated with extra human-induced bare ground in the catchment, including slopes well outside the main developed ski area. However, the past frequency of flooding on Allt Mor cannot be attributed reliably to any cause or group of causes, for two reasons. One is that the observations involve associations of events, not experiment. The second is that no quantitative measurements were made on flood volumes and areas of bare ground in earlier decades or in the 1970s and 1980s.

However, the possible implications of such floods should not be ignored. A flash flood occurred in a burn at Glenshee ski area when human-induced bare ground was at a peak in the catchment (Watson 1988). Flash floods below ski areas abroad have occurred at Les Arcs in the French Alps (Club Alpin Francais 1981) and elsewhere in the Alps (Simons 1988), in some cases causing major damage to property in the valleys. At the Allt Mor, big floods have been significantly less frequent since 1981, in association with the better state of the hill ground (see below).

The Cairngorm Estate Management Plan (HIDB 1987, p. 58) stated that the increased frequency of flooding on the Allt Mor "cannot be attributed solely to the development of Coire Cas as a skiing ground, not least because Allt a' Choire Chais is only one of three main tributaries to the Allt Mor". I agree with this. It was concluded in the Plan that "The high incidence of flooding remains a matter of concern and there is an urgent need to research the present situation and not undertake any developments that might make matters worse".

As major floods in the Allt Mor have been significantly less frequent in the last decade, in my view the issue is no longer a matter for concern. Research on past conditions would be of no value now, as past quantitative data on the relevant parameters were simply not collected. Instead, a watching eye should be kept, for the future.

6 HISTORY OF THE DEVELOPMENTS AND OF RESULTING GROUND IMPACTS

6.1 Topics covered

This Section is mainly on ground impacts. It gives only a brief summary of the ski developments, the construction of roads, car parks, buildings and vehicle tracks, and the operation of the ski area, as fuller details have been made public (e.g. Clyde 1981; Anderson Semens Houston 1981; Miller 1985; Cairngorm Chairlift Company 1986, 1993; HIDB 1987; Cramond 1990).

Section 6 is not fully detailed and comprehensive, since much relevant information, including references to other literature not cited here, is already available (e.g. Watson 1981; Miller 1985; HIDB 1987; Wood 1987, 1987a). This Section is intended to provide enough background information to aid an understanding of ground damage on the Estate. It concentrates on factors affecting ground damage, such as the impacts of vehicles, walkers, and skiers (including the spread of footpaths and more diffuse damaged areas), and the history of efforts to reinstate damaged ground.

6.2 Post-war events before the ski developments

Before the building of the public road to Coire Cas in 1960, Cairn Gorm had already become popular for skiers and walkers. Major factors were the promotion of downhill skiing by Speyside hoteliers and skiing organisations, the use of Glenmore Lodge by the Scottish Council for Physical Recreation from 1948, and the construction of the Army's Rothiemurchus "Hut" and the new road to it in 1954. Several footpaths extended into the foot of Coire Cas, by skiers walking up from the path below Clach Bharraig, and others into the middle of Coire Cas from the lower part of the Sron an Aonaich path to Cairn Gorm. Other footpaths were beginning to develop on the plateau and beyond the end of the stalkers' path from the Allt Mor up the lower part of Allt Creag an Leth-choin. Watson (1984) and Bayfield (1986) gave more detailed accounts on increases of footpaths then and after the ski developments.

6.3 Public roads and car parks

As the zigzags of the first public road to Coire Cas proved difficult in snow, a later road was built on a higher line. This was often blocked in big snowstorms, and a third "Link" road was made higher up, via the road to the Coire na Ciste car park. Construction of these roads and of large car parks left wide expanses of bare gravel on the cut and fill banks, especially on the Link road (Stewart 1986), and many boulders rolled on to vegetation below. The banks were fertilised and reseeded with agricultural grass, and subsequently heather, moss and other short hill plants have colonised, and also broom and small trees on banks at lower altitude.

Eventually the banks should become heather-dominated naturally. There is no need to sow or plant heather.

6.4 Damage mainly due to construction of ski facilities

In the 1960s, construction of buildings, chairlifts, tows and snow fences was done with the aid of tracked excavators and wheeled vehicles, which severely damaged vegetation, bared much soil, and led to serious soil erosion (Watson 1967; Watson, Bayfield & Moyes 1970; Bayfield 1971).

The damage rapidly worsened, reaching a peak in spring 1968, since when it has declined. McVean & Lockie (1969) stated that land around the ski lifts had "been completely denuded of its vegetation over an area of about 800 acres". In a review of their book, I stated that "the conservationist must be careful not to exaggerate the facts upon which his case is based", and that complete denudation had occurred only over several acres (Watson 1970). In a detailed survey, Bayfield (1971) found 8.8 hectares of completely bared ground, but this included all dirt roads, vehicle tracks and freshly bulldozed pistes. Nevertheless, vegetation damage and soil erosion were the most severe to be seen on any Scottish mountain.

Water often moved loose sediment downhill to bury intact vegetation, and this in turn killed most plants if the sediment was more than 5cm deep (Bayfield 1974). Tracked machines were also used to bulldoze wide pistes and narrow ski corridors through boulder fields, and dig trenches to catch blown snow on towlines. Bulldozing of pistes and excavation of tow trenches occurred at both Glenshee and Cairngorm ski areas. It was later found that a narrow corridor of snow fencing on either side of a towline, especially if wide enough to allow a piste machine to travel on the corridor, was sufficient to concentrate snow cover. This obviated the problems of damage and erosion from excavated trenches. It was also found that judicious use of snow fencing on either side of a piste provided good snow cover. As these lessons were known by the time that the Lecht development started, excavations for towlines and pistes were not needed there, and have not been permitted at Scottish ski centres since.

At Cairngorm ski area, bulldozers shifted many boulders off pistes and towlines in the 1960s, and did so for some years after large-scale excavation of towlines and pistes ceased (Watson 1981). This caused damage partly by leaving original hollows bare, and partly by the boulders burying and killing vegetation in the new sites. However, this practice has not been used at Cairngorm ski area in recent years. Damage on a smaller scale was caused by digging pits for pylon foundations, with the infertile spoil of subsoil left on the surface. Damage on a yet smaller scale occurred when cables were inserted partly or wholly into the ground, and when stones were removed to make way for posts for holding snow fencing.

An exploratory, preliminary survey of the problems at Cairngorm and Glenshee ski areas by Watson (1967), made in preparation for a team research project by Watson, Bayfield & Moyes, included suggested remedies. The main ones were i) channelling of people, including the construction of footpaths that could withstand heavy traffic, ii) "obligatory return tickets on chair lifts for all summer visitors might help to prevent people coming downhill on many different routes", iii) better surfaces and better drains on vehicle tracks, iv) "above all", a reduction of large-scale use of tracked vehicles on the ground, and consideration of the use of helicopters for carrying materials away from hard tracks. All four were later implemented, with satisfactory results.

6.5 Impacts by skiers

The cutting and trampling actions of skis and skiers' boots caused further damage to vegetation and soils on Cairngorm ski area (references in previous paragraph). The following quotation from Watson (1990a) for Glenshee applies to Cairngorm and other Scottish ski areas:- "Since the beginning of the developments, ski edges have caused localised damage by

shaving vegetation and soil off snow-free bumps. Trampling from skis and from skiers carrying their skis has also caused damage each year, especially on areas of concentrated use at low altitude" such as the bottom of Coire Cas opposite the Day Lodge and the hollow for beginners below the Mid Station. "Ground that is particularly vulnerable is on thick wet peat, especially where it is partly bare because of hagging or other peat erosion. Soils and vegetation on wet flushes and at mossy springs are also very vulnerable to damage by vehicles, skiers and walkers, and examples of this can be seen at Glenshee and other Scottish ski centres".

6.6 Impacts of snow fencing

Snow fences caused minor impacts when posts hammered into the ground caused slight movement of stones and soil. Snow fencing not only concentrated snow in both area and depth, but also reduced damage to vegetation and soils when skiers crossed snow with shallow or incomplete cover, or went on to snowless ground. Taller fences proved valuable at Scottish ski areas for catching drifted snow on exposed ridges, and wooden rails for keeping snow fences upright in gales.

Alteration of fencing locations led to better pistes and less damage to ground. Watson (1990a) stated for Glenshee, and it applies at all Scottish ski centres, "To reduce damage, it is important that the operators be allowed to alter snow fencing in location and height, in the light of operational experience and independent monitoring of damaged ground. Sticking rigidly to original suggested locations leads to worse damage than allowing flexibility. The need for subsequent changes would have to be argued on the basis of observed damage, and would be checked by the monitoring." This has been accepted by planning officials of Moray, Gordon, Kincardine & Deeside, and Perth & Kinross District Councils, and Grampian and Tayside Regional Councils.

Longer snow lie due to snow fences led to more heather foliage being killed by snow moulds. This striking result was measured on Cairngorm ski area in 1981 (Watson 1981). It has since been found regularly at the Lecht and Glenshee (e.g. Watson 1985a, 1988; Bayfield, Watson & Miller 1988), where the proportion of heather killed by snow mould has been estimated during annual monitoring. There has been gradual replacement of heather by grasses, which resist damage from skiers and machines better than heather.

6.7 Impacts by piste machines

To quote Watson (1990a), "Vehicles for piste maintenance ("pisters") have been used much more at Scottish ski grounds in the 1980s, and their use is now regular for grooming towlines and pistes, and for moving and packing down drifted snow on to snow-free areas. The combination of good pister use and good snow-fencing procedures has revolutionised Scottish ski areas and has done much to lessen the adverse effects of mild periods in winter. However, damage by pisters has inevitably increased greatly too. Although pisters exert a low pressure on the surface below, the metal grips on their wide rubber tracks can cut deeply. The damage occurs mainly when these grips cut into vegetation and soil when snow cover is thin or when the pister crosses snow-free patches. Damage is considerable if the vehicle turns on thin snow or snow-free ground, causing shearing. Pisters sometimes tear lumps of vegetation and roots out, and occasionally small lumps of soil, leaving small holes of bare soil behind. These holes often

become revegetated within the first growing season, but in severe cases locally the pisters can bare the soil in patches of several square metres at a time and this takes several years to recover". (At Cairngorm, such severe damage by pisters has not been seen by the writer).

In the early 1980s, pisters caused considerable damage on some parts of the Cairngorm ski area, leaving characteristic parallel ruts in the soil. "Since 1985 they have been the main single cause of fresh damage to vegetation and soils at the Glenshee ski grounds and at the Lecht also" (Watson 1990a). However, at Cairngorm ski area, strict use of pisters as laid down by the Managers has resulted in virtually no fresh damage in the late 1980s and early 1990s. During the early-summer inspections and autumn monitoring visits in 1990-93 (Section 9), virtually no fresh damage by pisters was seen. Further wider inspection with Mr Neil Baxter in September 1993 revealed only slight traces at a few places near the top of the Ptarmigan Tow; the small pieces of removed turf had survived in the wet conditions in summer 1993, and were replaced in their original sites.

A major factor which has reduced pister damage at Glenshee, the Lecht and Cairngorm ski areas is the changing of the location of snow fencing so as to get better snow cover on the places likely to be damaged.

6.8 Impacts by walkers

6.8.1 Increases in numbers of walkers

The easier access provided by the public road to Coire Cas and by all-season use of the chairlift led to a major increase of walkers. This occurred on Cairngorm Estate and surrounding ground including the Cairn Gorm plateau out to Ben Macdui, with the main concentrations on certain routes, particularly from the Top Station of the chairlift to the summit of Cairn Gorm (Countryside Commission for Scotland 1971; Morris, Hammond & Kessler 1974; Gilmore 1975; Wishart 1975; Fairman 1979; Anderson Semens Houston 1981; Watson 1981, 1988a, 1991; counts by Jo and Mollie Porter in Watson 1981; Wood 1987a; Mackay Consultants 1988; Whittome 1991; Cairngorm Chairlift Company 1992). Additional useful counts on the Northern Corries part of the Estate were made over a number of years by Mr Jo Porter when a ranger at Cairn Gorm (some data in Watson 1981, Supplement 2), and fewer counts per year but over a longer run of years by Watson (1981).

The various data show substantially fewer people going on to the plateau than to the top of Cairn Gorm, fewer on the plateau on days with bad weather than on days with good, and fewer when the top chairlift was working than when it was off due to high winds and other bad weather. The numbers of people using the chairlift have fallen greatly since a peak in 1972 (Table 1, and Cairngorm Chairlift Company 1993). Numbers counted per summer day on the plateau reached a peak in 1974 after a prolonged increase year by year since the chairlift opened in 1961 (Watson 1991). Since then they have fluctuated, with a smaller peak in 1981, but generally have been lower than in the summers between 1974 and 1981.

6.8.2 Diffuse widespread damage over large areas

On and off the ski area, walkers and to a much lesser extent skiers did more widespread diffuse damage to plants and soils over extensive slopes. This led to bared ground, vegetation damage, burial of vegetation by loose

Table 1. Numbers of chairlift visits in June-October (from Cairngorm Chairlift Company Ltd).

(As per Chairlift ticket sales confirmed 17.3.94)

1972	104,913
1973	100,994
1974	93,669
1975	86,418
1976	78,592
1977	76,064
1978	74,642
1979	74,631
1980	70,624
1981	60,904
1982	58,549
1983	59,248
1984	53,707
1985	49,283
1986	53,969
1987	52,372
1988	58,594
1989	62,846
1990	58,922
1991	61,291
1992	47,604
1993	48,352

grit and stones, and soil erosion (Watson 1967, 1981, 1985). The main areas affected in 1968 were on and near pistes, but damaged ground there has decreased greatly since 1970, due to reseeding and to channelling of machines and walkers. By 1981, the year of Watson's (1981, 1985) survey, the main areas of diffuse damage were on higher ground that had shown little of it in the late 1960s. Damaged ground there had increased slowly over the years, because of continuing low human impact combined with high altitude, poor conditions for plant recovery, and no reinstatement work.

Out of 14 transects on seriously disturbed ground in Watson's survey, six were on the upper parts of the Estate, including one on the Cairn Gorm plateau at Cairn Lochan, and eight on the plateau outside the Estate (Watson 1985, Fig. 2). The survey was repeated in 1988 (Watson 1989). Features of disturbed ground were generally less frequent in 1988 than in 1981. The frequency of some of these features (e.g. loose grit lying on vegetation) can be increased by gales and other climatic aspects as well as by human impact. However, freshly dislodged soil or freshly torn vegetation or freshly uprooted plants, all immediately adjacent to the mark of a human footprint, are unequivocal signs of direct human impact.

The frequency of dislodged soil in 280 sampling quadrats thrown randomly along 14 transects with fixed-end points was 15% in 1981 and 5% in 1988. The probability of such a decline or a more extreme one arising by chance is less than 1 in 1000. Torn vegetation beside a human footprint occurred in 2 quadrats in 1981 and 1 in 1988, and uprooted plants in 3 quadrats in 1981 and 1 in 1988, again showing less human impact on the area (Estate and National Nature Reserve combined). These signs of better stability of ground were attributed partly to fewer summer visitors since 1981, as reflected by fewer tickets sold per summer on the chairlift (Table 1) and fewer people seen per summer day on the plateau (Watson 1991). They were also associated with a run of good growing seasons for plants and with several snowy winters that provided protection.

The data indicated that ground coverage by plants increased on some disturbed transects between 1981 and 1988. On other transects, however, especially on the circular route from Cairn Gorm around the rim of the Northern Corries, the data indicated that plant cover had decreased.

A drawback of surveys using randomly thrown quadrats is that some of the differences between years are due to different spots selected by random numbers for the sampling in the two years, in other words, differences between quadrat sites rather than between years. This is a common problem in sampling. A common way to overcome is to use many randomised locations for sampling, so that errors introduced by quadrats at different spots cancel out. In this case there were many (280 quadrats thrown on the 14 transects on disturbed ground and 320 on undisturbed ground).

Nevertheless, the method of visual estimates on random quadrats was intended simply for demonstrating in 1981 that there were serious problems of vegetation damage, bare ground and soil erosion on Cairn Gorm and its plateau. It was not designed for obtaining the most reliable and accurate data on changes over the years. This is particularly so for the percentages of bare ground, ground coverage by plants, and loose grit lying on vegetation. Decisions on percentages inevitably involve more subjectivity than for all or nothing features such as the presence of freshly dislodged soil or uprooted vegetation beside a human footprint.

To obtain precise and accurate data on the proportion of bare ground over the years, permanent fixed sites are better. Watson (1989) recommended these at the end of the report on the 1988 survey. He stated "Further clarification and future checking require a more intensive monitoring study on a more frequent basis, preferably at least once a year. The methods used should be geared to successive monitoring of the same fixed sites. The problem is of sufficient public importance that a baseline for subsequent annual monitoring should be established soon." Indeed, NCC staff proposed fixed-site monitoring immediately after the Lurcher's Gully Public Inquiry, to obtain accurate data on changes in ground condition on that part of the plateau lying inside the National Nature Reserve, but the proposal was not implemented.

The 1981 survey by Watson involved plotting the extent of ground disturbed by man-induced soil erosion, mostly lateral movements but also many longitudinal rills and gullies (Watson 1985, map in Fig. 2). This map omitted areas of undisturbed ground within larger disturbed areas, unless these were more than 1 hectare in size each. Disturbed ground in these terms covered 403 hectares, 83% on the Estate and 17% in the National Nature Reserve. Lateral and linear erosion were scored in severity from 0 to 4, as in Watson 1985, Table 1). Areas with scores of 1, 2 and 3 for lateral erosion comprised 14, 84 and 3% of disturbed land on the Estate, and 19, 75 and 6% of it on the Reserve. The map in Watson (1985, Fig. 2) was for any disturbed ground, whether score 1 or 4.

This mapping survey was again intended to demonstrate that there was a serious problem, rather than as a basis for checking accurately any further changes in erosion over the years. Watson (1985, p. 368) stated, "As much of this mapping was done at a distance, it was obviously subjective to some extent. A more objective measure was subsequently made by going to 25 points chosen randomly within each 1 km square of the study area, making a careful, close-range assessment of ground within a radius of 10 m from each point, and scoring lateral erosion and linear erosion separately, as in Table 1. This omitted most of the study area between sampling points, but gave a more objective assessment at the points. It provided much of the data for Table 2" (in fact, all the data on lateral erosion) "and was the basis for the illustration of disturbed and undisturbed points in Fig. 3." It should be noted that some of the randomly chosen 25 points in the 1km squares fell on footpaths.

6.8.3 Depth of rills and gullies

The maximum depths of rills and gullies observed within each 1km square in the 1981 survey were noted in Watson (1985, Table 2), including squares on the Reserve as well as on the Estate. All squares in that Table were on the Estate, except squares 9902, 9801, 0003, 9999 and the last five in the Table. The deepest rills or gullies on squares on the Estate varied from 0.0 (i.e. no rill or gully) to 1.0m. These squares were those affected most by disturbed ground, except for omission of the two that included the public road ends, where the main forms of damaged and disturbed ground were of a different type (roads, car parks, pavements, gardens etc).

Inspection of rills and gullies within the same km squares in early summer 1993 showed no material change in maximum depths (Table 2). Some rills and gullies that were active in 1981 were not now active (they had become

Table 2. Greatest depth of rills and gullies in different km squares on Cairngorm Estate in summer 1993, and change from 1981 (+ recovering, - deteriorating, and = no material change). Squares entirely off or nearly all off the Estate are omitted, as are squares where the greatest depth in 1981 was off the Estate.

Km square	Greatest depth (m)	Change from 1981
0004	0.7	+
9904	0.2	=
9905	0.2	+
9903	1.0	+
0005	0.2	+
9702	0.1	=
0006	0.2	+

stabilised naturally, had vegetation growing in their sides and bottoms, and no longer involved cutting into the soil). This Table excludes the 1992 landslips at the headwall of Coire Cas, which entailed sloughing of spoon-shaped banks, not rills or gullies.

In summer 1981, I also measured the longest distances in spreads of grit washed from higher up. These data were not published but are now given. The longest were 150m on the headwall of Coire Cas, 300m south-west of Fiacaill a' Choire Chais, 400m on the north-west slope of Cairn Gorm, 400m in Coire an Lochain (debris slide), 500m by the path north from Miadan Creag an Leth-choin, 500m at the Goat Track, and 700m from Fiacaill a' Choire Chais towards the zigzag road up Coire Cas.

6.9 Proliferation and deterioration of footpaths

Along the main walkers' routes, impacts on a narrow front led to extension and widening of existing footpaths, increase of new footpaths, proliferation of supplementary braided "pathlets" alongside each main path, and deterioration in path condition (becoming wetter, boggier, rougher and looser). These features have been well described for Scottish mountain paths by Aitken (1985). On Cairngorm Estate, path problems have been studied much (Bayfield 1973, 1985, 1986; Baugh 1979; Watson 1984; Lance, Baugh & Love 1989; Lance, Thaxton & Watson 1991). A graph in Bayfield et al. (1988, Fig. 17) showed that the four main paths on the lower slopes of the Northern Corries had widened greatly since the early 1970s, and continued to widen from 1985 to 1988.

6.10 Footpath repairs

Some early repairs were done i) on the Northern Corries path near the car park, notably in 1975 to the corner, ii) on the foot of the upper steep part of the path up Fiacaill a' Choire Chais, and iii) on the steep bank where the continuation of that path drops to the zigzag road above the Mid Station. This early work proved relatively ineffective, and insufficient to withstand the severe pressures at Cairngorm Estate. It was fragmentary, dealt with very short sections, and was done by different bodies.

By the early 1980s, the condition of the main Northern Corries path and the path from the Sugar Bowl via the reindeer enclosure to the Chalamain Gap had become very poor (wet, boggy, rough and loose). In the writer's view they were among the worse mountain paths in Scotland. A few other paths on the Estate had become poor, with some parts very poor. In 1985, the HIDB began a programme of path repairs, initiated by Mr K.S. Bryers, with advice from Dr R. Aitken of the CCS's Footpath Management Project, and with Scottish Conservation Projects and its subsequent commercial arm Pathcraft Ltd doing most work. Appendix 12 gives details.

The HIDB commissioned repairs on the main Northern Corries path from the car park westwards, in 1985. Path repairs have been done each summer since. The paths treated were i) the Northern Corries main path as far as the first slope west of Allt Coire an t-Sneachda, ii) the path starting at the car park at the forest rim by the Sugar Bowl, then across the Allt Mor, up to the Reindeer Company's enclosure, south from there to the end of the wet peaty section, then for about 750m westwards along the edge of the escarpment, and from the hilltop east of Caochan Dubh a' Chadha westwards most of the way to the Chalamain Gap, iii) the worst parts of

the Goat Track in Coire an t-Sneachda, and iv) up the east side of Allt na Ciste from the car park. Further details are given below, in Section 11, Appendix 3 and Appendix 12. It is the largest programme of path repairs so far done on any mountain area of comparable size in Scotland.

It is important to realise that comments on paths in this Study rest on a baseline survey which started in 1990, i.e. after the two worst paths (paths i) and ii) in the previous paragraph) had been greatly improved by repairs, and after path iii) had been repaired. Hence the comments do not and cannot give any appreciation of the massive improvements to these paths since before the repair programme began. A baseline in the early 1980s would have been more meaningful for this, but the present Study is the first baseline. However, some impression of the scale of improvement since 1985 can be gained from photographs (Appendix 11).

At the annual Estate monitoring meetings, NCC representatives have occasionally raised concern that repaired paths might be so good as to attract people further into the massif who might otherwise not have gone there, thus leading to greater pressures on more vulnerable ground at higher altitudes. A neighbouring private landowner at one meeting thought that there might be value in making a circular route from the car park into the Northern Corries, rather than repairing linear paths which led into his estate. The reaction from the HIDB and later HIE was that they would welcome a footpath strategy from NCC and later SNH, covering not only the Estate but neighbouring land also. NCC representatives said that they hoped to develop a footpath strategy, but it has not so far appeared.

The Cairngorms Working Party (1993) did not produce such a strategy, though stating generally that there should be a major programme of path repair and maintenance throughout the Cairngorms Area (from Laggan to the Forest of Birse). However, the need for a strategy has become greater. Kincardine and Deeside District Council's draft local plan (1991) states under "Footpaths in Remote Areas" that "Footpath signs and improvements should all be avoided in these parts of the District", including the mountainous core of the Cairngorms (i.e. local authority planners apparently taking a different line from the CWP).

6.11 Channelling on to hard tracks

In the 1970s, further damage by walkers and vehicles on the ski area was greatly reduced by channelling Company vehicles and people on to a new gravel track to the Ptarmigan Restaurant, and by using helicopters for transporting new tows, concrete, snow fences and other heavy equipment. This channelling also allowed already damaged ground to recover slowly.

6.12 Revegetation methods and natural colonisation

6.12.1 Early and recent reseeding

Reseeding with agricultural grass seed mixtures and fertiliser, sometimes also with basic slag, lime and mulches, and up to the early 1980s with a bitumen emulsion to reduce water loss, was begun in 1965 and continued to date. Clover has also been used, for instance on the car park banks at Coire Cas. Some of the damaged verges on the main Northern Corries path have been reseeded with a native hill species (wavy hair grass), but this species withstands wear poorly. It is important to remember that the best

mixture for withstanding wear in a heavily trampled site should differ from that for simply covering ground in a site which was damaged by machines in the past but is now very seldom visited by people.

Reseeding greatly reduced soil erosion from bared ground and restored plant cover there (Watson 1967; Watson, Bayfield & Moyes 1970; Bayfield 1971). At 600m, grass cover on bared ground became fairly complete within a few years, and there is now virtually 100% plant cover. Reseeding produced a thin cover of roughly 50% even at 1100m within a few years (Watson, Bayfield & Moyes 1970). Growth generally slowed down after the first year, but continued again after a further application of fertiliser.

Bayfield (1980) gave a more detailed account, and Paul (Appendix 4 in Cairngorm Chairlift Company 1986) noted changes in the mixtures and the amounts sown per unit area over the years. The area reseeded in 1965-84 totalled 24 hectares, and Paul's Appendix includes a diagram map showing areas reseeded each year. Details since 1984 are in Appendix 13 below.

In 1987 the Company bought a hydroseeder vehicle (Cramond 1990). Its tank contains a slurry of grass or other seeds, fertiliser, and additives such as a glue-like soil stabiliser, organic mulch, or alginure seaweed derivative. Hydroseeders can spray tank contents up to 40m from a track (varying with wind direction and speed), and up to 200m using extension hoses. They can spray at an upward or downward angle to treat track banks.

6.12.2 Colonisation of reseeded areas by native hill plants

It was obvious in the late 1960s that reseeding acted as a nurse crop which speeded up the colonisation of bared ground by native hill plants (Watson, Bayfield & Moyes 1970; Bayfield 1980, 1986). This fits international experience on subalpine and alpine ground (e.g. Gunnlaugsdottir 1985 in Iceland; Elliott et al. 1987 in Alaska). Miller (1985) gave a useful review of the problems in Scotland.

To be more specific for Cairngorm ski area, "Up to about 750m, the swards have acted as a nurse crop for heather and other local species, which have become dominant after 5-8 years" (Bayfield & Miller 1988), and "above 750m colonization by native species has been very slow, apart from mosses, which became dominant after about 5 years. Some sown grasses still persist on high ground after nearly 20 years. Light dressings of fertilizer at intervals of 2-3 years have, however, been necessary in order to maintain satisfactory cover". At 1000m, a bulldozed patch that had been seeded with agricultural grasses in 1968 had almost complete plant cover in 1989, mainly of native hill species, though they invaded very slowly until about 1984 (Bayfield 1990).

More recently, Bayfield (unpublished) measured the colonisation of bared ground at different altitudes on Cairngorm ski area, 25 years after reseeding with agricultural grasses and fertiliser. At the bottom, reseeded patches have generally become dominated by heather. At the top, mosses were the main colonists in early years, but herbs such as dwarf cudweed and alpine lady's mantle became increasingly abundant in later years. On reseeded areas, vegetative cover by hill species greatly exceeds that on bared areas left unseeded. A bared bulldozed piste at 1000m that was reseeded had almost complete plant cover 25 years later, and more than twice the cover that was on a similar adjacent area left unseeded.

6.12.3 Reseeding with grass species native to hill areas

In recent years, the suggestion has increasingly arisen whether reseeding mixtures at such altitudes should comprise species that occur naturally on Scottish mountains. So far, agricultural lowland mixtures have been mainly used, involving species that do not occur naturally on Scottish mountains. Watson (1967) raised this suggestion in the early years at Cairngorm and Glenshee ski areas, but the point has been made with more substance in recent years for Scottish conditions (Miller 1985; Watson 1988, 1990a; Watson & Walker 1987; Watson & Bayfield 1988).

Red fescue has been a major component of the mixture of agricultural grasses used at Cairngorm, the Lecht, Glenshee and Glencoe ski areas, and has been much used in alpine and subalpine areas abroad to revegetate bare ground and reduce erosion. However, it produces too much cover and litter at some sites. This acts against colonisation by local native species (Younken & Martens 1987), and small patches showing this have occurred at Cairngorm, the Lecht, Glenshee and Glencoe ski areas. Furthermore, Bayfield (unpublished) has found that it and other lowland species which do not occur naturally high on Cairn Gorm, still persist 25 years later. Bayfield (1980) suggested that mixtures of upland species are better for such situations, where lowland species would be likely to persist. There is certainly a case for using species that occur naturally on hill land, when considering reseeding for areas of high conservation value, such as the Northern Corries or a projected new tow at Marquis' Well.

Revegetation trials using commercial seeds mixtures of species that occur on Scottish hill areas have provided useful results (Bayfield, McGowan & Paterson 1991; McGowan, Bayfield & Paterson 1991; McGowan & Bayfield 1993). An important finding is that two seeds mixtures of species that occur on hill areas gave as good ground coverage on damaged path verges on hill land in the Yorkshire Dales as did an "agricultural" mixture whose main component is not naturally on hill land (Bayfield & Miller 1986; published by Bayfield, Watson & Miller 1988, Table 1). Bayfield, Watson & Miller wrote (p. 406), "These were all species found in adjacent, undamaged ground, and the cover produced was similar to that provided by an agricultural mixture like that used on the Cairn Gorm ski slopes". However, it must be realised that the Cairn Gorm slopes rise to much higher altitudes with a more severe climate and thinner soils than hill land in the Yorkshire Dales. Further trials on Cairn Gorm would be useful.

When commercial grass species which occur naturally on hill areas were sown as a nurse crop on mineral soil south of the Lecht, they produced better vegetation cover than an agricultural-type sowing of perennial rye grass (Bayfield, McGowan & Paterson 1991; McGowan & Bayfield 1993).

One should note that the "commercial" mixtures mentioned by these workers are seeds mixtures from grass species that occur on hill ground, but the species are also widespread on lowland and thus the seeds mixture may possibly be derived from lowland plants. The "native" mixtures mentioned by these workers comprise material taken from plants actually growing on the hill. Elsewhere in the present Section, "native" is taken to be not this narrower sense, but the wider sense of species that occur as native on hill ground, as opposed to lowland agricultural species that do not grow naturally on hill ground (e.g. perennial rye grass and red fescue).

A mixture of species that occur on Scottish mountains has been used for reseeding at Aonach Mor ski area from the start (ASH 1986a) and has since been recommended for areas damaged by proposed new developments there (McGowan, Paterson & Bayfield 1991). It contains sheep's fescue, common bent, sweet vernal grass and wavy hair grass; these were the same species as in the mixture used earlier for reinstatement of the bulldozed banks of the Glen Ey road (Watson & Bayfield 1988; see further below).

No rigorous scientific experiment has been done on a Scottish ski area to compare the success of such mixtures of upland species with typical agricultural lowland mixtures. However, results from the above-mentioned trials in the Yorkshire Dales and near the Lecht indicate that the mixture of species native to hill areas is at least as successful as the agricultural mixture, and near the Lecht was more successful. Also, experience of results from the native hill mixture at Aonach Mor also points to its being as successful as the agricultural ones have been at Cairngorm ski area (Dr N.G. Bayfield, personal communication).

On the other hand, it does not necessarily follow that the Aonach Mor mixture would be as successful on the upper parts of Cairn Gorm, where the thin, gritty, freely-draining granitic soil, greater exposure, and generally more frequent dry periods in summer render conditions for plant establishment less favourable. Trials high on Cairn Gorm would be useful.

The main reason in the case for using native hill species was that the agricultural grasses gradually decrease, to be replaced by native hill species, and so one should move straight for the native species from the start. A second reason was that some agricultural constituents such as perennial rye grass have a high demand for fertiliser, and on infertile mountain soils looked poor in the second year unless fresh fertiliser was added. A third reason was that native hill species fitted the landscape and also fitted conservation requirements better in areas of value for nature conservation. A fourth reason is that it fits international experience of the success of native species and lower fertiliser rates on mountain land abroad (e.g. Brown & Johnston 1976; Redgate & Porter 1982).

Watson & Bayfield (1988) suggested a native grass mixture for the extremely steep, unstable, infertile, dry gravelly banks of a controversial bulldozed vehicle road in Glen Ey, and this was implemented as a condition for the landowner receiving retrospective planning permission. It was applied by commercial hydroseeding. Different low-altitude and high-altitude mixtures were suggested for proposed new developments at Glenshee (Watson 1990a). The recommended rate of fertiliser for Glen Ey and Glenshee, as for Aonach Mor, is substantially lower than for typical agricultural mixtures. Since the native species also tend to be tougher and more resistant to impacts, much might be gained by using them from the start. Although seeds of some species are expensive, a fairly inexpensive mixture can be provided by merchants, and the lower fertiliser rate appropriate for the native species is a benefit.

A note of caution is that advertised seeds from species which are native on Scottish hills are unlikely to be derived from high Scottish hills and may possibly be from lowland sources or even foreign ones. Hence, if contamination with local vegetation of high conservation and scientific interest must be avoided, seeds would have to be gathered locally.

6.12.4 Transplanting hill sods, plant fragments and "live mulches"

Other revegetation techniques include transplanting sods or plants in whole or in part, including chopped moss fragments and "live mulches" from rakings of vegetation litter. This has been studied on hill land in Scotland and northern England (e.g. Bayfield, McGowan & Paterson 1991; McGowan, Bayfield & Paterson 1991; McGowan & Bayfield 1993). Live mulches and transplanting appear successful in speeding up revegetation, but are more expensive than current techniques (Bayfield, McGowan & Paterson 1992). They would be justifiable where there was substantial benefit to amenity and where other methods had not been successful enough.

Many transplants of hill sods and some heather cuttings have been made on Cairngorm Estate, to revegetate bare ground at the sides of newly repaired paths, and some of this is described below in Section 11 and Appendix 3.

6.12.5 Lowland sods, lowland topsoil, and peat

Cairngorm Chairlift Company have successfully used sods of lowland grass turf in recent years to cover steep bared banks in lower Coire na Ciste and the top of the M1 Tow extension. They were used in summer 1992 to line roadside drains below the Ptarmigan Restaurant, and near the Mid Station to delineate gravel track edges for vehicles and walkers. These were successful in autumn 1992. (Note added in September 1993:- they are still successful. The sods in the drains near the Ptarmigan Restaurant have withstood the heavy rain in May 1993 and other severe weather remarkably well. There was no appreciable amount of sediment on top of the grass sods in the drains. Hence the sods had totally prevented damage to drains from scouring, and also deposition of scoured grit lower down.) A drawback of lowland grass turves is that they look incongrous and out of place in a high hill environment, but native hill plants should gradually invade, as they have done on drains without lowland sods.

Lowland topsoil was used successfully on the surroundings of a large septic tank constructed in lower Coire Cas in the late 1980s. The resulting vegetation was of agricultural weeds, whose seeds had been in the topsoil. The soil is gradually being colonised by hill species. Lowland topsoil added to the surface of bared ground before reseeding would provide a medium for rapid recovery of vegetation and reduction of erosion. It would be colonised by hill species, but one would expect that this colonisation would proceed far more slowly than on patches not treated with lowland topsoil. Lowland topsoil suffers from the same amenity drawback as lowland grass turves (see last sentence in the previous paragraph), and in the first year the flowering of agricultural weeds looks even more incongruous than lowland grass sods.

Peat is the main soil type at the Lecht ski area, large areas at Glenshee and Glencoe ski areas, and much of lower Coire Cas and lower Coire na Ciste. It is the natural medium for adding to bared ground so as to increase the organic and moisture contents, and so increase the success of revegetation. Following advice by the writer it has been used successfully at Glenshee and the Lecht, and was suggested for the Hump in Coire Cas if large-scale intervention had been used there (Watson & Walker 1987). It has been little used at Cairngorm ski area because there has been no easily accessible deposit. However, a small accessible deposit lies close to the Coire na Ciste car park (see Section 12 below).

Table (below) on plant resilience to and recovery from trampling, from Bayfield et al. (1988, Table 17).

	(a) initial loss of cover	(b) recovery rate
Dwarf shrub heaths:		
Sub-montane heather	severe	slow
Montane heather	severe	very slow
Blaeberry-crowberry	moderate	moderate
Grasslands:		
Bent fescue	slight	fast
Mat grass	slight	slow
Stiff sedge	moderate	fast
Three-leaved rush	moderate	slow
Moss heaths:		
Woolly fringe moss-stiff sedge	severe	fast
Blanket bogs:		
Deer grass-heather	moderate	slow
Heather-cotton grass	moderate	slow

Table 17.
Relative susceptibility of some important montane vegetation types to mechanical damage: (a) initial loss of cover, and (b) recovery rate based on studies by Bayfield (1979), Pryor (1985) and Dargan (1988). The data given here are generalized. Actual plant responses vary with ground conditions, levels of use and other factors. Furthermore, the experiments on which they are based involved a single period of damage. Recovery from extended periods of damage could involve different responses. In the above Table, slow recovery should be taken to indicate several years, moderate recovery several months to a year, and rapid recovery a few weeks or months, where the initial damage amounts to an arbitrary 50% of cover. Initial loss of cover could range from less than 25% (slight) to more than 90% (severe), but the level of disturbance necessary to cause such damage would vary with the type and season of disturbance, and ground conditions.

The above Table gives a useful sketch of relative differences in the initial losses of ground coverage of different plant communities as a result of trampling, and in their recovery rates. Of particular importance in "ground conditions" are the state of the soil structure, the water regime in the soil profile, and the nature and thickness of any organic surface horizons. Note also that the deer sedge - heather community is not restricted to blanket bogs, and is characteristic of peaty podzols with an iron pan, peaty gleyed podzols and peaty gleys, i.e. soil types with less than 50cm thickness of peat.

6.12.6 Resilience of different plant communities to damage

It was noticed that vegetation damage by walkers on Cairngorm ski area tended to be worse on some plant communities than on others. This led to experiments on the impacts of trampling and on recovery rates of vegetation after trampling (e.g. Bayfield 1980; Pryor 1985), and to methods for restoring vegetation (Bayfield 1976, 1980; CCS 1980; review by Bayfield & Miller 1988, with a published summary in Bayfield, Watson & Miller 1988; up to date review by Bayfield & Aitken 1992).

6.12.7 Natural colonisation without reseeding

Natural colonisation without reseeding is slowe at Cairngorm ski area (Bayfield 1980, 1986). A patch at 1000m, bulldozed in 1967 and not reseeded, was only partly vegetated after 22 years (Bayfield 1990). However, colonisation was fairly good even at 1000m on the verges of bulldozed vehicle tracks in the Cairngorms (Bayfield, Urquhart & Rothery 1984). Watson (1981) found some colonisation of disused old paths at higher levels on Cairn Gorm and Ben Macdui, even on very exposed land.

6.13 Changes in attitudes to ground reinstatement

In 1986, Cairngorm Chairlift Company was concerned about earlier plans to bulldoze The Hump in lower Coire Cas. In the end the Company chose far less intervention and much lower impacts, after independent assessment of the likely impacts of different options and a recommendation of a minimal impact option (Watson & Walker 1987). This scheme was implemented with virtually no ground damage. Later works on a new tow from the Coire Cas car park uphill to the east, and in 1992 on the M1 extension and the alterations to the top of the track to the Ptarmigan Restaurant, were done with very little impact. The 1992 works involved removal of bulldozed, partly vegetated ridges that had been left from the more interventionist methods used in earlier decades, and then reinstatement of the ground.

6.14 Early factors militating against minimal-impact development

Watson (1988) stated "It helps understand what has happened to the condition of the hill at Glenshee if readers realise that all Scottish ski developers started up with little money", which the ski company itself raised. This applies to Cairngorm and other Scottish ski areas except Aonach Mor, where the start was assisted by large sums of public money. Tracked machines pulled up equipment for ski tows, buildings and snow fences in early years at Glenshee, Glencoe and Cairngorm areas, and "they did so on the open hillside, not on prepared, hard vehicle tracks. Given the money that each company had at the outset, no Scottish ski development would have started if the companies had had to make vehicle tracks and use helicopters for flying in all equipment right from the start".

The report "Skiing at Cairngorm. A Policy Paper" by the Countryside Commission for Scotland (CCS 1989) stated, "Early development of Scottish ski-fields has been heavily criticised for its pioneering style of construction and management and hence the higher standards of care now employed by the ski-field operators are welcomed ... The Commission believes that there is opportunity to build on this work, in particular to **... continue efforts to remedy early development damage, particularly on**

higher ground where the main problems now exist. In these comments, the hostile conditions of weather and thin infertile soils must be recognised; also, there is little experience in remedial work to damaged vegetation on the highest areas of the Cairngorms. **In these difficult circumstances, the Commission would be prepared to contribute to the costs of special remedial work or of obtaining appropriate advice".** This commitment now rests with Scottish Natural Heritage, which resulted from the merging of the CCS with the NCC for Scotland in 1992.

6.15 Impacts by reindeer, sheep, red deer and hares

Severe damage on a very localised scale resulted from the Reindeer Company's fenced enclosure. The hut, small paddocks nearby, main gate and path to it were located on fairly thick peat lying over glacially-derived mineral soils. Deer sedge and heather dominated the vegetation. This vegetation type withstands trampling very poorly. Bare peat became the surface on the most heavily used ground, and trampling by reindeer churned up the wet peat, which eroded in rain. On a small area of heavily trampled ground, the peat has eroded down to the underlying mineral soil.

Sheep have long summered on Cairn Gorm and the plateau. Since the ski developments, fertilised reseeded grass at Coire Cas attracted them more than nearby ground that was not reseeded, and to a lesser extent this happened with reindeer (Watson 1979). Sheep did some damage to reseeded grass on steep gravelly banks, when their sharp hooves uprooted plants and churned soils. They also did some damage on steep slopes, such as on the headwall of Coire Cas below the cairn on Fiacaill a' Choire Chais, and on and above the Goat Track. In both places and elsewehere on steep slopes, the writer witnessed sheep dislodging loosened stones up to 15cm in size, which then rolled to lie on vegetation. There are now no sheep; the grazing lease, which was on nearby Abernethy Estate, ended in 1990.

Red deer have been virtually absent on Cairngorm ski area since years before the main developments began, but their former trails are still visible. These caused a negligible amount of bare ground, were narrow, and took good lines for avoiding boggy ground. Following a major increase of red deer within the forest at Glen More in the 1970s and 1980s, the breakdown of the perimeter forest fence, and a general increase of deer on neighbouring estates, red deer have increased substantially on the Estate since the late 1980s. Culling in the last few years has reduced numbers. A large further increase of red deer could reduce ground stability by grazing damage to reseeded grass, broom, and scrub trees, and by trampling on reseeded areas and gravelly banks. Culling should prevent this.

Mountain hares have long favoured reseeded patches (Watson 1979), but their numbers are low and of negligible impact. Indeed, their close grazing may benefit early reseedings, by encouraging tillering.

7 LOCATIONS AND METHODS FOR MONITORING DAMAGED GROUND ON THE ESTATE

7.1 Fixed marked sites

Following discussions on the hill, Dr G.R. Miller produced notes which summarise the new methods based on measurements at permanent marked sites; these notes are reproduced in full in Appendix 2. Table 3 shows an example of a completed field sheet. The map in Fig. 2 shows locations.

Path (i) in order of priority for monitoring at fixed sites was the Northern Corries path from Allt Coire an t-Sneachda to Allt Coire an Lochain, a very wet poor section. The east continuation of this to the car park was formerly one of the worst paths on the Estate due to heavy use, but was greatly improved by repairs before the Study began. It was decided that this east section, path (iii) in Dr Miller's notes, should be monitored as a check on the efficacy of the repairs, as third in priority.

Path (ii) in priority for monitoring was the Marquis' Well path, formerly the main route from the top of the chairlift to Cairn Gorm summit. It widened rapidly, but after the more direct path was made from the Restaurant straight up to the summit, use of the Marquis' Well path declined greatly. However, it still leads to erosion and transport of water-borne sediments on to vegetation further downhill. It is possible that it might be heavily used again in future, as a result of signposting.

The fourth path in priority, from the zigzag road to the top of Fiacaill a' Choire Chais has a clearly defined lower section, measured and treated separately below (in Dr Miller's notes it is path (iv), but the two sections are so different that they have been measured separately since and are treated separately below. In the map in Fig. 2 they are shown as (iv) and (v). The section up the steep upper ridge (v) shows a proliferation of pathlets and a wider band of disturbed ground. This upper section is intermediate between a path proper and a broad slope of widespread diffusely disturbed ground without any path.

Path (vi) in priority ((v) in Dr Miller's notes) strikes south uphill from the Northern Corries path west of Allt Coire an Lochain, and carries on up the broad hill nose to Miadan Creag an Leth-choin. It was chosen because my preliminary observations suggested that it was being used more than previously, and was widening as a result.

Another area (vii) suggested for monitoring was a wide slope on Coire Cas headwall ("sixth area" in Dr Miller's notes). This, the most severely damaged slope on the Estate, is very vulnerable to erosion. It was agreed that all seven sites should be monitored using marked sites. Later, path (viii) was added, east of path (iv) and joining it at both ends.

7.2 Paths, diffusely damaged slopes, and major problem sites with discrete damaged ground (not monitored by fixed marked sites)

All these places were visited by the writer (including walking the entire route on each path), were described with detailed notes, and were mapped and photographed. In some cases, photographs had been taken in earlier years, and repeated inspection and photographs from the same spots in 1990-93 allowed subjective comparisons on whether there was a

Table 3. A completed field sheet from monitoring at fixed sites.

20-9-93

MONITORING RECORD SHEET

Path: FIXED PATH ..... Transect no. ..... Date .....

Record each patch of ground crossed by the transect line by entering the measurements for the start and end of each section and by ticking the appropriate column below:-

VEG = totally covered by vegetation
BARE = completely bare ground
VEG/BARE = mosaic of vegetated and bare ground

For VEG/BARE, estimate by eye the percentage of bare ground in the section.

RECORDER TOM FRASER

Tape cm	Transect section (cm)	VEG	BARE	VEG/BARE % bare
140	140			25%
237	97			90%
257	20		✓	
358	101			85%
400	42			65%
450	50			95%
550	100			65%
604	54		✓	
672	68			60%
820	148		Rocks ✓	
885	65			95%
932	47			60%
943	11	✓		
949	6		Rock	
1000	51			30%

Transect section (cm)	VEG	BARE	VEG/BARE % bare

VEG	BARE	(%BARE = BARE)
11	228	761.494

TOTAL %BARE = 77

broad trend towards improvement or deterioration, or simply no material change. It was agreed that monitoring with marked sites could be started on some of these places in future, if it were decided from subjective estimates, photographs, or rapid quantitative checks that a material trend for the worse seemed to have occurred and that this should be checked accurately. Similarly, some places now being monitored with fixed sites might be dropped in future if reinstatement became so successful as to render further monitoring superfluous. However, it would be prudent if monitoring at fixed sites could be maintained at a few places long-term, to provide a certain measure of continuity.

7.3 Monitoring on the ski area

7.3.1 Background and rationale

The main purposes of monitoring a ski area are (from Watson 1988):-

- "to have a reliable basis for checking trends in the state of the hill;
- to allow preparation of a work programme to rectify problems of vegetation damage, soil erosion, unsatisfactory drainage, and damage to tracks, verges and fences;
- to assess the success of remedial measures".

To this should be added the restoration of vegetative cover to bared ground and the identification of remnant construction litter and other forms of litter. At the Lecht and Glenshee, it has also helped find areas with good natural snow lie and to improve snow-holding on old and new pistes.

The Cairngorm ski area has long shown problems of vegetation damage, bared ground and soil erosion (Watson 1967; Bayfield 1971; Watson 1985). Bared peat at the Lecht ski area increased rapidly within a few seasons of the centre's opening, and the Lecht Ski Company sought advice from Grampian Regional Council. This led to the Company commissioning annual monitoring, as a condition for planning permission for new tows. The condition on monitoring was made by Moray and Gordon District Councils. Monitoring has been done since September 1984. Glenshee differed in that the main cause of damaged ground away from the public roads was bared ground caused before the Company began operations, by Dundee Ski Club's use of tracked machines for transporting ski tows and other materials (Watson 1988). Annual monitoring by the writer began at Glenshee ski area in 1987. Again, monitoring was made a condition for planning permission for new tows, in this case by Kincardine & Deeside District Council.

7.3.2 Procedure

The agreed procedure, which has worked well at the Lecht and Glenshee, and has worked well so far at Cairngorm ski area, is that the writer visits the ski ground on a day in early summer each year, soon after the area is free from snow. The visit is made in the company of the Manager. The purpose of this visit is to inspect the hill, discuss any problems of fresh damage on the spot, and decide on remedial measures to be taken by the Company that summer. After the visit I produce a brief report covering these points, and the Company circulates this to local authorities, Scottish Natural Heritage, and at Cairngorm ski area to Highlands & Islands Enterprise. Detailed monitoring work follows in autumn at the end

of the plant growing season, including a check on the efficacy or otherwise of the remedial measures taken earlier in the summer. A report is sent subsequently to the Company, for circulation to agencies as above. Examples at the Lecht are in Watson (1985a) and Watson & Smith (1991), and a brief published review in Bayfield, Watson & Miller (1988), and at Glenshee in Watson (1992) and Watson & Rae (1992).

7.3.3 Scope

After Watson (1988), "The work involves assessing the following;-

- the extent of vegetation damage, bare ground and soil erosion;
- the depth, length and breadth of rills and gullies;
- the success of methods of reinstatement such as reseeding and the installation and improvement of drains;
- vegetation composition and the health of major vegetation types and plant species relevant to protecting the condition of the hill (i.e. excluding minor plant constituents and uncommon species).

7.3.4 Comparison with procedure at Aonach Mor

The report on the "Environmental Design and Management of Ski Areas in Scotland" (ASH Environmental Design Partnership 1986, p. 47) stated that "Monitoring will be of most practical benefit when used in conjunction with what are termed least acceptable change (LAC) values" (in fact an error for limits of acceptable change), as used in some wilderness areas and forest parks in the USA (Stankey et al. 1985).

At Aonach Mor, LAC values were agreed before the ski facilities were constructed, and have been applied since. Bayfield, Watson & Miller (1988) briefly compared arrangements for monitoring at Aonach Mor with those at the Lecht and Glenshee. Both arrangements emphasise impacts on vegetation and soils. The features being monitored at Aonach Mor also include changes in use by people, visual appearance, snow lie, and hydrological characteristics, reflecting differences in emphasis (e.g. hydro-electric generation by British Alcan from the water catchment at Aonach Mor).

Bayfield, Watson & Miller (1988) concluded "The monitoring schemes at the Lecht and Aonach Mor actually have much in common, from the initial review of site information through to the monitoring and review stages. The main difference is the range of characteristics being monitored, which to some extent varies according to the site, and the absence of the LAC stage at the Lecht. However, in practice there is agreement at the Lecht about which areas should be rehabilitated, even though they amount to only a few square metres in some cases".

In practice, LAC values on vegetation damage and bare ground at Aonach Mor have been greater than the normal working practice with the monitoring scheme at the Lecht and Glenshee then, and at Cairngorm ski area since 1990. In other words, action would generally be taken at Glenshee and Cairngorm ski area with less damage than at Aonach Mor.

At Cairngorm ski area, for example, remedial action was taken in 1992 on patches as small as 10x10cm in areas seen by many people near the Ptarmigan Restaurant and close to the road at the top of the M1 Tow

extension. Yet there is little point in taking much trouble to revegetate patches of bared peat even 2x2m in size if the peat is on flat ground in a place hardly ever visited by summer tourists and is of a tough fibrous consistency that is very unlikely to erode. The working practice now agreed at the Lecht, Glenshee and Cairngorm ski areas follows this flexible approach in relation to site features, likelihood of erosion, and likelihood of being seen by visitors.

It is possible that emphasis on an agreed set of LAC values might lead to insufficient flexibility and vigilance in looking afresh on each visit at all possible forms of damage, including ones not considered earlier. However, this should not arise if the monitoring consultant and others present are observant and experienced in this field.

The arrangements at Aonach Mor involve annual meetings attended by representatives of various bodies. In the case of Cairngorm Estate, the problem of expensive extra annual meetings to discuss the ski monitoring does not arise. For some years, HIDB/HIE have organised and hosted an annual June monitoring meeting on all aspects of general interest on Cairngorm Estate, which is attended by representatives of many interested agencies and neighbouring landowners. The ski monitoring has been discussed at each June meeting since monitoring on the ski area started.

If one looks past the jargon of the term LAC, the key point - which applies to any monitoring scheme - is to agree on standards to be set. The only differences between the two schemes are that the Aonach Mor working group a) agreed on standards before the ski facilities were constructed (not applicable at Cairngorm ski area), b) review results each year, and c) if necessary change the standard-setting. Clearly, b) and c) might be seen to be more accountable if criticism from outside were to arise. Given the sensitivity of issues at Cairn Gorm, it may be useful to consider for Cairngorm ski area whether an interested sub-group of the annual June meeting should discuss and agree standard-setting, and review it in future. Preparation might involve prior circulation of a statement on possible standards, along with the early-summer inspection report.

7.3.5 General results so far

The full results are given unabridged in Appendix 4. In general, the summer visits and the autumn monitoring have proceeded well, and much has been learned as a result by those doing the monitoring and by the Company, including useful lessons from failures as well as successes. The two-way contact and discussions on the hill have been frank, open, and highly beneficial. The Company has greatly improved the handling of spoil from pylon excavations and former excavated ridges, the restoration of vegetation cover on disturbed ground, the treatment of existing turves for later use, the formation of good walking surfaces on tracks and restaurant areas, and the creation of drains and of obstacles in certain drains to divert and reduce the flow of surface water before it does much damage.

As a by-product, conflict between different interests has declined at the Lecht and Glenshee since annual inspections and monitoring began. One reason for this is that bodies which were suspicious or opposed became more content in the knowledge that independent examination of the problems was being undertaken rigorously. Another was the production of regular detailed impartial information twice a year, along with better contact, better understanding of the problems, and better-informed attitudes. The presence of the local NCC officer (now SNH) on the annual inspection at Glenshee helped improve understanding and cooperation on both sides. Hence it is likely that these indirect benefits will occur at Cairngorm too.

7.3.6 Action Plan for future installations

It was agreed at Glenshee that if any major new developments were to go ahead, such as those described in the environmental impact assessment by Watson (1990a), an Action Plan should be agreed once the facilities had been constructed. This would set out the reinstatement work to be done, giving priorities, a timetable, and responsibility for the various works. It was to be done by the writer after inspecting the facilities with the Manager. In effect it would be an inspection report, but would be specific to that development, would add more detail than usual about the important jobs to be done, and would be done immediately after construction work, and so not necessarily in early summer immediately after the thaw.

8 RESULTS OF 1991-93 MONITORING ON THE ESTATE

8.1 Introduction

The results here are from monitoring at fixed sites marked by permanent metal pegs, at eight locations chosen because they showed much damage.

8.2 Methodology

A question with any method is whether it provides reasonably consistent results when repeated by the same observer on the same site, and when repeated by a different observer. A preliminary test was made in 1993, and a fuller one is planned for 1994. On 25 October 1993, Mr Baxter, Mr Fraser and Alison Robb made separate measurements at Transect 2 on the Northern Corries path. Next day, Mr Fraser and Alison Robb repeated measurements, starting at the transect's opposite end. On each day they did not know one another's measurements. On the second day they did not have their measurements from the first day. No measurements were discussed aloud.

The data showed that the method was reasonably repeatable when used by the same observer and different observers (Table 4).

8.3 Results from 1991-93

Table 5 shows summary data from the eight locations for 1991, 1992 and 1993 together. The data showed little material change.

This fits with the writer's general, more anecdotal observations that the condition of ground on the Estate has stopped showing a major trend towards deterioration as in the mid 1970s-early 1980s, and is now fairly steady.

8.4 Notes on footpaths

Detailed descriptive notes additional to those on footpath problems in Section 11 are in Appendix 3.

Table 4. Repeatability of the method for monitoring at fixed sites. A preliminary test of the method was made at Transect 2 on the Northern Corries path in October 1993 by Neil Baxter, Tom Fraser and Alison Robb. Values shown are for the total length of bare ground on a transect 10m across, expressed as a percentage. Measurements on 26 October started from the opposite end of the transect, i.e. where measurements ended on 25 October.

	25 October	26 October
Neil	53	-
Tom	57	54
Alison	56	59

Table 5. Summary data on percentage of bare ground from monitoring at fixed marked transects at locations (i) to (viii) in 1991-93.

		1991	1992	1993
(i)	Allt Coire an Lochain	51	53	56
(ii)	Marquis' Well	76 (77)	78 (80)	- (77)
(iii)	Northern Corries	61	62	58
(iv)	To top of Fiacaill Tow	40	38	45
(v)	Fiacaill a' Choire Chais	71	73	73
(vi)	Miadan Creag an Leth-choin	47	55	55
(vii)	Coire Cas headwall	79 (86)	84 (87)	- (87)
(viii)	Path east of (iv)	56	54	63
	Overall mean	60 (61)	62 (63)	- (64)

- because of early snow in autumn 1993, a few transects at the higher locations at (ii) and (vii) could not be measured. Means for the transects that were measured there in 1993 are in parentheses. Values in parentheses for 1991 and 1992 are for the same transects that were measured in 1993, and so are directly comparable.

Six of the 1992 means showed increases on the 1991 means, and two showed decreases. On the hypothesis of no change (i.e. equal numbers of increases and decreases), such a result is far from statistical significance, and so confirms the hypothesis of no change.

Three of the 1993 means showed increases on the 1992 means, two showed decreases, and three were the same. This is not remotely significant statistically and so confirms the hypothesis of no change.

Only location (i) had means with two successive increases over the three years. Even so, only four of its 15 transects showed two successive increases.

NOTE. These data are preliminary, and will require thorough checking before final publication. This report gives only a provisional summary of them. A full account will be the subject of a future report entirely on this topic.

9 RESULTS OF 1990-93 MONITORING ON THE SKI AREA

The information is presented by showing the original summer inspection and autumn monitoring reports for 1990-93 unabridged (Appendix 4).

The main point that has become clear is that there has been hardly any fresh damage from the previous winter's skiing operations. This is despite this set of four winters being among the least snowy since the ski developments began in 1961, and so more damage than usual being expected.

Damage from the previous winter's skiing operations was confined to i) a few small marks of pisters on vegetation and soil in lower Coire Cas, which had disappeared by autumn, ii) a few similar marks on vegetation and soil near the top of the Ptarmigan Tow in 1993, where in addition some tiny torn sods were in good condition in September after a wet summer and were put back flush with the ground, and iii) small patches of bared wet peat at pressure points where snow cover was thin or absent in the lower parts of Coire Cas and in a lower part of Coire na Ciste that is seldom seen by summer walkers. The bared patches in Coire Cas have been treated each summer, and cover by reseeded grass and invasion of native hill species has been good (Appendix 4, autumn 1991 and autumn 1992 reports).

The time spent on summer inspections and autumn visits also covered new works on the M1 extension, nearby works on the upper part of the vehicle track, and mound removal and ground reinstatement in that area. During visits with Company managers, many problems due to past works were also discussed, and solutions agreed. This was highly relevant to the more general problems of ground damage on the Estate as a whole.

10 NATURAL RECOVERY AFTER HUMAN-INDUCED DAMAGE

10.1 Signs indicating natural recovery

This was assessed from past experience of the area along with measurements and other observations on plants and soils. For example, patches of bared grit where natural terraces have been broken by walkers, and patches of bared peat caused by machines away from hags, are signs of past damage, and plants colonising the bared surfaces differ in species composition and abundance from those on intact soils of similar type nearby.

A good sign of colonisation of completely bared peat is the pioneering lichen Cladonia uncialis, which is yellowish in colour. As it is extremely susceptible to damage by breakage when dry, its presence in good condition indicates that human use has declined and that there is a trend towards recovery. Other reindeer lichens, Dicranum mosses, the hare's tail cotton grass, mat grass, heath rush, heather, cowberry, blaeberry, sorrel and dwarf cornel are frequent colonisers on bared wet peat in hollows in lower Coire Cas and Coire na Ciste. Bare wet amorphous peat affected by fertiliser runoff at the lower altitudes has been colonised by the moss Polytrichum commune, and in very wet places by the common cotton grass. Appendix 4 gives some examples on the patches of bared peat opposite the Day Lodge in Coire Cas. Completely bared mineral soil is colonised by mosses, lichens, grasses and heaths, with the grasses and heaths gradually taking over if human use of the area is low or has ended.

Other obvious signs of recovery are the absence or relative scarcity of footprints of people, sheep and deer, marks of machines, and other signs of human-induced damage noted in Appendix 1, and the occurrence of plants colonising areas bared by human impact (e.g. in the middle of paths).

10.2 Summary on areas of damaged ground and their recovery

Completely bared peat is confined to the low parts of Coire Cas below the Mid Station and the low parts of Coire na Ciste below the bottom 200m of the Aonach Tow. Bare peat at the peat hags in the hollow below the Mid Station was there before the ski developments, as was the bare peat in the many peat hags in the lower parts of the Northern Corries. There is also bared peat along many paths on the lower ground, especially on the Northern Corries main path, the path near the Reindeer Company's enclosure and the western part of the path to the Chalamain Gap. However, the amount of bared peat along paths has declined greatly, following path repairs since 1985.

The writer's opinion based on past experience of the area and on photographs taken in past years and from the same positions in 1993 is that the amount of damaged ground on what were the most severely damaged places on the main ski grounds, apart from tracks and paths, is now far less than it was. Reseeding has been necessary for this degree of recovery but not sufficient; it allowed natural recovery and colonisation of hill plants to be more rapid. Areas not reseeded have recovered much by natural processes, but still have more bare ground than before the developments.

The most severely damaged places were the bulldozed piste in lower Coire Cas, the ground at and immediately west of the bottom of the Car Park Tow, the slope west of the M1, the upper parts of the White Lady and M1, the

slope west of the Coire Cas Tow, the surroundings of the Ptarmigan Restaurant, the slope from the top of the Ptarmigan Bowl by the Marquis' Well to Cairn Gorm summit, the slope from the Ptarmigan Restaurant to the headwall of Coire Cas, the headwall itself, and the ridge of Fiacaill a' Choire Chais. However, there are still severe problems of bare loose grit and stones on the headwall, the slope from the Ptarmigan Restaurant to the headwall, and on Fiacaill a' Choire Chais.

The bulldozed pistes and excavated corridors for towlines were completely bared, but are now well vegetated, except for the highest excavated towline trench on the top part of the Ptarmigan Tow above the Ptarmigan Bowl. Many disused routes for tracked vehicles in Coire Cas and the White Lady above the Middle Station were once continuous trails of severely damaged ground. Now, only occasional patches of partly bared ground remain, and the original trails are hard to follow without prolonged search and detailed inspection. In the top part of Coire na Ciste, vehicle tracks that formerly caused deep ruts are still visible, but have become quite well vegetated and are no longer a focus for serious erosion.

Many small patches that were partly bare before the developments, because of the severe climate, now have less bare ground than before, due to reseeding. This improvement is mainly at lower altitudes. In my opinion, the amount of bare ground at altitudes above 1000m is now far greater than before the developments, though materially less than it was at its worst in 1981. That it is still far greater than before the developments is mainly due to continuing problems on the wide slope from the Ptarmigan Restaurant west to Fiacaill a' Choire Chais, as noted above.

The old path from Clach Bharraig to the chairlift's Top Station has been used far less in the last decade. In the 1970s and early 1980s it had become a broad band of eroding grit and rough stones, but is now much narrower and is being colonised well by heather and other hill plants, especially in its lower parts. The Marquis' Well path to Cairn Gorm had become as broad as a road in the late 1960s and early 1970s, and was highly conspicuous as a wide pale stripe as far away as the road from Grantown to Tomintoul. With the channelling of visitors on to the direct rock path to Cairn Gorm summit, it has narrowed and is being colonised by hill plants. Most other paths show signs of natural recovery, though a few show a trend towards deterioration, and a few are approximately steady in condition. Repairs since 1985 have greatly facilitated faster natural recovery of bare ground beside some paths that were formerly the worst on the Estate.

11 PROBLEM SITES AND RECOMMENDATIONS FOR THEM

11.1 Rationale and methods

This section follows to a large extent the prior experience from the Glenshee Environmental Baseline Study (Watson 1988), where the suggestions have proved useful in practice. Each of the problem sites or types described below is given an initial letter within each sub-section. After each letter, or in a few cases after a sub-heading, there follows within brackets a six-digit grid reference from the Ordnance Survey's 1:10 000 map, so that the site can be located exactly. There then follows a number unique to each site, which has been put on the map in Fig. 2 to help readers locate sites easily. The same number is used in the review of monitoring (Appendix 5), the list of proposals for monitoring (Appendix 6), and the summary implementation table (Appendix 7).

Many of the recommendations below are considered necessary to safeguard the stability of ground by reducing serious soil erosion or the potential for it, and by avoiding large-scale damage to vegetation cover on steep slopes. Where in my view there is no risk of further serious erosion, I recommend doing nothing if the places involved are out of sight of footpaths, tracks, car parks, summer chairlifts and buildings, and hence are unlikely to be seen by many people. In this sense, "doing nothing" means leaving the place for gradual recovery by nature. In places with no risk that are on or near ground visited or viewed by many people in summer, I recommended certain actions to improve visual amenity.

With footpaths and tracks, the problems are minor or negligible in terms of the stability of the hill, and cover a very small proportion of the Estate. Here, recommendations are intended to help improve surfaces for walkers and vehicles, and improve the immediate appearance of verges and surrounds. Where path repairs have been carried out and suggestions for further improvements are made, this should not be taken as criticism of the repairs, but as comment to help improve the paths in future.

In cases where the recommendation is to check annually or once every few years, my intention is that most of this would be done by the Cairngorm Ranger Service in the course of their normal duties on the hill, and thus without many special visits. I could show to the rangers the variation in responses on different paths and affected slopes, including distinguishing between impacts of climate and human impacts. I could supervise this work, making an occasional check myself with or without a ranger.

The checks suggested in the recommendations would involve careful inspection of paths, identification of new problems and suggestions for overcoming them, including field notes on these aspects and on approximate locations and availability of repair materials (e.g. gravel, boulders) nearby. It is recommended that rangers and/ or trained other labour assisting them actually carry out minor maintenance repairs each summer on all paths so far repaired on the Estate and all paths being monitored at fixed locations. Experience following the initial major repairs on the Northern Corries path and on other Estate paths, as well as on paths repaired on other Scottish hills shows clearly that, if minor repairs are not done for several years, larger-scale works become necessary. Traditional practice was that stalkers and gamekeepers walked paths each

summer, carrying spades. They opened blocked drains, and added gravel, rocks and turves where problems had arisen since the previous summer. This is well summed up by the proverb "A stitch in time saves nine".

All recommendations are summaries for consideration and discussion, as I thought it unnecessary at this stage to give full details. Detailed technical advice can be provided by me in any of the cases described below, if it is decided that any recommendations require this. Possibly a more rigorous site visit might be needed in some cases, along with Chairlift Company managers and/or others, before action is taken.

Recommendations on ground stability are rated in priority, as :-

Class I - urgent, should be tackled as soon as possible

Class II - important

Class III - fairly important, should be tackled after Class I and II types

Class IV - not serious, but may become a risk to ground stability if a deteriorating trend were to set in

Class V - unimportant because it is on such a small scale or is on flat ground where there is no risk of erosion.

Other classes concern amenity, not ground stability:-

Class A - urgent for improving visual amenity in places seen by many people in summer

Class B - important for amenity

Class C - fairly important

Class D - not serious, but could become so if a deteriorating trend were to set in

Class E - unimportant because hardly any people go there in summer - leave to nature to recover.

Class A-E categories are separated from Class I-V categories; rating them VI-X would imply a lesser priority for visual amenity, which is not necessarily the case and is not intended. In extreme cases, safeguarding ground stability must have priority. A deteriorating trend, if severe enough, could threaten buildings and other facilities, and have far worse consequences for visual amenity than any of the minor threats posed to amenity by the Class A or B features at Cairngorm Estate. Ultimately, the viability and success of any ski ground depends on smooth, vegetated pistes, without ground affected by erosion and freshly exposed boulders.

Nevertheless, around the buildings, car parks, chairlifts and other places that are heavily visited in summer, and where there are no threats from cumulative instability of ground, it could be argued that problems of visual amenity are as great a priority as, or even greater than, some of the lesser problems of ground instability in discrete small areas on the

slopes higher up. For example, some summer visitors might not wish to use the facilities, or might decide not to pay a return visit, because of poor visual amenity. This is speculation at present, and sound decisions on this would first require a survey of visitors' attitudes. Nevertheless, surveys elsewhere indicate that it would be wise to pay attention to visual amenity and to correct problems remaining from the past.

The summary implementation table (Appendix 7) includes an overall priority for each problem site, in terms of 1st or 2nd or 3rd categories (given in the Table as 1 or 2 or 3). It is a weighted estimate incorporating for each site the two individual priorities for Class I-V and Class A-E categories. Because there was no simple objective way of weighting, the scoring for the single overall priority is more subjective than for the individual categories, and more dependent on the writer's experience of the history of problems on the Estate. Nonetheless, there was general agreement on the scorings by Mr Tom Paul, who has had long and great experience of the area. The main reason for overall priority scores was to make it easier for managers to take practical decisions on reinstatement.

11.2 Past damaged ground not on ground now in material use

This mainly involves former vehicle routes, such as at the top of Coire na Ciste below the Ptarmigan Restaurant (several places, 1). These routes have generally been disused by vehicles since the 1960s, when tracked machines were used for transport and construction of pylons and other equipment. Another former vehicle track up the west side of the M1 Tow has not been used by vehicles in approximately the last decade, has been reseeded, and shows ground recovery. Recommendation:- in general, leave such ground for natural processes to heal over. Classes V and E.

However, there are a few places which, although reasonably stable now, nevertheless give some cause for concern. These are:-

a. (000047, 2). Wide slope west of M1 Tow

Patches of mostly bare grit on the slope west of the middle part of the M1 Tow, and within the big upper bend in the track in upper Coire Cas. These arose in the past due to tracked machines, but some patches have since had sediment added from above, washed down from the track. The latter problem has now been greatly reduced by alterations to the track in summer 1992. However, the largest patches are obvious to people on the track, and small-scale erosion still occurs there in heavy rain and rapid thaws.

Recommendation:- on the largest patches bigger than 2m wide, reseed and fertilise, after raking the bared ground so that underlying topsoil is brought to the surface. If such topsoil is lacking, plant colonisation would be speeded up by adding a thin layer of peat. Unfortunately, peat is scarce on the ski area, but an accessible deposit is beside the bottom station at Coire na Ciste (see Section 12). Classes IV and D.

b. (006049, 3). Ruts east of Ptarmigan Restaurant

These are relics of wheel ruts from former use of vehicles when normally hard ground was soft during thaws. They were prominent in 1981 and still eroding then, but have become stabilised by natural vegetation growth and the placing of some sods. However, they are conspicuous in an area seen by

many people. Recommendation:- carefully remove vegetation from the ruts and the ridges on either side of each rut, top up the rut holes with local grit spare from other works, and then put the vegetation on top, making sure that any edges to turves are well covered with soil. Classes V and C.

c. (979062, two bank slips east of 980063, 985067,985070, 984071, and west of 000072, 4)

These are landslips by Allt Creag an Leth-choin (first three grid references), Allt Mor (second three, the last being by far the biggest of the seven), and Allt na Ciste (seventh). In addition there is a small slide on the Allt Mor's east side south of the 985070 one, a smaller one on the east side of Allt a' Choire Chais just above where it meets Allt Mor, and a big one on the east side of Allt Mor inside the forest and north of the footbridge on the path to the Reindeer Company's enclosure.

The largest slide on Allt Creag an Leth-choin when visited was roughly 50x20m (distance along the burn x distance up the slope), and the next largest 25x15m (all values rough eye estimates). The bigger one was overhanging much at the top, and the smaller one a little; overhangs signify undercutting. Heather sods which had fallen from earlier overhangs lay on gravel below, providing approximately 8% and 20% vegetation cover.

The largest slide on the corner at the Allt Mor was roughly spoon-shaped, about 15m across at the bottom but 40m three-quarters of the way up, tapering to an upper tip. From the widest point, a broad band of heather ran down almost all the way to the bottom, showing that the slide did not tear away this band. At the bottom, stones were concentrated at the south end. These had rolled down the slide, and at the north end was a bank of steep sand. Broom was colonising the bare gravel in places. The vegetative cover including the heather band was about 30%.

The lower slide on the Allt Mor's west side, south of the path to the Reindeer Company's enclosure, was about 10x75m, with a big overhang surmounted by growing heather, and thus indicating major undercutting. Many boulders had rolled to the foot of the slide and many into the burn below, and stones were concentrated above the boulders. The big slide on Allt Mor's east side south of the footbridge showed colonisation by broom.

There was an old slide on the east of Allt na Ciste, roughly 30x100m. Broom had colonised well on the best-stabilised part on the north side, but the slide as a whole was 60% bare, with much loose small scree.

These slips resulted from slope failures in torrential rainstorms and floods, since enlarged by floods widening the slips and cutting deeper. Floods contributed to the slope failures and may have been the main cause of them in the first place. However, inspection of the biggest slip on the Allt Mor in 1962 showed that the topmost point on it was at a deer trail, and landslips elsewhere commonly start at a weak point on an animal trail or human path. The main damage was caused by a large flood on the Allt Mor in summer 1956, during a severe thunderstorm and rainstorm. This resulted in many debris flows and much damage by flooding in several parts of the Cairngorms (Baird & Lewis 1957), including some remote areas that were seldom visited by people. Other major floods have occurred on the Allt Mor since, causing further damage (Hudson 1978; McEwen 1981; Watson 1981).

The landslips are gradually being colonised by vegetation. The broom that has beeen a major colonist on slips at the Allt Mor and Allt na Ciste is continuing to spread, and is flowering and seeding well. Heather turves which fell from overhanging banks above have grown well, are useful for stabilising loose ground, and are centres for the spread of plants colonising outwards from the turves.

The slips are in the Allt Mor Site of Special Scientific Interest, designated because of the unusual combination of large glacial and fluvioglacial banks, along with extensive fan deposits of boulders and gravel swept down by floods on to the banks of the Allt Mor further downstream. It is possible that the damage from floods in the 1970s and up to late 1981 was exacerbated by the amount of loose material already made available by the 1956 and 1960 floods. Because of the SSSI designation, the area should be left to nature to recover.

The landslips could become a threat to ground stability downstream in future if they were to expand in size. They are major scars, but many landscape scars in mountain areas are natural and typical (e.g. rock slides, debris flows, solifluction flows, massive fluvioglacial terraces, and active moraines), and there is no reason for tampering with them unless they pose threats to the ground below or downstream.

Recommendation:- at present, leave to nature to recover. However, an occasional walker has been seen walking and sliding down the biggest landslip at the Allt Mor, causing further loosening of an already loose unstable slope. Consideration should be given to erecting a sensitively worded sign at the top, requesting walkers not to do this, and explaining why. Classes IV and C.

d. (986071, 5). Remains of the old zigzag public ski road

Walkers seldom use this. The surface has begun to break up from the weather, and vegetation is colonising.

Option A:- remove tarmac and reinstate underlying ground by reseeding. If so, the linear road banks should be broken, as they look unnatural. Tarmac could be dumped locally in a hollow, after stripping vegetation and soil there as in Appendix 8 and replacing them on top of the tarmac (Option A1). Or, it could be removed off the hill and used as roadfill (Option A2).

Option B:- hide tarmac by covering with peat and then reseeding. Option C1:- leave tarmac to break up slowly and be colonised slowly by plants. Colonisation could be speeded up by reseeding broken patches (Option C2).

Recommendation:- go for Option C1 until the matter has been fully discussed. Classes V and C.

e. (995074, 6). Recent drains above and below road to Coire na Ciste

These were dug by excavator as part of a tree-planting scheme (f. below) proposed by CCS and carried out jointly by CCS/HIDB. The main new drains were connected to the chief existing drains that run below the Coire na Ciste road. This led to swifter runoff and soil erosion. Some new drains eroded severely, and gravel, sand and silt were washed far downstream on to vegetation. Stones put into the drains to reduce water speed did not

prevent erosion, and were incorrectly put in. New drains in 1989 above the road, as part of the planting scheme, also eroded. Drains are conspicuous, as the pale unearthed stones contrast with the black peat.

It was later decided that some should be filled. Of the four below the road, the main one was partly filled in December 1991 by Pathcraft Ltd and the other three not treated. Of the seven above the road, four were filled in their lower parts, and three throughout. Runoff will have been reduced, but less than it might have been.

Recommendation:- fill in all drains and reinstate ground. Classes IV and B.

f. (996076 and several others, 7). Large peat "dollops" dug out for a joint CCS/HIDB tree-planting scheme on flat bogs at Bathaich Fionndag below the road to Coire na Ciste, and many boulders excavated and conspicuously pale. Voluntary conservation organisations criticised this. They suggested removing trees from the dollops, replanting native trees on hillocks, banks and ridges where conditions for tree growth are better than in the bogs, discarding exotic species, and turning dollops over.

After four years, vegetation under the dollops is dead, many new plants are colonising the bare upturned peat, and the dollops adhere to the ground more than they did in the first winter, and so would be harder to turn. Recommendation:- leave the ground to recover. Classes V and C.

g. (999074, 8). Ground damaged by tracked vehicle on way to dollops, on either side of Allt na Ciste

This was done in December 1989 with wet snow on the ground. The biggest scar in autumn 1992 was about 10x4m on the bank on the east side of the burn; some big sods that had been turned upside down were still in that position, so the vegetation had died. The ground was also torn up prominently by a tracked vehicle on the steep bank between the car park and the burn, and on the east side above the bank on the way north to the fence gate. There was a churned morass where a vehicle stuck in the flat bog further east, south-east of the prominent pointed hillock. Recommendation:- reinstate a smoother ground surface by spade and leave to nature to recover, but reseed bared patches on the steep banks by the burn, especially on the peaty west side. Classes V and C.

h. (988062, 9). Boulders below lower banks of public roads and car parks

These rolled down when excavators were working. Some rolled far, but most were along and near the foot of the banks. They were very conspicuous in 1981 after construction of the Link road and the lower car park at Coire Cas, because most boulder surfaces were pale and unweathered, contrasting with the dark heather. They are now less conspicuous because of lichen growth and weathering. Recommendation:- leave to nature to recover. Classes V and D.

i. (994032 and others, 10). Debris slides in Coire an t-Sneachda and Coire an Lochain

These started at the corrie rim in Coire an t-Sneachda and went down big gullies all the way to the corrie floor, and in Coire an Lochain mainly

below the rock slab and buttresses. They occurred in intense rain during an overnight thunderstorm on 4 July 1976. In autumn 1981 I estimated vegetation cover on the biggest slide in Coire an t-Sneachda, where it flattened out in a fan beside the big lochan. Sandy gravel had 30% cover of grass, stony gravel 20%, rocks mixed with gravel at the side 10%, and a stretch of rocks 0%. The main gravel patch deposited in Coire an Lochain had no vegetation in May 1981, but on a smaller gravel patch to the south-west some old vegetation was growing through, giving 50% cover overall. Recommendation:- leave to nature to recover. Classes IV and D.

11.3 Ground in material use: vehicle tracks, covered in the ski monitoring

a. (994055, 11). Track, drains and banks in Coire Cas below Mid Station

The track has a good surface but the steepest part is somewhat slippery for walkers coming downhill. As a result, some walkers go downhill too near the drain or in it, which damages the reseeded grass. The bulldozed infertile gravel banks have been colonised by starry saxifrage in wet places, and heather has invaded the less steep banks. Track verges below the steep part are well covered with thick grass.

In May 1993, much of the steep part of the track was washed away up to a depth of 60cm by flooding from a blocked culvert under the track below the Scottish Ski Club Hut. Gravel was swept on to vegetation for a distance of 150m further down, as well as on the reseeded verges beside the open drain on the east side of the track. The track has been remade with sharp-angled stones and quarry dust, and the culvert and cross drains re-opened.

Recommendation:- any gravel more than 3cm deep on the vegetation is to be spread out more widely by hand shovelling. The gravel on reseeded verges is to be raked off. Classes IV and C.

b. (995053, 12). Duplicate lower track immediately above Mid Station

Water runoff from the main zigzag track has been causing erosion on the lower duplicate track. Recommendation:- divert water by better drains higher up, narrow the lower track to the minimum required by vehicles, and add sharp-angled stones, or add bitumen emulsion (which has worked well at Glenshee ski area), to the track surface. The upper duplicate track at the bottom of the Coire Cas Tow was narrowed in 1992, and grass turves laid to delineate the edge for walkers had survived and proved successful up to autumn 1993. Classes V and B.

c. (996054, 13). Vehicle area around pister garage below Mid Station

Some turf is overhanging at the back. Other turves have fallen, a few the right way up, but one the wrong way up, leading to loss of vegetation. The bank is too steep and unstable. Recommendation:- rake big loose stones down to the foot, and put in heaps to fill any depressions, with spare soil and turves on top of the stones. Cut overhanging turf back to create a convex edge at the top. Then put the turves at the foot, or, where the bank is less steep and unstable, dig them in here and there, flush with the ground. Heather sods should be 30cm square or bigger, but grass turves can usefully be divided into sods 15cm square. Classes V and B.

d. (west of 996053, 14). Vehicle area around White Lady building and back of Mid Station

There is a considerable amount of partly bare ground, largely caused by insufficient delineation separating areas for vehicles and walkers from areas where neither should go. Recommendation:- make a clear boundary, at any rate for the summer, and fence "no-go" areas in summer for vegetation recovery. Classes V and B.

e. (998049, 15). Track, drains and banks from Mid Station up to big bend below top of Coire Cas Tow

These are generally in good condition. In 1990-92, filled cross drains were opened, new ones opened, and the track resurfaced. A fuller account is in the early-summer inspection report for 1992 (Appendix 4). The area immediately above the bottom of the Mid Station had some washouts of grit during a big thaw and heavy rain in May 1993, with much grit washed on to vegetation on the steep bank below.

Two small bank slips below the big bend, on the uphill side, were caused during the main thaw in 1990. At one point a patch consisting of the upper 5cm layer of reseeded grit sloughed off and piled up at the bottom.

Recommendation:- immediately above the Mid Station, the steep bank is to be raked to remove excess grit and stones, and then reseeded. A better raised edge is to be made on the outer edge of the road. The intention is to narrow down the road by about a half on the widest parts, to reduce the area for rapid runoff. On the higher parts of the road below the big bend, on slopes less than 30 degrees, light surface raking would create better conditions for seeding. On steeper banks such as the two that slipped, cut the bank to reduce the angle, put cut turves on to the foot of the slope, cut horizontal grooves across the slope, and hydroseed. During a brief inspection in 1990, I suggested that inserting some boulders might help stabilise the worst slip, but a more detailed inspection would be useful before any works were implemented. Classes IV and B.

f. (001047, 16). Track, drains and banks from big bend up to Ptarmigan Restaurant

A full account is in the early-summer inspection report for 1992 (Appendix 4). Major works were carried out in summer 1992. These markedly improved the track surface, greatly reduced soil erosion from the track surface, reduced sediment flow on to vegetation downhill, and reduced the number of walkers taking short-cuts downhill and damaging the ground while doing so.

Inspection in September 1993 showed that the outer edge of the track is still not well enough defined and high enough in a few places. Walkers had moved some of the sharp-angled chips laid on the track, down on to the outer bank. Also, heavy rain in summer had torn several rills in the steep upper part of the track, and the resulting grit and sharp-angled stones washed from the track had moved down to fill more of the spaces between and on top of boulders in the French drain. The French drain may eventually not work properly if this continues, especially the upper parts of it; the lower parts are still unaffected by washed-out material. The track on the steep section should be narrowed to the minimum possible, with more cross drains added. The rills in the track surface should be

raked, to reduce damage from further rain and thaws.

Recommendation:- annual check. Classes IV and C, would have been III and B before the 1992 works.

g. (005049, 17). Vehicle and pedestrian tracks immediately around Ptarmigan Restaurant and Top Station

There is a wide band of bared grit on the vehicle track north to the septic tank. The surface of the pedestrian walkway around the Restaurant was improved following suggestions made in the 1990 summer inspection report. This also reduced the number of stones rolling down on to vegetation below. Other improvements have been carried out, of importance for amenity. They are described fully in the early-summer inspection report and the autumn inspection report for 1992 (Appendix 4).

There is, however, a wide strip of bare ground on the south-east side. This is partly because the layout of the walkway, the beginning of the track to Marquis' Well, and the beginning of the track to the Ptarmigan Bowl are less clear than they might be. Moreover the use of boulders and "islands" as obstructions has not worked effectively, largely because of the above inadequate layout and partly because the obstructions are not sufficiently obstructive and can readily be walked over. The Company Manager raised this issue in the first summer inspection.

Recommendation:- narrow the vehicle track to the septic tank and delineate edges better. Have a more detailed discussion of the layout for pedestrians, on site, with a view to proposals for a better layout. Classes V and B, would have been V and A before the 1990-92 works.

h. (east of 989059, 18). Short track west from top of Coire Cas car park

Immediately west of the bridge over the burn, there was a considerable amount of partly bare ground in 1990 during the first summer inspection. It had been reseeded, but results were poor because of continued trampling by walkers and occasional scuffing of the edge by vehicles. I suggested that a clear delineation be made to separate vehicles and walkers in summer from areas under repair. An "island" was made, with a fence around it, and reseeding has been very successful. In 1992 it showed a strong growth of clover and heath rush (autumn inspection report 1992, in Appendix 4), as well as reseeded grasses. Hawkweed and rosebay willow herb had colonised. The short section of track from the bridge to the car park is wide, and has no obvious barrier edge at the north side; the result is that rounded stones on the north side have rolled down on to vegetation.

Recommendation:- stones should be raked up. It would be beneficial to narrow the track, with clear edges delineated for summer vehicles and walkers. Classes V and B.

11.4 Ground in material use: footpaths

a. (005046, 19). Direct path, Top Station to Cairn Gorm summit

The main drawback is that the path took a straight line uphill, as usual for a path formed by walkers as against one constructed for ascent and

descent like the old deer-stalkers' paths. Severe erosion, path widening and sediment flow on to vegetation downhill led to the subsequent construction of a boulder path by the Company. This greatly reduced erosion. A chain fence on either side on the first section up from the Top Station prevented walkers from straying on to ground at the side, and greatly reduced damage there. However, only the middle band between the fences consists of a boulder path, and on either side is a band of ground without set boulders, where trampling prevents revegetation of the bared loose grit and stones. Walkers going uphill often handle the fence, so leading to trampling further towards the fence than would otherwise be the case. Cross drains were dug on the steep section, with boulders forming bridges for the path above them, in an attempt to reduce water flow directly down the slope. This worked to some extent, but led to increased sediment flow off the drain-ends on to vegetation on the west side. Later, some of the boulder bridges fell in and other drains became clogged with grit. Moss, grasses, sedges and rushes have been colonising spots that receive little or no impact, such as cracks between boulders and spaces below them and at the side of them.

This path still has big problems, even accepting its present poor alignment. One is that rocks were inserted to create a smooth overall surface. This is acceptable on a flat area, but on a steep slope is less easy to climb and descend. This is because the surface is more slippery for walkers, as most of the stone surfaces are at an angle facing downhill. It is particularly slippery when there is some snow or ice.

The downhill angle of the rocks does little to reduce the speed of water flowing downhill. To reduce water speed, the main surfaces should be at least horizontal, and there is benefit in some being slightly aligned into the slope. This creates conditions for water flow more like waterfalls in a burn, thus leading to safe diversion of water and lower water speed. Because water speed is reduced little, the need for drains is greater. However, the orientation of rocks is less important for erosion here, where the rocks are above the grit on either side and the path therefore does not take the form of a drain like most hill paths. The main cause of fast runoff and erosion is the bare trampled grit on either side. Thus, although the orientation of the rocks must lead to faster runoff to some extent, if the entire width of the path comprised rocks there would be less erosion and vegetation burial, and less need or no need for drains.

Another drawback of the way in which boulders were placed is that few spaces were left between them, and these became largely or wholly filled with grit eroded from higher up. This reduced the rock path's capacity to act as a French drain. At the bottom end of the path, spaces boulders were filled at surface level with cement, which adds an artificial appearance.

A second problem is that the rock path is not wide enough, given the heavy traffic. One can see this by watching people on the path. Often, two people walk abreast, which is roughly the width of the path, but when meeting one or more in the opposite direction, they have to go to the side, off the rock path. As a result, the grit at the sides is heavily trampled and churned, with very little vegetation and considerable erosion.

A third problem is that walking to the side is too easy on the upper part of the path. On the bottom section, where a simple fence with a single chain on either side restricts walkers, the width of bare ground on either

side of the rock path was only 2m in autumn 1992. Higher up, beyond the chained section, in many places it was 18m on the east side and 6m on the west side. Immediately above the point where the fence ends, the width of bare ground is 7m on either side, compared with only 2m below this point.

Because of the wide expanses of bare grit exposed on either side of the path, the steep gradient, and the greater likelihood of frost heave and subsequent looseness with bare grit than with vegetated grit, runoff was greater, leading to erosion and vegetation burial. The deepest active rill on the bare grit beside this path was 30cm in 1981, but the deeper rills have been flattened out by walkers' feet since then. However, after this was written, heavy rain and a rapid thaw in May 1993 led to new fresh rills up to 25cm deep, and consequent deposition of grit further downhill.

Recommendation:- there are several options. Option A:- take a new sinuous line up the steep section to the skyline, using a well constructed wide rock path without cross drains, with a fence on either side all the way to the summit, and with signs requesting people not to take short cuts and explaining why. Water must be guided to places on the downhill side where it is safe to do so, at short intervals. Possible drawbacks are that many people may take short cuts, and that drainage from the downside would be difficult to construct safely, without running into high expense.

Option B:- accept the present straight line, but re-arrange rocks to produce a better walking surface. Make the rock path wider for the full width, remove and fill cross drains, and have a fence on either side of the rock path all the way to the summit.

Option C:- as Option B, but widen the rock path without changing the present rock path, inserting the new rocks to make a good walking surface, and make a fence on either side to the summit.

Option D:- continue fences to the summit, or at any rate to the skyline as seen from outside the Ptarmigan Restaurant, where the gradient becomes markedly less. Also, place enough boulders on the bare grit at the sides, as obstructions to divert people on to the rock path.

Option A is possibly the best, but expensive, and Option D the least that should be done. For Options B-C, consideration should be given to using some well-placed boulders as obstructions to reduce the numbers of walkers going up the bare grit on either side of the rock path, as against the alternative of a wider rock path right up to the fences. Some quartzite boulders on the bottom part of the current path have apparently done this effectively. It may be argued that this reduces the path width too much for the large numbers using it, thus leading to congestion and people being forced to move to the side. However, this does not appear to have done damage on the bottom part where the quartzite boulders seem to have been fairly effective and grass has been growing well around them. Further observations of people using the path, and further discussions, should be made before taking any decision on which of these options, or others, should be implemented. Classes IV and B.

b. (007047, 20). Top Station by Marquis' Well to Cairn Gorm summit

This path soon became a wide track after the chairlift was built, and has been used by vehicles at times. Since the direct rock path was made, use of the Marquis' Well path has declined greatly.

However, it is still a major source of water runoff, erosion and sediment flow on to vegetation downhill, especially at the main spring thaw. In autumn 1992, a rill on the first steep 100m up from the Top Station was 30cm deep, and the biggest one on the steep part below the Marquis' Well was 2m wide and 60cm deep. In 1992 it was obvious that this very large rill was being colonised by Dicranum mosses in the sides and bottom, and so was beginning to recover. However, after this was written, the heavy rain and quick thaw in May 1993 led to fresh new rills up to 50cm deep, and deposition of grit and topsoil further downhill. The corner of the path opposite the top pylon of the Ptarmigan Tow is a major washout point. This path is now being monitored at permanent fixed sites. An early washout of sediment resulted in a bare patch about 100 sq m in area, above the Anchor for the Ptarmigan Tow. The sediment completely buried and killed plants underneath. It originated about 200m further up the path, at a steep part. Further up, the side track is recovering well, with some vegetation growing on it, but is still vulnerable at the top.

This path is being monitored by the new monitoring scheme at fixed sites marked by metal pegs (path (ii) for monitoring).

Recommendation:- fill the main erosion rills with boulders, stones and gravel packed down, after removing any vegetation with its topsoil and replacing them on top later, flush with the ground surface. There are loose boulders and stones available locally. At the very least, boulders and stones in all rills would greatly reduce water flow and sediment flow, even if rills are not completely filled with gravel. Boulders placed at the upper vulnerable part of the side track above the Anchor (last sentence two paragraphs up) would reduce the risk of further erosion and sediment flow there. On the lower, east verge, the path edge is poorly defined and lacks a barrier, and so sediment readily flows over the edge. Such a barrier should be made using boulders and cobbles placed at key points such as the corner opposite the top pylon. Classes III and D.

c. (006049, 21). Top Station to Ptarmigan Bowl

This track was formerly made by vehicles, but is now popular with summer walkers who go to a snow patch at the top of the Ptarmigan Bowl. The track ends about 50m below the snow patch, on a stretch of vegetation dominated by mat grass. This is a very resilient vegetation type, which is why there is no sign of a path beyond. Recommendation:- narrow the track, delineate edges better, and restrict the track to the horizontal parts, avoiding having it on a cross slope where walkers' feet move grit and stones downhill. In the summer inspection report for 1992, the possibility was raised that this path might be continued as a circular route joining the Marquis' Well path above the snow patch and so back to the Ptarmigan Restaurant, to prevent people wandering off the present path after it ends. However, more detailed inspection of the ground suggests that the mat grass beyond the path end is withstanding human impact well enough. Further down, the track leading to the bottom of the Ptarmigan Tow had a surface of almost completely bare grit and gravel in 1981, but has become partly covered by vegetation as a result of lower use and natural recovery. Classes V and B.

d. (997043, 22). Fiacaill a' Choire Chais down to about top of Fiacaill Tow

On the top part there is no clear footpath. Walkers take various lines downhill, but there are some braided sections due to heavy use. Between these and on adjacent ground there are many signs of damage.

On the whole, the top part shows widepread diffuse damage on a broad front across the whole width of the ridge, and spreading down on either side, with much rolling of stones and grit. It is so steep that a walker coming downhill inevitably causes further loosening of grit, as many of the steps taken involve a small slip downhill, with the boot rolling on grit. Indeed, the surface is so loose and unstable that on the steeper sections a walker has to take care not to fall. That does not happen where there is a boulder to walk on. This part shows much vegetation damage, soil erosion, and movement of stones and grit on to vegetation.

In 1981 it was showing severe damage and rapid deterioration, but appears to have stabilised since the mid 1980s. The data from the 1988 survey indicated more damaged vegetation than in 1981 (Watson 1988a). When I inspected it in detail in 1990-92 it seemed to be in balance, showing no further material deterioration but yet no further material improvement. It is now being monitored at fixed sites (location (v) for this).

On the lower part, where the route begins to diverge to the east, off the main ridge, a path becomes obvious, and early repairs using boulders on this section can still be seen, but the work was poorly done. The path is still eroding considerably, leading to washouts of sediment down the path and on to vegetation as far as 700m downhill, for most of the way down to the zigzag road. On the lowest part where the path angle eases on a shelf and runs through more continuous vegetation, the path is in better shape but is still prone to washouts and water from above.

Recommendation:- if these problems are to be rectified, a well constructed rock path would have to be made on the lower steep part east of the main ridge. Below it, put stones into any rills. On the upper steep part on the main ridge, problems are intractable, and ultimately insoluble without making a completely new rock path. This could be designed to merge with existing firm boulders as far as possible. It would have to be easy to walk on, so as to avoid the possibility of walkers taking easier lines on either side. Any decisions on this upper part should await more information from the monitoring of fixed sites. Classes IV and C.

e. (995049, 23). From about top of Fiacaill Tow down to road above Mid Station, two main routes east and west, join at both ends

This path was deteriorating rapidly in 1981 but has since shown some signs of recovery as well as some signs of further washouts of grit. Since the mid 1980s, the stiff sedge appears to have been doing quite well and withstanding trampling on fairly stony parts. As noted for the above path 22, this section is subject to washouts of water and sediment from above, which do further damage to path 23 as well as depositing sediment on the path verges and adjacent vegetation. These problems can be tackled properly only by tackling path 22. Another problem is that on the lower part there are too many routes. Some walkers taking the more easterly routes end too far up the zigzag road, on steep gravel banks which they then damage by plunging down on to the road.

Recommendation:- fill rills with small stones, especially where the path steepens. At the spots where the eastern routes diverge, erect sensitively worded signs requesting walkers to use the westerly routes because they are easier, take less time, and cause less damage. The main east and west routes are being monitored at fixed sites (paths (iv) and (viii) for monitoring). Classes III and C.

f. (989058, 24). Top of Fiacaill Tow down east side of Ridge Poma to car park

A few paths on the upper slope are in fairly good condition on gravel, though loose in places. The narrower paths on the lower slope are in poor condition because they are on thick wet peat, and so have become churned. They have been formed mainly by walkers coming downhill.

Recommendation:- the only way to repair the peaty paths would be to introduce rocks and gravel, which would be expensive and would look conspicuous against the dark heather (at present, the paths are inconspicuous at a distance). Another option is to erect a sensitively worded sign on the ridge above the top of the Fiacaill Tow, informing walkers that the best route down is the more easterly one to the zigzags above the Mid Station, and explaining that the ridge route is leading to damage and is unpleasant for walking on the churned, wet lower section. The paths would then be allowed to recover naturally. Classes IV and D.

g. (988059, 25). Start of Northern Corries path as far as first corner

This has been repaired but there were obvious small problems in autumn 1992. Stone chips had been kicked down on the sides, lying on peat, and on the first slope the peat at the north side was churned by bootprints. The path there was not wide enough, and lacked defined edges. The part as far as the gate in the snow fence and the end of the roped section needed stone chips or gravel. At the top of the wooden boards, gravel had washed on to the north side and the plastic matting was exposed. This was due to too fast water movement, because the flat boulders placed higher up had not been inserted in such a way as to reduce water speed, and because of a lack of cross drains. Loose stones and cobbles had gone into the north side. The section west of the pipe below the wooden boards had loose stones on the north side, rolling down on to vegetation.

Recommendation in autumn 1992:- make appropriate cross drains and defined edges, and widen the path in places. If rocks are added, ensure that they break water flow. Classes V and C.

After this was written, further repair work was done in June 1993. I inspected this in September 1993. New drains had been dug in the wet peat above the path, and nearby cross drains were working well. Turves of sedge dug from the new drains had been placed into bare peat on ground beside the path; this was well done. Gravel had been added to the path, but the edge was still not clearly defined, and some peat had mixed with the gravel in some places at the path edges. The rock path at the east end near the ski tow had been improved in layout, but the boulders tend to face downhill. Hence water flow will not be reduced as much as it might have been, and the rocks are less easy to walk down on and a slip is more likely. Loose stones had been dealt with effectively. Now Classes V and D.

h. (986054, 26). Northern Corries path to Allt Coire an t-Sneachda

Formerly one of the worst-damaged paths on the Estate, this was very wet, wide and peaty in places, and rough in others. The HIDB funded major repairs, which transformed the path surface, successfully concentrated use in the middle hardened section, and allowed plants to colonise and recover on formerly damaged areas at the side. However, walkers do occasionally walk at the side, as was raised at the 1992 Estate monitoring meeting.

Seeds of wavy hair grass were sown on the sides along one part, and have grown into plants that are contributing further seed. The reason for using them was that NCC had banned the use of the commercial agricultural mixture used on the ski area, on the grounds that the path was in an SSSI. However, seeds of wavy hair grass are very expensive. Also, this species does not withstand wear well, as it does not form a tuft. A better mixture would involve cheaper species which occur naturally on hill land and withstand wear better. At this low altitude there is no need to reseed on thin peat, as the hill vegetation, especially heather and deer sedge, recovers fairly quickly if obstructions make people stop walking on it in large numbers. Most of the minor improvements suggested in the description in Appendix 3 involve obstructions with this aim in view.

Recommendation in autumn 1992:- consider the minor improvements suggested in Appendix 3, especially those emphasised there. There is no need to reseed or use other techniques for revegetation, unless obstructions fail to produce an improvement. This section is being monitored at fixed sites (path (iii) for this), and decisions on what to do could await further data from the monitoring. Classes V and D.

After this was written, further repair works were done in June 1993. I walked the path in September 1993, after months of generally poor weather when the hill was wetter than usual. Near the west end, a new drain had been made in peat above the path, and other new such drains towards the east end. Nearby cross drains had been improved, and were working well.

Some sods of heather and sedge dug from drains had been laid on bare patches beside the path. The heather sods were too shallow for such tall heather, and are unlikely to do well. Two were laid on top of compacted grit, and the sides had not been packed in with peat or grit to cut evaporation. The sedge sods had been inserted better, into bare peat.

Many cuttings of heather and some of bell heather had been notched at regular intervals in straight lines into bare peat that was formerly part of the path, in several places near the west end, in the central part, and towards the east end. These look artificial; it would be better to notch in a less regular way. Bell heather does not do well in bare wet peat, and is best on drier sites with thin peat or more gravelly soils. Heather and bell heather withstand trampling poorly. Transplants of deer sedge would be better for this site, splitting sods into small sections with a spade.

In several places, people are obviously still walking on parts outwith the defined new path. Extra obstructions from boulders will be needed to divert people. Still Classes V and D.

i. (987051, 27). Upper path to Allt Coire an t-Sneachda

This was monitored in the earlier mnonitoring scheme. Inspections in 1989-93 showed that it was in a fairly steady state, if anything tending to show slight recovery. However, a visit in September 1993 after a poor summer when the hill was wetter than usual showed that the peaty parts had deteriorated as compared with 1992. My own opinion based on counts of people is that it has been used less in recent years than in the 1970s and early 1980s. Recommendation:- check it every few years, meanwhile no further action. Classes V and C.

j. (983043, 28). Allt Coire an t-Sneachda to site of former Jean's Hut

The detailed path description (Appendix 3) shows that in autumn 1990 this path was showing marked signs of recovery, with good colonisation and growth of vegetation, and a material improvement in path surface condition. Clearly this is a result of lower numbers of people, following the removal of Jean's Hut from its former site far up Coire an Lochain. Recommendation:- check it every few years, meanwhile no further action. Classes V and C.

k. (981046, 29). Allt Coire an t-Sneachda to Allt Coire an Lochain

As path repairs had been done on some of the formerly worst paths, this was the worst-damaged path on the Estate when I inspected it in autumn 1990. The first section up the steep bank beyond the burn was a wide band of bared, trampled peat, with a sinuous line of boulders inserted in July 1989 to form stepping stones. Beyond, it became better, but there were some poor sections of braided path with rough surfaces, where the path had widened greatly. Other poor sections were in wet patches which were morasses in wet weather, again leading to walkers taking new routes on drier ground immediately adjacent, and so widening the path. Further details are in Appendix 3. This path is in the new scheme for monitoring at fixed sites (path (i) for that).

Recommendation in autumn 1990:- if further path repairs on a large scale are agreed, this is an obvious one to be considered. The first slope up from the burn needs major reinstatement. One option is to use the present line, adding many boulders to form a rock path along with the scattered boulders already there. A second option is to form a new, zigzag line slightly further north. This would be less expensive and better, but would require rope fencing of the present thick bare peat, and liming and reseeding of it, to hasten recovery. Classes V and C.

After this was written, path repair works were carried out in late 1990 on the first peaty slope beyond the crossing of Allt Coire an t-Sneachda. Large boulders were inserted in the bare peat on either side of the main path line, as blocking obstructions. Holes where these boulders had been excavated were filled with peat, and some turf was added to the bare peat. The main path route in the centre was defined by boulders to be stepped on, and some small boulders were cleared from the path immediately beyond the start of the wide peaty slope, to make a better lead in to the path. These works greatly improved the path, but people still walk on the peat at the sides, especially in dry weather, and the dry friable peat then moves more readily in rain and wind.

The wet parts of the path beyond the first slope showed some deterioration in September 1993 as against early May 1993. Up to date classifications for the first slope now Classes V and D, but rest of path still Classes V and C.

l. (977042, 30). Allt Coire an Lochain to Allt Creag an Leth-choin

In 1990-92, most of this path (all of it beyond where the path to Miadan Creag an Leth-choin breaks off to the south) showed clear signs of recovery in surface condition and in colonisation by vegetation, and it is obviously less used now than in former years. My own view, based on seeing where people go, is that it has been largely superseded as a route off Ben Macdui and Cairn Lochan by the more direct path on the north nose of Miadan Creag an Leth-choin. Recommendation:- check every few years, meanwhile leave to nature to recover. Classes V and D.

m. (978040, 31). Up north ridge to Miadan Creag an Leth-choin

This path has become more conspicuous since 1981, and the detailed path description (Appendix 3) shows that it is braiding, widening, and deteriorating in surface condition, though still in generally good shape. It is now being monitored at fixed sites (path vi) for this). Recommendation:- monitor, no other action meanwhile. Classes IV and C.

n. (991029, 32). Goat Track in Coire an t-Sneachda

This was a former red deer trail from Coire an t-Sneachda to the plateau, so "Deer Track" would be a better name; there were no goats. The steepest path on the estate, it is subject to severe problems of loose stones and erosion. Deer climbed and descended this zigzag trail carefully, seldom loosening a stone. Walkers on ascent caused few problems, but walkers descending in a hurry did much damage, and some even indulged in the beginnings of "scree running", sliding down the gravel at speed and also taking short cuts. Boots scuffed vegetation, uprooted plants and dislodged sods. Consequently the path eroded severely, and the surface became unstable and loose. Stones and grit moved down on to intact vegetation, and some buried it, causing further problems of instability.

The path was already in a poor state and deteriorating rapidly in 1981, but in my view is now no worse than it was then. However, it is still poor. The worst sections were repaired in 1989 by HIDB, and this greatly improved these. However, this merely staved off the problems. The entire path requires either repairs throughout, done to a very high standard, or else a material reduction of people using it.

In the recent new edition of the Scottish Mountaineering Club's District Guide to "The Cairngorms" (Watson 1992a), the route is mentioned as a way from the car park to Ben Macdui, as it would not be a comprehensive guide if it omitted obvious paths deliberately. However, I warned (p. 76) that "the Goat Track is rather loose and unstable in places". This was added to deter people. There is no doubt that the Goat Track is an unsuitable place for inexperienced or unfit walkers; it is so loose that a slip is likely, and so steep in places that a fall could result in serious injuries.

Recommendation:- it would be worth considering whether to deter descending walkers by erecting a sensitively worded warning sign at the top, explaining that the path is loose and unstable, and poses risks of a fall,

and suggesting that walkers return by the easier and safer routes nearer Cairn Gorm. Meanwhile check path condition annually, and keep major repairs as an option if the path deteriorates markedly. Classes III and C.

o. (979028, 33). Miadan Creag an Leth-choin to Loch Coire an Lochain

This steep path is very subject to runoff and erosion. The detailed description in Appendix 3 shows that it is in a fairly steady state and has not been deteriorating in recent years. If there were a big increase in use it would be vulnerable to severe erosion. Recommendation:- keep a check on it every few years, and meanwhile no action. Classes IV and C.

p. (979039, 34). Slanting path west of above, to Northern Corries path at Allt Coire an Lochain

This showed some signs of recovery of plant growth in autumn 1990, though overall its condition was steady. Recommendation:- check it every few years and meanwhile no further action. Classes IV and C.

q. (980025, 35). Miadan Creag an Leth-choin to Cairn Lochan

This slope has much naturally bare ground, and is fairly steep, so loose grit, rolled stones and erosion are frequent. The detailed description (Appendix 3) reveals some poor sections high up. However, these were already there, and deteriorating rapidly, in 1981. Since then, numbers of people on the plateau have declined (Watson 1991), and the path is now no worse than in 1981. The upper parts could become a serious problem if visitor numbers were to increase materially. Recommendation:- keep a check on it every few years, meanwhile no further action. Classes IV and C.

r. (south of 995030, 36). Plateau north rim, above debris slides

The worst debris slide in Coire an t-Sneachda originated in heavily trampled bared ground showing many human footprints, on the edge of the plateau above. The writer found this on close inspection during the night of 4 July 1976 when a storm occurred; the rills that started the debris slide began on the plateau rim, within the Estate.

Recommendation:- placing boulders and cobbles well into the ground on this trampled bare section would reduce the risk, by intercepting water early on and by acting as a sufficient barrier to prevent people wandering about all over this area. As the site is sensitive and seen by many people, the work would have to be carefully done, for example, ensuring that boulders were placed right way up, with lichen on the upper side. Needs further discussion. Meanwhile no urgent action needed. Classes IV and C.

s. (984071, 37). Forest edge car park to Reindeer Company's enclosure

This path from the Sugar Bowl has been repaired over almost all its length. The detailed description (Appendix 3) shows some small problems suitable for small-scale repair. Most of these problems were remedied by work in summer 1993, and there is now no need for further work in the meantime. Recommendation:- check every few years. Classes V and D.

t. (981065, 38). Reindeer enclosure to Caochan Dubh a' Chadha

The first part up the peaty slope was in poor condition in autumn 1990, with wide wet parts on churned-up peat. Along the edge of the escarpment, the path was wide and braided, but generally in fairly good condition. The steep slope at the west end, down to the burn, had been repaired by HIDB.

The detailed path descriptions (Appendix 3) show conditions in autumn 1990, including suggestions for minor repairs on the steep brae at the west end. Since then, repairs have been made on the east peaty slope and along the escarpment, and on the steep west brae, in 1992 and 1993. The section south from the enclosure to the corner had much work done in June 1993. Appendix 3 includes notes from December 1992 and August 1993, covering new repaired parts and suggestions for minor repairs on these. The descriptions also include notes south of the enclosure, made in August 1993. Recommendation:- keep a check every few years. Classes V and D.

u. (972061, 39). Caochan Dubh a' Chadha to Chalamain Gap

Most of this apart from the first repaired section was a very poor path in autumn 1990, with wide wet peaty parts which were worse than on even the main Northern Corries path before it was repaired. The detailed description (Appendix 3) covers repairs that had been done by then on the lower parts, the state of the path beyond in autumn 1990, and the subsequent repairs done to it, with suggestions for further small changes. Recommendation:- keep a check every few years. Classes V and D.

v. (976064, 40). Caochan Dubh a' Chadha down burnside to footbridge below reindeer enclosure

The detailed description (Appendix 3) shows some problems on this path, mainly at wet places. In general, however, the condition when inspected in autumn 1990 was fairly steady. Since then, some further repairs and improvements have been carried out. Recommendation:- keep a check on it every few years, meanwhile no further action. Classes V and C.

w. (999071, 41). Coire na Ciste restaurant to top of chairlift

The detailed description (Appendix 3) shows that the path up the first slope is in very poor condition, as the route was on a plant community of heather and deer sedge over thick peat, and the peat is now bare, wet and trampled over a considerable width. Further up, there are some sections with loose gravel, but generally in a good state, and then the last flattish part is narrow but with a poor surface of wet churned peat in wet conditions. The path continues beyond, southwards to the top of the upper Coire na Ciste chairlift, running roughly along the line of the chairlift. It is better drained, narrow, seldom braided, and in generally quite good condition. Recommendations:- take a new line for the first slope, and reinstate the bared peat after rope fencing, by reseeding and liming. Discuss timing, and meanwhile keep an annual check. Classes IV and C.

x. (000070, 42). Coire na Ciste car park up Allt na Ciste burnside, and nearby paths

Some parts are wet, and some rough and loose (detailed description in Appendix 3). Some repairs were done in late 1990. Recommendation:- check every few years, meanwhile no further action. Classes V and D.

y. (000051, 43). Beside White Lady Chairlift

This was in a deteriorating state in 1981 but is now fairly steady in condition, and shows some signs of recovery by vegetation. It would be vulnerable to a material increase in use, as it is so steep. Recommendation:- keep a check on it every year, meanwhile no further action. Classes IV and C.

z. (000052, 44). Beside White Lady Tow

This is not really a continuous footpath, but a path was beginning to develop there in 1981 along some parts. Since then it has not extended, and is beginning to show signs of recovery with vegetation growth, although there are still some loose parts. On the 1991 summer inspection, I suggested that cobbles or boulders placed in the small rill there would help reduce water flow. This route would be vulnerable to a large increase of use. Recommendation:- keep an annual check on it, and put cobbles in the rill, meanwhile no further action. Classes IV and C.

za. (997079, 45). East of Allt na Ciste to forest edge

In autumn 1991 this showed signs of recovery with vegetation growth, and the surface condition showed a trend towards improvement. A small part was damaged by an excavator in December 1990, which dug a few large peat "dollops" for tree planting, at the edge of the path and in one case on the path. Recommendation:- repair the damage done by the dolloping, and check every few years. Otherwise, leave to nature for further recovery. Classes V and D.

zb. (990067, 46). Clach Bharraig to Ptarmigan Restaurant

This was the old path from Glen More to Cairn Gorm. It widened and deteriorated greatly in the late 1960s and 1970s, and was at its worst in 1981. Since then it has greatly improved in surface condition and plant growth, and has become much narrower, especially on the lower parts up to the top of the tall heather zone. This is obvious on photographs taken in 1981 and now. An old section used formerly by deer ponies is now hard to find, above Clach Bharraig. So is the first part of the path where it heads uphill above the main lower road to Coire Cas. Recommendation:- check every few years, but otherwise leave to nature to recover. Classes IV and C.

zc. (997056, 47). From Sron an Aonaich down to Coire Cas car park

A series of gritty paths through heather on a fairly steep slope. The lines are too direct for such a steep slope, and show most of the defects of direct straight paths formed by walkers. These paths were extending and deteriorating rapidly in 1981, but have since tended to become slowly better. There are still serious problems, however, noted in the detailed description (Appendix 3).

Recommendation:- carry out changes suggested in Appendix 3. At the least, water flow and washouts of grit on to vegetation should be reduced on the higher part, all the way to the skyline, by inserting boulders and cobbles. At the bottom, above the road, a loose part with bare gravel has

lost much depth of soil. Rake off loose stones, some of which are lying on vegetation. Either make a rock path, or introduce some peat and reseed, adding a temporary fence. Keep an annual check. Classes IV and C.

zd. (996054, 48). To Scottish Ski Club Hut

A short steep straight path on rocks with wooden steps. The rocks do little to reduce water speed. Excavation for drainage at the hut's back and sides left much bare rock and bare gravel, leading to rapid runoff. Plastic drains were not put in effectively. A nearby path to a memorial added to the problems, with 30cm depth of soil gone on the steepest part.

Recommendation:- remove the memorial plaque and erect at the Day Lodge where it would be more appropriate. Fill the eroded path with boulders and cobbles. Remove the pile of old wood from the hollow to the north-west. Stabilise the bank behind and beside the hut by better placing of boulders and cobbles, and by reseeding bare gravel. Remove plastic drains. Make a new open drain from the north-west side of the hut straight down to the White Lady Burn. Keep an annual check. Classes V and C.

11.5 Ground in material use: ski facilities, covered in the ski monitoring

a. (999071, 49). Gravel slide beside lower chairlift at Coire na Ciste

There was already a landslip, due to undercutting by the burn, as on the east side. However, it was materially enlarged and made looser by the excavation, and by dumping excavated gravel down the slope.

The bank above the excavated terrace had turves of damp fertile lowland grassland laid on it by the Company in the late 1980s. Many gaps between turves were left open. These green turves look incongruous against the background of hill gravel and heathery dark slopes. However, they have prevented further gravitational and water movement of gravel, and have continued to grow well. By autumn 1990 they had been invaded strongly by heath rush. The area patched with sods is about 12m along the upper side of the terrace, varying in width from 2m to 4½m. The topmost part was not patched; here there was peat with some heather. Bearberry was growing right on the very top, above the excavation line. Beyond the patched section, the top of the bank overhangs considerably.

Below the terrace, the slide goes for about 100m down to the burn, and is 32m wide at the widest point not far below the terrace. There are two main slides below. The south, smaller one is only 4m wide on the lower half, and has a surface mainly of loose stones, but heather, some grass, and some heath rush have colonised. It has an almost complete cover of heather half way up to the excavated terrace, 25% heather cover about a quarter of the way down from the terrace, and 20% cover about 3m below the terrace.

Electric cables at the north end are exposed, and further south have been dug in along a line of small posts.

More than half way down the big north slide is a terrace, with heather growing well on it. It would be useful to extend this terrace sideways, and thus form a horizontal berm (Schiechtl 1980; Coppin & Richards 1990) to stop movement of water and gravel straight downhill, hold moisture better, and so aid vegetative growth. The big slide also has large clumps of tall

heather on the bottom half, which are relics of heather sods excavated and dumped from higher up. These act as useful sources of stability.

Recommendation:- further lowland sods should not be brought in, but those already there should be left. Any gaps between sods should be filled preferably with nearby peat (or if not, by grit), packed in well. If it is agreed that the bank above the terrace should be vegetated, the cheapest and best solution long-term would be to lay a thin layer of peat on the surface, reseed with grass, and fertilise. Beyond the patched section, the bank overhangs. This should be cut back, and the turves that result should be placed on the bank below, flush with the ground surface.

The main problem is the slide below the excavated terrace. At present the slide is fairly steady in condition, and has not deteriorated in recent years; if anything, it shows some vegetative recovery. However, it is still in a serious condition, and looks bad. On the big north slide, the terrace could be extended sideways as noted above. On other parts, seeding with broom would be worth while, as broom has strongly colonised the smaller slide on the east bank of Allt na Ciste and the big slides at the corner of Allt Mor. It might be useful to plant broom directly, in shallow longitudinal cuts into the bank. Keep an annual check. Classes IV and C.

b. (000044, 50). Top of Coire Cas Tow track

There is a fairly large bare patch here that is unnecessarily wide (summer inspection report, 1992; "the intention is to narrow it down by reseeding in due course, but there is no risk of serious erosion as the gradient is so low"). Recommendation:- reseed. Annual check. Classes IV and C.

c. (999044, 51). Bulldozed corridors in upper Coire Cas

These were bulldozed to make narrow corridors for skiers through bouldery areas. With today's knowledge and experience of snow fencing they would not be made and would not be necessary. The bulldozed straight ridges certainly look artificial and inappropriate. Reinstating them could be done with little impact, following the procedures used successfully for removing earth mounds below the Ptarmigan Restaurant in 1992. However, it would be a bigger task at the corridors in Coire Cas, because so much of the bulldozed ridges involves boulders rather than earth, and because there is no obvious place to put the boulders into. Also, the removed boulders have begun to be colonised by lichens and have weathered, and so are beginning to look more natural. Recommendation:- a detailed discussion on site would be required before deciding on action. Check every few years. Classes V and B.

d. (999060, 52). Foot of tow east of Coire Cas car park

The mound at the bottom was put in with very little impact, and vegetation growth has been good. Recommendation:- keep an annual check, meanwhile no further action. Classes V and D.

e. (000052 and 007049, 53). Dug trenches for White Lady and Ptarmigan Tows

These were excavated to catch snow for skiers going up the tows. With recent experience of snow fencing they would not be dug and would not be

necessary. However, reinstating the ground would now cause worse short-term damage than leaving the trenches as they are. Inspection in autumn 1990 showed that they were stable in condition, and if anything showing slight signs of recovery of vegetation growth. Recommendation:- check annually, otherwise no further action. Classes IV and C.

f. (990059, 54). Bare peaty patches opposite Day Lodge

These were mapped and estimated in size and vegetative cover by Mr Richard Smith in December 1991, as part of the autumn monitoring (his sketch in Fig. 5, and his detailed patch-by-patch notes in Table 1 of the autumn 1991 monitoring report in Appendix 4).

Other notes were made by me in December 1992:- "New reseeded patches good. As well as reseeded grass, which was seeding, dwarf cornel was colonising the edges, many healthy seedlings of heather and some of cloudberry. The biggest and one of the worst-vegetated patches was 3x1m, with 40% vegetative cover. Patch near foot, 5 sq m, had Dicranum moss colonising and heather, with 35% plant cover overall. Bottom reseeds opposite Day Lodge had velvet bent, heath rush, common cotton grass, hare's tail cotton grass, common sorrel and Dicranum moss colonising. Heath rush was the commonest colonist and common cotton grass next, both seeding well; both are good signs, as they thrive on wet peat and are resistant to trampling. Hare droppings were adding to fertility on the patches opposite the Bottom Station. Here there were many heather seedlings, which on some patches were the next commonest plant after the reseeded grasses. Cowberry and blaeberry seedlings were also there. Opposite the gate above the Bottom Station, the reseeding had been least successful, with only 3% cover from the reseeded grasses and the main vegetation consisting of some moss; some heather seedlings were growing".

Recommendation in autumn 1992:- continue reseeding the worst-vegetated patches, and light fertiliser dressings on the rest. On the poorest ones, add some lime. Transplanting small sods of heath rush and cotton grass (dug from the fenced tree-planting area or nearby) would speed up recovery, on patches where the reseeding fails to provide a good cover. Classes V and B.

Since this was written, inspection in September 1993 showed that reseeding had been the most successful of any summer so far, with very good coverage of plants. This was associated with unusually wet ground in summer and autumn 1993; desiccation of seedlings in dry weather is the main reason why reseeding of such peaty patches is generally poor. Plant cover is now so good that I decided that there was no need for quantitative monitoring here in autumn 1993 or subsequently, unless there is obvious marked deterioration in future. Now Classes V and D.

g. (993055, 55). Bare peaty patches in hollow below Mid Station

These were also mapped and estimated in size and vegetative cover in December 1991 by Mr Richard Smith as part of the autumn monitoring (Fig. 5, and Table 2 in the autumn 1991 monitoring report in Appendix 4). They have been reseeded or fertilised each year in 1990-93 like those by the Day Lodge, and show similar success and colonisation by native hill plants. The wettest patches are still partly bare, however.

Recommendation in autumn 1992:- same as in f. in above paragraph. On the

wettest patches, dig shallow drains by spade. I suggested this at the Lecht, where wet peat is a big problem. Shallow drains are used each year there, reducing surface water and helping revegetation. Classes V and C.

Since this was written, inspection in September 1993 showed good plant cover from reseeding. Remarks in f. apply here too. Now Classes V and D.

h. (001068, 56). Bare peaty patches at foot of Aonach Tow

These have been there for several years, like the patches opposite the Day Lodge. They are on the bottom 120m of the piste near the tow, on the south side of a hollow. The biggest is about 3x2m and the others 3x1, 2x2 and three of 1x1. Recommendation:- keep an annual check. Classes V and E.

11.6 Ground in material use: public roads and car parks

a. (988066, 57). Public road verges, banks and drains

Generally quite good condition, but a few drains debouching on to the slope below the road downhill from the main lower road to Coire Cas are unsatisfactory, with washouts of gravel on to vegetation without a proper safe water course. The road verges are not hardened, and much gravel washes out in heavy rain here and beside the Coire na Ciste car park. At the latter, up to 30cm of gravel was washed out in May 1993, with a vertical tarmac edge exposed. Classes III and C.

The drains above the Link road were large and numerous, and contain no obstacles to reduce water flow, but there is no point in changing them now that there is a good cover of vegetation on the surrounding ground. Annual check. Generally Classes IV and C, but some parts III and C.

b. (989061, 58). Car park surfaces, verges and banks

Generally quite good. The shutes by the car park at Coire na Ciste have nothing to reduce water speed. The Coire na Ciste car park is on a marked slope except at the east end, and runoff is considerable in rain. In 1990-92 there were active rills up to 10cm deep in the surface at the lower, western end. Some grass was coming in at the sides in places which are less used by vehicles. Recommendation:- consider improving the drainage along with a surface less likely to move (e.g. sharp chips) on the lower parts at Coire na Ciste. Annual check. Generally Classes IV and D, but III and C for lower part of Coire na Ciste car park.

There is some damaged ground between the top end of the lower Coire Cas car park and the top end of the upper car park. A metal staircase leads up here, and on its north side is a wide track with a surface of smooth flat stones. On the stair's south side is a 30x5m patch of bare gravel. Recommendation:- reseed. Classes V and C.

11.7 Ground in material use: diffuse widespread damage on large slopes

a. (004044, 59). Entire slope from Ptarmigan Restaurant and direct path to Cairn Gorm round to the east end of the headwall of Coire Cas

This is the second worst area for vegetation damage and soil erosion on the Estate, and the worst in terms of the large area. This slope has long

had severe problems of vegetation damage, loose grit and stones, and movement of grit and stones downhill on to vegetation. The only parts not showing these problems are where continuous boulder fields have acted as sediment traps and have also withstood walkers' feet without damage.

These problems were at their worst in autumn 1981, but have since eased, in association with fewer people using the chairlift and seen on the plateau since 1981 (see 6.8.1). However, they are still serious, and the slope is so high and exposed that vegetation recovery is very slow. Even as far down as the road up from the big bend, there is much evidence of deposition of loose grit washed down from higher up. In 1981 I followed it all the way up to its sources, in some cases in grit spreads washed down from the direct path to Cairn Gorm, but in most cases to the traverse, where human footprints that had slid in loose grit were tell-tale signs.

The issue was raised in the summer inspection report for 1992, now in Appendix 4:- "This has been a problem for years, and during detailed examination of the entire hillside in 1981 I found that it was caused by small numbers of walkers traversing the steep hillside much higher up, after coming up the chairlift and lower part of the granite path to Cairn Gorm, but then moving off the path as a short cut to the plateau, and as a short cut on the return route. Tom Paul agreed that walkers were the cause, and said that unfortunately this route was described in a book by E.L. Cross, even though this route was not a path at all, and that this led to increased numbers" (I have deliberately not mentioned this short cut in the 1992 SMC District Guide to "The Cairngorms"). Detailed ground inspection shows that foot slipping on the unstable loose surface is frequent, leading to further instability.

Recommendation:- as walkers cross this slope on a wide front, there is no point in considering a path. In any case it would be easier on a horizontal traverse to walk at the side of a rock path than on it; the traverse is not on a sufficiently steep slope to make walkers go on a path for safety reasons. It would be beneficial to reduce walker numbers on this slope. This could be attempted by closing the chairlift to walkers on the most vulnerable days, or successively in summer generally or by further restrictions at the car park or public road. Short of such actions, the only feasible suggestion involves sensitively worded signs at the Top and Bottom Stations of the chairlift, in the Day Lodge and Ptarmigan Restaurant, and at key places on the granite path, requesting walkers not to cross this slope, and explaining why. The Ranger Service could help by talking with walkers who are seen moving on to this slope. Meanwhile, keep an annual check on the state of the slope. Classes II and B.

b. (001041, 60). Headwall of Coire Cas, from its east end to its south-west corner directly under the cairn at the top of Fiacaill a' Choire Chais

The western slope north of this corner is in fairly good condition, has always been fairly well vegetated, and has escaped heavy use because its broken remains of cliffs offer a much more arduous route than most of the ground around. The headwall is the most severe problem area for vegetation damage, bared ground and soil erosion on the Estate, though the previous one (59) surpasses it in that it covers a much larger extent of slope, though with less damage per unit area.

There was always a low vegetative cover on the headwall, because snow lies long there. However, the amount of bare ground was greatly increased by walkers taking short cuts from the big bend on the Coire Cas road straight up to the plateau behind the headwall, and particularly by walkers returning from the plateau. The slope is so loose that walkers slide, causing further loosening and more plant damage. In many places, 30-40cm of soil has gone, as is clear from inspecting those parts of the boulders whose lack of lichen cover shows that they were formerly under the ground (Watson 1985). Most natural terraces have been broken. The deepest rill was 0.5m in 1981, with many rills over 10cm deep, and this still applies.

The slope was at its worst in autumn 1981, when it showed signs of rapid deterioration. Since then, in association with fewer people using the chairlift in summer and fewer seen on the plateau (6.8.1), it has not worsened. If anything it has become slightly better, with a little plant recovery and a better surface (Watson 1988a), and this still applied in 1990-93. In 1988, data indicated that mosses had significantly increased in ground coverage and in frequency of occurrence per quadrat, compared with 1981; also, the frequency of damaged vegetation had declined.

However, the slope is still so loose and bare that it is highly vulnerable to heavy rain and big thaws. For example, at the main thaw in 1992, a number of landslips occurred in the middle of the worst-affected part of the slope. Most were small. However, the largest measured by Mr N. Baxter in September and early October 1992 was 30m long, with the washed-out debris spread downhill for another 20m; the slip varied between 2 and 5m wide and 30cm to 1m deep. A few others were of fair size. One of these was 25m long, with debris washed down for another 20m, and was 3-5m wide and up to 60cm deep. A third fairly large one was 19m long, with debris for another 15m below, and was 1.5-3m wide and up to 60cm deep. A fourth was 11m long, 2.5m wide and 30cm deep, and a fifth had a total length including debris of 40m.

This slope is one of the areas being monitored at fixed sites (location (vii) for this), and a few transects for the monitoring were affected by the landslips. There were also several washouts of grit on to the snow in May 1993, associated with a big thaw and heavy rain.

Recommendation:- the ground at the landslips should be reinstated and stabilised in 1994, after detailed discussion on site as to the best methods. Whatever is decided, the methods would use local boulders and gravel by reworking them, followed by reseeding, fertilising and transplants, and small roped or taped areas to discourage walkers, along with sensitively worded signs informing walkers about the problems. In the long term, this slope poses severe problems that cannot easily be solved. A rock path would not work, as it would be too easy to walk on smoother ground on either side.

A sensitively worded sign at the top would be useful, requesting walkers not to take this route on descent, and to go back by Fiacaill a' Choire Chais or Cairn Gorm summit, and explaining why. A similar sign at the big bend on the road in the upper part of Coire Cas would also be useful.

At present there is a run of years with lower numbers of people on the upper parts of Cairn Gorm than in the 1970s and early 1980s. If numbers were to increase to levels as high as or higher than those in the mid

1970s and 1981, severe increasing damage to this slope would be probable. There would then be greater concomitant risks of landslips during intense rainstorms and rapid major thaws. In such an eventuality, one of several possible courses of action would be closure of the chairlift to walkers on certain days or seasons (as in 59 above), or a reduction in numbers using the road to Coire Cas (e.g. only buses in the summer). If people were to be restricted, it might be enough to do so in the first place on days with high risk (e.g. when there are thaws and after heavy rain). Classes I and D for landslips, and Classes II and D for the headwall as a whole.

c. (997037, 61; and 006045, 62). Slopes west of Fiacaill a' Choire Chais and north of Cairn Gorm

Slope 61 is the hillside west of the steep upper part of Fiacaill a' Choire Chais, west of the plateau edge to the south of the cairn at the top of Fiacaill a' Choire Chais, and south as far as the most northerly crags in Coire an t-Sneachda. Slope 62 is the entire upper north hillside of Cairn Gorm from the direct path east to the steep slope running south-west from Ciste Mhearad to the tor east of Cairn Gorm summit, and north to the top of the Ptarmigan Bowl.

Both slopes showed increasingly widespread diffused damaged ground in the mid and late 1970s, reaching a peak in autumn 1981. The problems were the same as on slopes 59 and 60, involving loose grit and stones moving on to vegetation, vegetation damage and reduction, and rapid runoff and soil erosion in heavy rain and major thaws. However, the effects were less severe than on slopes 59 and 60; far fewer people went on slope 61 than on 59 and 60. Although many more went on slope 62 than on any of the others, it had a lower gradient than all three others, and so foot slipping per walker was more infrequent. Moreover, slope 62 had a better cover of vegetation than the others, associated with its lesser exposure to prevailing winds and its irrigation from snowfields of moderately long duration but not too long duration.

The main cause of the widespread diffuse damaged ground was clearly the impact of walkers at all seasons, though most damage per walker occurred during thaws when the ground was soft and saturated. Bootprints in loose grit were frequent signs.

In 1981 these two slopes appeared to be heading for severe problems like those already clearly evident by then on slopes 59 and 60. It is likely that this would have occurred if visitor numbers on the upper parts of Cairn Gorm and the plateau had not dropped. However, the evidence indicates that both slopes have improved since 1981, with better ground stability (Watson 1988a). This was associated with fewer bootprints in loose grit, and fewer plants torn or uprooted or buried beside a bootprint.

A useful index is the use of ground by hill birds. Although other factors affect the abundance of hill birds, changes in their relative use of damaged and undamaged ground may well be a sensitive indicator. Watson (1988a) found that the number of quadrats with animal faeces suggested more use of damaged ground by ptarmigan, dotterel and mountain hares in 1988 than in 1981, relative to undamaged "control" transects.

A group of ptarmigan was found in 1988 on one transect on damaged ground on slope 59 west of Cairn Gorm. None was seen there during many searches

in 1981, and none on slopes 60, 61 and 62 in 1981, yet they were common on undamaged ground nearby in 1981. Each year in 1988-93 I often saw ptarmigan on slopes 60-62, occasionally in large numbers, as they used to be before the developments. In spring-summer 1981, no ptarmigan territories were on slopes 59-61, although ptarmigan numbers generally were high in that year. In 1984, a pair had a territory in the middle of slope 62 and this has applied in several years since. In August 1985 a covey was spending much time on formerly severely damaged ground on slope 59, and in August 1988 a small flock was there, close to the direct path.

Recommendation:- keep an annual check on these slopes, in case conditions deteriorate and require action. Meanwhile leave to nature to recover.

Overall ratings for damaged ground on both slopes 61 and 62 are Classes IV and D.

11.8 Ground in material use: reindeer hut

a. (983071, 63). Reindeer hut

This hut was placed in an unsuitable site on a heather-deer sedge community over fairly thick peat, a ground type very vulnerable to trampling and very slow to recover. Heavy trampling by reindeer and to a lesser extent by people has led to two large patches of bare peat with conspicuous pale boulders projecting, one below the hut and one above. Up to 45cm thickness of peat has disappeared by erosion. However, these patches have been less used in recent years, possibly because of diversion to boardwalks, and vegetation is colonising the bare peat, so the ground is recovering and is reasonably stable. Recommendation:- leave to nature to recover. Recovery could be speeded up by reseeding and fertilising the bare patches. Classes V and C.

12 FUTURE ACTION PLANS

12.1 General

One of the remits for this Study was that the baseline information produced should form a basis for annual Action Plans for reinstatement works on paths and other damaged ground on the Estate, including the ski area. Future monitoring and other inspections could then check the efficacy of the reinstatement. The Action Plan would be brought up to date each year and reviewed annually. The annual Action Plan would change in the light of fresh damage or other problems highlighted by subsequent annual monitoring and recovery. Hence some new problems might appear, and old problems that had been solved satisfactorily could drop out. The Action Plan would therefore be a rolling, flexible one, entailing a realistic commitment for each year and avoiding unnecessary monitoring. Nevertheless, it would be advisable for monitoring of some features to continue for some years, irrespective of changes in the Action Plan, in order to give continuity.

12.2 Preventing and reducing damage

An important aspect of future Action Plans is not simply reinstatement of existing damage, but prevention and reduction of damage caused by future proposed installations. The following sub-sections are partly adapted from material in the Glenshee Environmental Baseline Study, and Appendix 8 below gives further information.

12.2.1 Reducing damage from possible future installations

1. Fly in all pylons, concrete for pylon foundations, snow fencing, and other large items by helicopter.
2. Do not use piste machines for transporting materials outside the skiing season.
3. Save all removed turves, topsoil, and top layers of subsoil separately, and store them carefully, following the specifications for the Glas Maol Tow and adding the more detailed ones in Watson & Walker (1987); both sets are in Appendix 8. Replace removed turves and soil according to these specifications. When new developments are carried out, this is the best action to safeguard ground stability, improve amenity after damage, and reduce costs of reseeding and other maintenance in the long term.
4. Treat stones from excavations according to the specifications for the Glas Maol Tow. If spare stones and gravel are left from foundation pits and a vehicle track is near, remove them down to the car park.
5. Reduce damage from skiers and pisters at points of heavy pressure by extra snow fencing, or taller fencing, or by moving fencing so that the gap is on harder ground.
6. When excavating a bank, do not leave overhanging turves at the top, and do not leave a bank steeper than 35 degrees, as the bank in later years will be unstable.
7. Do not straighten or steepen or deepen water courses, as this leads to damage to stream banks from flooding.
8. Ensure that all drains lead into safe water courses before digging them. This applies also to places where drains debouch on to the hill below roads and car parks.
9. Reduce water speed on tracks and drains by removing water at sufficiently frequent intervals in cross drains, and by adding stones to

break water flow. A useful practice in some cases is to add sharp-angled chips or other sharp material which is more freely draining and interlocks under pressure, thus being less likely to move with surface runoff.

10. On the most severely trampled areas of wet bared peat, reduce surface water and so increase vegetation growth by digging small drains through the peat with a spade.

11. No pister use on snow-free patches.

12. Avoid short-cuts with machines on snow-free vegetation, in places where a hard track nearby offers an alternative, albeit longer, route.

13. In places where round pebbles are common, do not leave these on gravelly banks even at low angles, as they roll down on top of vegetation.

14. If some subsoil is left after installations have been put in (e.g. on mounds beside pylon foundations), cover it thinly with peat to increase moisture content and vegetation growth.

15. Avoid damp hollows for gaps between snow fences; damp spots are more likely to suffer damage from trampling and machines.

16. For future excavations involving banks of roads and car parks, save and re-use all turf, topsoil and upper subsoil as noted above. If any bared gravel is left at the end, cover thinly with peat. Do not reseed except on such bared patches. Reseeding all over gravel banks leads to bright green grass that looks incongruous and out of place in the hill landscape for years. Moreover it attracts deer, sheep, hares and other animals, and thus causes traffic hazards because of the likelihood of more vehicles colliding with or avoiding these animals.

In the above sub-section, peat is mentioned as a useful material to spread thinly on disturbed gravelly subsoil, as a means of increasing the soil's water and organic content, and so improving the likelihood of successful reseeding and colonisation by hill plants. The point is also stressed in Appendix 8, on Detailed specifications for reducing damage. A major problem is that there is no easily accessible source of thick peat at Cairn Gorm. However, there is a thin deposit on a wet area west of the restaurant at Coire na Ciste, close by the car park. At present this area is largely bare of vegetation as it is so wet, and this was so before the developments took place. It would be a useful source of peat for careful stockpiling at Coire Cas for selective use on some sites where the exposed bared subsoil is very gritty. The peat could be excavated carefully, following instructions in Appendix 8, and a thin layer could then be spread by spade on the underlying mineral soil. The area could then be reseeded and fertilised, and fertilised in subsequent years. This should provide a better vegetative cover than at present, and improve the area's appearance. There are also useful peat deposits within Glenmore Forest, which would be worth investigating with Forest Enterprise.

12.2.2 Snow lie

The provision of a complete and deep snow cover in key places is of great importance for preventing and reducing direct impacts of skiers and machines on underlying vegetation and soil. It also leads to a more grassy type of vegetation which is more resistant than heather to impacts of skiers and machines, and requires less snow before it is skiable. There is one qualification to this. Compaction of snow by skiers and machines can lead to deeper frost penetration of the underlying soil. If so, runoff in saturated surface soils is less likely to drain downwards, and this can lead to faster runoff and soil erosion, as documented in Russia (Baiderin 1978, 1980). Erosion because water is unable to drain downwards through

frozen soil is common in the Arctic without any human impact, and occurs occasionally in the Cairngorms on areas with and without human impact. Erosion thought to have occurred as a result of snow compaction was observed by the writer on Cairngorm ski area in the late 1960s and on a vehicle track at Glenshee in later years.

Some research relevant to this was done by Mr Robert O'Brien when a post-graduate student at the Department of Geography, University of Dundee, in the late 1960s and early 1970s. In his study of freeze-thaw cycles and soil movements on Cairn Gorm, he stated that "Displaced soil often forms palmate spreads of coarse sand and gravel on vegetation mats and snowbeds. The effects of this type of small-scale mass transfer are most marked in areas of human disturbance" (NCC Production 89, Lurcher's Gully Public Inquiry). However, erosion events due to impermeable frozen ground have been too infrequent in Scotland to distinguish reliably between those associated with human-induced snow compaction and those associated entirely with natural processes. Erosion thought to have occurred from this cause was very localised on the ski area, and at most covered a patch of several square metres. It is unimportant on Scottish ski areas compared with the actual and potential amounts of damage due to machines and skiers directly damaging vegetation and soils. Hence, snow cover as a protective benefit far outweighs any costs.

Appendix 10 gives a rationale for assessing snow lie by inspecting the hill rather than measuring snow lie. It is based on Watson (1988, 11.8; and 1990a, Appendix 2). I should admit that I once wrote (Watson 1983) that collection of data on snow lie would be useful at Scottish ski areas, as in the Swiss Alps. However, I later realised that this was a flawed comparison; the main reasoning is given in Appendix 10. Also, greater experience from a long-term survey of snow patches over a large part of Scotland including the Cairngorms and the Mounth, along with detailed inspections of snow-patch vegetation and a more rigorous consideration of the issues, led to the change in statements in Watson (1988, 1990a).

It is now clear that the best assessment of potential snow lie comes mainly from a detailed inspection of plant communities along with observations of drifting snow in relation to topography. It is also useful to consider snow lie caused by changing the location and number of snow fences, especially in relation to winters of varying snowfall and storm frequency. Measurements of snow lie and snow structure at a small number of fixed points at snow ribbons on Scottish ski areas, though of possible academic interest, are of no practical value to ski operators, and indeed are likely to be misleading. It was for this reason that I advised the HIDB and Cairngorm Chairlift Company in 1989 that there was no value to such fixed-point measurements being commissioned on Cairngorm ski area. A snow-monitoring scheme was terminated at the end of the 1989-90 season.

12.2.3 Ending the promotion of walkers' routes

Promotion of a route above timber line, such as the former Ptarmigan Trail, leads to more impacts on land that can hardly withstand existing pressures let alone extra ones. Signs indicating "Ptarmigan Trail" were removed in 1993, and the booklet that mentioned this Trail is out of print. Recommendation:- any reprint of the booklet should avoid mention of this Trail. Any proposed new Trails on the Estate should be publicised only after thorough consultation and agreement with the appropriate bodies.

13 ACKNOWLEDGEMENTS

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Mr Tom Paul, former Manager of Cairngorm Chairlift Company, was completely frank in answering my numerous questions about past operations. I knew that withholding some information might have put some past actions in a better light. Because of this, I appreciate his cooperation and honesty. This led to a more comprehensive report, with better understanding of issues. My intention, as at Glenshee, was not to criticise past actions by the Company and others, but to learn lessons of use now and in future. I thank Mr Tim Whittome, former Deputy Manager and now Manager, for being so willing to accept suggestions, and for cooperation on many visits. Mrs Muriel Mackay cheerfully and efficiently ran the office. Other Company staff were invariably cooperative.

I thank Mr Neil Baxter, Chief Ranger on the Estate for HIDB/HIE and the Company, for many useful discussions on and off the hill. He, Mr Tom Fraser of the Company, and Ranger Alison Robb did the work on monitoring at fixed sites; this required care and dedication in difficult conditions.

I had good discussions about soils with Mr Alexander D. Walker, formerly in charge of the Grantown office, Macaulay Institute for Soil Research. Dr Gordon R. Miller contributed much in field discussions to find a method for producing accurate data on bare ground. Dr Neil G. Bayfield, my colleague on the early team research on human impact at ski areas, kindly allowed me to summarise recent unpublished measurements by him on Cairn Gorm. For useful discussion I thank Dr Desmond B.A. Thompson of Scottish Natural Heritage, Mr Keith Wilson of Pathcraft Ltd, and Dr Robert Aitken who also permitted me to copy those parts of his unpublished reports on the Footpath Management Project (1985,1988) that deal with the Estate.

Mr David Patterson, Manager of Glenshee Chairlift Company, allowed me to quote from reports (Watson 1988, 1990a) which his Company commissioned. I had many good discussions on the hill with him, Mr James McIntosh (Manager of the Lecht Ski Company), Mr Bruce Forbes (former Manager at White Corries) and Mr Robert M. Clyde at Cairngorm ski area back to 1966.

Mr Robert O'Brien allowed me to quote from his unpublished work on soil movements and freeze-thaw cycles on Cairn Gorm. The editor of "Biological Conservation" permitted me to copy Watson (1985) for Appendix 1.

14 REFERENCES

AITKEN, R. (1985). Scottish Mountain Footpaths. CCS, Perth.

AITKEN, R. (1985a). CCS Footpath Management Project, Second Interim Report. Edinburgh.

AITKEN, R. (1988). CCS Footpath Management Project, Fourth Interim Report. Edinburgh.

ANDERSON SEMENS HOUSTON (1981). Environmental Impact Analysis. ASH Environmental Design Partnership, Glasgow.

ASH ENVIRONMENTAL DESIGN PARTNERSHIP (1986). Environmental Design and Management of Ski Areas in Scotland. A Practical Handbook. Report to Countryside Commission for Scotland and Highland Regional Council. Glasgow.

ASH ENVIRONMENTAL DESIGN PARTNERSHIP (1986a). Proposed Ski Development. The Snowgoose. Aonach Mor Development Plan. Glasgow.

BAIDERIN, V.V. (1978). Effect of winter recreation on the soil and vegetation on the slopes in the vicinity of Kazan. Soviet Journal of Ecology 9, 76-80.

BAIDERIN, V.V. (1980). Experimental modelling of ecological consequences of winter recreation. Soviet Journal of Ecology 12, 140-147.

BAIRD, P.D. & LEWIS, W.V. (1957). The Cairngorm floods, 1956. Scottish Geographical Magazine 73, 91-100.

BAUGH, I. (1979). The Condition of Some Footpaths in the Northern Cairngorms. Nature Conservancy Council, Edinburgh.

BAYFIELD, N.G. (1971). Some effects of walking and ski-ing on vegetation at Cairngorm. Symposia of the British Ecological Society 11, 469-485.

BAYFIELD, N.G. (1973). Use and deterioration of some Scottish hill paths. Journal of Applied Ecology 10, 635-644.

BAYFIELD, N.G. (1974). Burial of vegetation by erosion debris near chairlifts on Cairngorm. Biological Conservation 6, 246-251.

BAYFIELD, N.G. (1976). Effects of substrate type and microtopography on establishment of a mixture of bryophytes from vegetative fragments. Bryologist 79, 199-207.

BAYFIELD, N.G. (1979). Recovery of four montane heath communities at Cairngorm, Scotland, from disturbance by trampling. Biological Conservation 15, 165-179.

BAYFIELD, N.G. (1980). Replacement of vegetation on disturbed ground near ski lifts in the Cairngorm Mountains, Scotland. Journal of Biogeography 7, 249-260.

BAYFIELD, N.G. (1985). Effects of extended use on footpaths in mountain areas in Britain. In Bayfield & Barrow, pp. 100-111.

BAYFIELD, N.G. (1986). Penetration of the Cairngorms Mountains, Scotland, by vehicle tracks and footpaths: impacts and recovery. Proceedings of the National Wilderness Research Conference: Current Research (Ed. by R.C. Lucas), pp. 121-128. Forest Service General Technical Report INT-212, USDA.

BAYFIELD, N.G. (1990). Re-establishment of Mountain and Moorland Vegetation: Field Trials at Cairn Gorm and Ben Nevis, 1989. Institute of Terrestrial Ecology, Banchory.

BAYFIELD, N.G. & AITKEN, R. (1992). Managing the Impacts of Recreation on Vegetation and Soils: a Review of Techniques. Institute of Terrestrial Ecology, Banchory.

BAYFIELD, N.G. & BARROW, G.C. (1985). The Ecological Impacts of Outdoor Recreation on Mountain Areas in Europe and North America. Recreation Ecology Research Group, Ashford.

BAYFIELD, N.G., McGOWAN, G.M. & PATERSON, I.S. (1991). Progress Report: Trials of Revegetation Techniques at the Lecht, Aonach Mor, Cairn Gorm, and Ben Nevis. Institute of Terrestrial Ecology, Banchory.

BAYFIELD, N.G. McGOWAN, G.M. & PATERSON, I.S. (1992). Preliminary Report on Glen Gairn Road Verge Planting Trials. Institute of Terrestrial Ecology, Banchory.

BAYFIELD, N.G. & MILLER, G.R. (1986). Reinstatement Trials 1986. Report No. 2 to Yorkshire Dales National Park. Institute of Terrestrial Ecology, Banchory.

BAYFIELD, N.G. & MILLER, G.R. (1988). Restoration of Vegetation in the Scottish Uplands: a Review. Institute of Terrestrial Ecology, Banchory.

BAYFIELD, N.G., URQUHART, U.H. & COOPER, S.M. (1981). Susceptibility of four species of Cladonia to disturbance by trampling in the Cairngorm Mountains, Scotland. Journal of Applied Ecology 18, 303-310.

BAYFIELD, N.G., URQUHART, U. H. & ROTHERY, P. (1984). Colonization of bulldozed tracks in the Cairngorm Mountains, Scotland. Journal of Applied Ecology 23, 343-354.

BAYFIELD, N.G., WATSON, A. & MILLER, G.R. (1988). Assessing and managing the effects of recreational use on British hills. Ecological Change in the Uplands (Ed. by M.B. Usher & D.B.A. Thompson). British Ecological Society Special Publication 7, 399-414.

BAYFIELD, N.G., WATSON, A., MILLER, G.R., WALKER, A.D. & SMITH, I.R. (1988). Lurcher's Gully: Ecological Implications of Development for Skiing. Report to Highlands & Islands Development Board and the Nature Conservancy Council. Institute of Terrestrial Ecology, Banchory.

BROWN, R.W. & JOHNSTON, R.S. (1976). Revegetation of an alpine mine disturbance: Beartooth Plateau, Montana. Research Note INT-206, USDA Forest Service.

CAIRNGORM CHAIRLIFT COMPANY LIMITED (1986). Development Plan for the 1980's and 1990's. CCC, Aviemore.

CAIRNGORM CHAIRLIFT COMPANY LIMITED (1992). Cairngorm Chairlift Survey of Chairlift Use and Visitor Movements July-September 1991. CCC, Aviemore.

CAIRNGORM CHAIRLIFT COMPANY LIMITED (1993). Cairngorm Ski Area Development Plan May 1993. CCC, Aviemore.

CAIRNGORMS WORKING PARTY (1993). Common Sense and Sustainability. A Partnership for the Cairngorms. The Scottish Office, Edinburgh.

CLUB ALPIN FRANCAIS (1981). La catastrophe ecologique des Arcs. Bulletin d'Information et de Liaison de la Commission Nationale de Protection de la Montagne. 12.

CLYDE, R.M. (1981). Some Criteria for the Development of Downhill Ski-ing Areas in Scotland. Evidence lodged with Scottish Development Department for Lurcher's Gully Public Inquiry, Kingussie.

CONROY, J.W.H., WATSON, A. & GUNSON, A.R. (Eds 1990). Caring for the High Mountains. Proceedings of the Conference on Conservation of the Cairngorms. Centre for Scottish Studies, Aberdeen, & Natural Environment Research Council.

COPPIN, N.J. & RICHARDS, I.G. (1990). Use of Vegetation in Civil Engineering. London.

COUNTRYSIDE COMMISSION FOR SCOTLAND (1971). The Speyside Project. Interim Report 1070/71. CCS, Perth.

COUNTRYSIDE COMMISSION FOR SCOTLAND (1978). Scotland's Scenic Heritage. CCS, Perth.

COUNTRYSIDE COMMISSION FOR SCOTLAND (1980). Re-establishment of Vegetation in the Uplands. Information Sheet Plants, 5, 6. CCS, Perth.

COUNTRYSIDE COMMISSION FOR SCOTLAND (1989). Skiing at Cairngorm. A Policy Paper. CCS, Perth.

CRAMOND, R.D. (1990). Cairngorm - conservation and development: living together. In Conroy, Watson & Gunson, pp. 15-29.

DARGAN, E. (1988). Hills under Siege. BSc thesis, University of Birmingham.

DUNLOP, B. (1981). Evidence lodged with Scottish Development Department for Lurcher's Gully Public Inquiry, Kingussie.

ELLIOTT, C.L., McKENDRICK, J.D. & HELM, D. (1987). Plant biomass, cover, and survival of species used for stripmine reclamation in South-central Alaska, USA. Arctic and Alpine Research 19, 572-577.

FAIRMAN, S.J. (1979). Access-related Patterns of Mountain Recreation. A Study in the Cairngorms. BA thesis, University of Manchester.

GILMORE, D. (1975). Recreation - its Impact and Management in the Northern Cairngorms. MSc thesis, University College, London.

GLENSHEE CHAIRLIFT COMPANY (1987). Development and Management Plan for Glenshee Ski Centre 1987-1991. GCC, Cairnwell, Braemar.

GUNNLAUGSDOTTIR, E. (1985). Composition and dynamical status of heathland communities in Iceland in relation to recovery measures. Acta Phytogeographica Suecica 75, Uppsala.

HIGHLANDS & ISLANDS DEVELOPMENT BOARD (1987). Cairngorm Estate Management Plan. HIDB, Inverness.

HOUSE OF COMMONS SCOTTISH AFFAIRS COMMITTEE (1985). Session 1984-85. Highlands and Islands Development Board. Vol. 1. Report and Proceedings of the Committee. HMSO, Edinburgh.

HUDSON, I.C. (1978). Flash flood on Cairngorm, 4 August 1978. Journal of Meteorology 3, 241-242.

KINCARDINE & DEESIDE DISTRICT COUNCIL (1991). Draft Local Plan. KDDC, Stonehaven.

KING, R.B. (1971). Vegetation destruction in the sub-alpine and alpine zones of the Cairngorm Mountains. Scottish Geographical Magazine 87, 103-115.

LANCE, A.N., BAUGH, I.D. & LOVE, J.A. (1989). Continued footpath widening in the Cairngorm Mountains, Scotland. Biological Conservation 49, 201-214.

LANCE, A., THAXTON, R. & WATSON, A. (1991). Recent changes in footpath width in the Cairngorms. Scottish Geographical Magazine 107, 106-109.

LAND USE CONSULTANTS (1972). Cairngorm Estate Survey. LUC, London.

McEWEN, L.J. (1981). An Assessment of the Geomorphic Impact and Significance of the Flash Flood occurring on 4th August 1978 on the Allt Mor, Glenmore, Inverness-shire. MA thesis, Department of Geography, University of St Andrews.

McGOWAN, G.M. & BAYFIELD, N.G. (1993). Monitoring of Upland Revegetation Trials 1992. Institute of Terrestrial Ecology, Banchory.

McGOWAN, G.M., BAYFIELD, N.G. & PATERSON, I.S. (1991). Restoring Native Plant Cover by Seeding and Live Mulching: Progress of Trials on Peat and Mineral Soils to 1990. Institute of Terrestrial Ecology, Banchory.

McGOWAN, G.M., PATERSON, I.S. & BAYFIELD, N.G. (1991). Aonach Mor: Environmental Appraisal of Proposed Tow K. Institute of Terrestrial Ecology, Banchory.

McVEAN, D.N. & LOCKIE, J.D. (1969). Ecology and Land Use in Upland Scotland. Edinburgh.

MILLER, G.R. (1985). Ecological Implications in the Management of Cairngorm Estate. Institute of Terrestrial Ecology, Banchory.

MILLER, G.R. (1986). Ecological Impact of Downhill Skiing Developments in North East Scotland. Institute of Terrestrial Ecology, Banchory.

MILLER, G.R. (1986a). Development of Subalpine Scrub at Northern Corries, Cairngorms SSSI. Institute of Terrestrial Ecology, Banchory.

MORRIS, D., HAMMOND, E.C. & KESSLER, C.D.J. (1974). Cairngorms National Nature Reserve. A Report on the Characteristics of Visitor Use. Nature Conservancy Council, Aviemore.

NETHERSOLE-THOMPSON, D. & WATSON, A. (1981). The Cairngorms. Melven Press, Perth.

PAUL, T.J. (1986). Grass reseeding above 500m. on Cairngorm. Appendix 4 in Cairngorm Chairlift Company (1986).

PITKIN, P.H. (1979). Some Possible Effects of Further Development of the Skiing Facilities on the Vegetation of the Cairngorms. Nature Conservancy Council, Edinburgh.

PRYOR, P.J. (1985). The effects of disturbance on open Juncus trifidus heath in the Cairngorm Mountains, Scotland. In Bayfield & Barrow, pp. 53-62.

REDGATE, R.M. & PORTER, D.F. (1982). Reclamation research in a Canadian alpine setting. A Quarterly Bulletin on Health, Safety and the Environment 8, 3, 18-19. BP, London.

SCHIECHTL, H.M. (1980). Bioengineering for Land Reclamation and Conservation. Edmonton.

SCOTTISH AFFAIRS COMMITTEE (1985). Second Report Session 1984-85. Highlands and Islands Development Board. HMSO, London.

SCOTTISH DEVELOPMENT DEPARTMENT (1982). Findings of the Lurcher's Gully Public Inquiry, Kingussie. SDD, Edinburgh.

SIMONS, P. (1988). Apres ski le deluge. New Scientist 117, 49-52.

STANKEY, G.H., COLE, D.N., LUCAS, R.C., PETERSON, M.E. & FRISSELL, S.S. (1985). The Limits of Acceptable Change (LAC) of Wilderness Planning. Forest Service Technical Report, INT-176, USDA.

STEWART, D. (1986). Roads in Hills and Mountains. North East Mountain Trust, Aberdeen.

THOMPSON, D.B.A., GALBRAITH, H. & HORSFIELD, D. (1987). Ecology and resources of Britain's mountain plateaux: land use conflicts and impacts. Agriculture and Conservation in the Uplands (Ed. by M. Bell & R.G.H. Bunce), pp. 22-31. Institute of Terrestrial Ecology, Grange-over-Sands.

WATSON, A. (1967). Public pressures on soils, plants and animals near ski lifts in the Cairngorms. The Biotic Effects of Public Pressures on the Environment (Ed. by E. Duffey), pp. 38-45. Natural Environment Research Council, London.

WATSON, A. (1970). Book review of "Ecology and Land Use in Upland Scotland" by McVean & Lockie. Journal of Animal Ecology 39, 785-787.

WATSON, A. (1976). Human impact on animal populations in the Cairngorms. Landscape Research News 1, 12, 14-15.

WATSON, A. (1979). Bird and mammal numbers in relation to human impact at ski lifts on Scottish hills. Journal of Applied Ecology 16, 753-764.

WATSON, A. (1981). Detailed Analysis. Evidence lodged with Scottish Development Department for Lurcher's Gully Public Inquiry, Kingussie.

WATSON, A. (1982). Effects of human impact on ptarmigan and red grouse near ski lifts in Scotland. Annual Report of the Institute of Terrestrial Ecology, 51. Cambridge.

WATSON, A. (1983). Scottish ski developments. Environmental damage and lessons for the future. Aberdeen Ski Club Journal 1983-84, 25-26.

WATSON, A. (1984). Paths and people in the Cairngorms. Scottish Geographical Magazine 100, 151-160.

WATSON, A. (1985). Soil erosion and vegetation damage near ski lifts at Cairn Gorm, Scotland. Biological Conservation 33, 363-381.

WATSON, A. (1985a). Monitoring at the Lecht 1985. Report to Lecht Ski Company. Institute of Terrestrial Ecology, Banchory.

WATSON, A. (1988). Environmental Baseline Study for Glenshee Ski Centre 1987. Institute of Terrestrial Ecology, Banchory.

WATSON, A. (1988a). Dotterel Charadrius morinellus numbers in relation to human impact in Scotland. Biological Conservation 43, 245-256.

WATSON, A. (1989). Ground Disturbance, Soil Erosion and Vegetation Damage at Cairn Gorm in 1988 compared with 1981. Institute of Terrestrial Ecology, Banchory.

WATSON, A. (1990). Human impact on the Cairngorms environment above timber line. In Conroy, Watson & Gunson, pp. 61-82.

WATSON, A. (1990a). Environmental Aspects of the Environmental Impact Assessment for Glenshee Ski Centre 1990. Institute of Terrestrial Ecology, Banchory.

WATSON, A. (1991). Increase of people on Cairn Gorm plateau following easier access. Scottish Geographical Magazine 107, 99-105.

WATSON, A. (1992). Early-summer Inspection at Glenshee Ski Area, 1992. Report to Glenshee Chairlift Company.

WATSON, A. (1992a). The Cairngorms. Scottish Mountaineering Club District Guide.

WATSON, A. (1993). The Cairngorms. Scottish Mountaineering Club District Guide.

WATSON, A. & BAYFIELD, N.G. (1988). Ground Reinstatement on the Glen Ey Road. Institute of Terrestrial Ecology, Banchory.

WATSON, A., BAYFIELD, N.G. & MOYES, S.M. (1970). Research on human pressures on Scottish mountain tundra, soils and animals. Productivity and Conservation in Northern Circumpolar Lands (Ed. by W.A. Fuller & P.G. Kevan), pp. 256-266. International Union for Conservation of Nature and Natural Resources, Morges.

WATSON, A. & RAE, S. (1992). Glenshee Monitoring Autumn 1992. Report to Glenshee Chairlift Company.

WATSON, A. & SMITH, R. (1991). Lecht Monitoring Autumn 1991. Report to Lecht Ski Company.

WATSON, A. & WALKER, A.D. (1987). Environmental Report on Possible Alterations at the Hump in Coire Cas. Report to Cairngorm Chairlift Company. Institute of Terrestrial Ecology, Banchory.

WATSON, R.D. (1993). The History and Development of the Glenmore National Forest Park. Save the Cairngorms Campaign, Inverness.

WHITTOME, T. (1991). Cairngorm Chairlift Survey July-September 1991. CCC, Cairngorm, Aviemore.

WISHART, C.W. (1975). The Impact of High Level Access on the Central Cairngorms Plateau. MA thesis, University of Aberdeen.

WOOD, T.F. (1987). Methods for assessing relative risk of damage to soils and vegetation arising from winter sports development in the Scottish Highlands. Journal of Environmental Management 25, 253-270.

WOOD, T.F. (1987a). The analysis of environmental impacts resulting from summer recreation in the Cairngorm ski area, Scotland. Journal of Environmental Management 25, 271-284.

YOUNKEN, W.E. & MARTENS, H.E. (1987). Long-term success of seeded species and their influence on native species invasion at abandoned rig site A-01, Caribou Hills, N.W.T., Canada. Arctic and Alpine Research 19, 566-571.

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Soil Erosion and Vegetation Damage near Ski Lifts at Cairn Gorm, Scotland

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ABSTRACT

Damage to soils and plants is well known at ski grounds, but a survey at Cairn Gorm during 1981 showed severe damage also extending on to the adjacent plateau well inside the Cairngorms National Nature Reserve. It was distinguished from natural damage by diagnostic features associated with human footprints. Areas visited by many people showed more plant damage and soil erosion than areas seldom visited. Disturbed land covered 403 ha, 17% of it in the Reserve. Disturbed land had a higher proportion of grit lying on vegetation than undisturbed land, a lower proportion of ground covered by vegetation, a higher proportion of damaged vegetation, and a higher frequency of plant burial, rill erosion, and dislodged stones and soil. Disturbed land had less bilberry, least willow, ground lichens and mosses, and other species besides grasses, sedges and rushes. On slopes of 15–29°, foot-slipping increased with slope gradient on disturbed but not on undisturbed land. Disturbed soil had less water, fine particles and organic matter.

INTRODUCTION

It is well known in a number of countries that human impact has damaged soils and plants on ski grounds, such as at Cairn Gorm in Scotland, but the less obvious damage on the nearby Cairn Gorm plateau and corries has not been documented. This paper gives results from a survey there, which revealed serious land degradation on a fragile arctic–alpine area of outstanding conservation value, much of it inside the Cairngorms National Nature Reserve.

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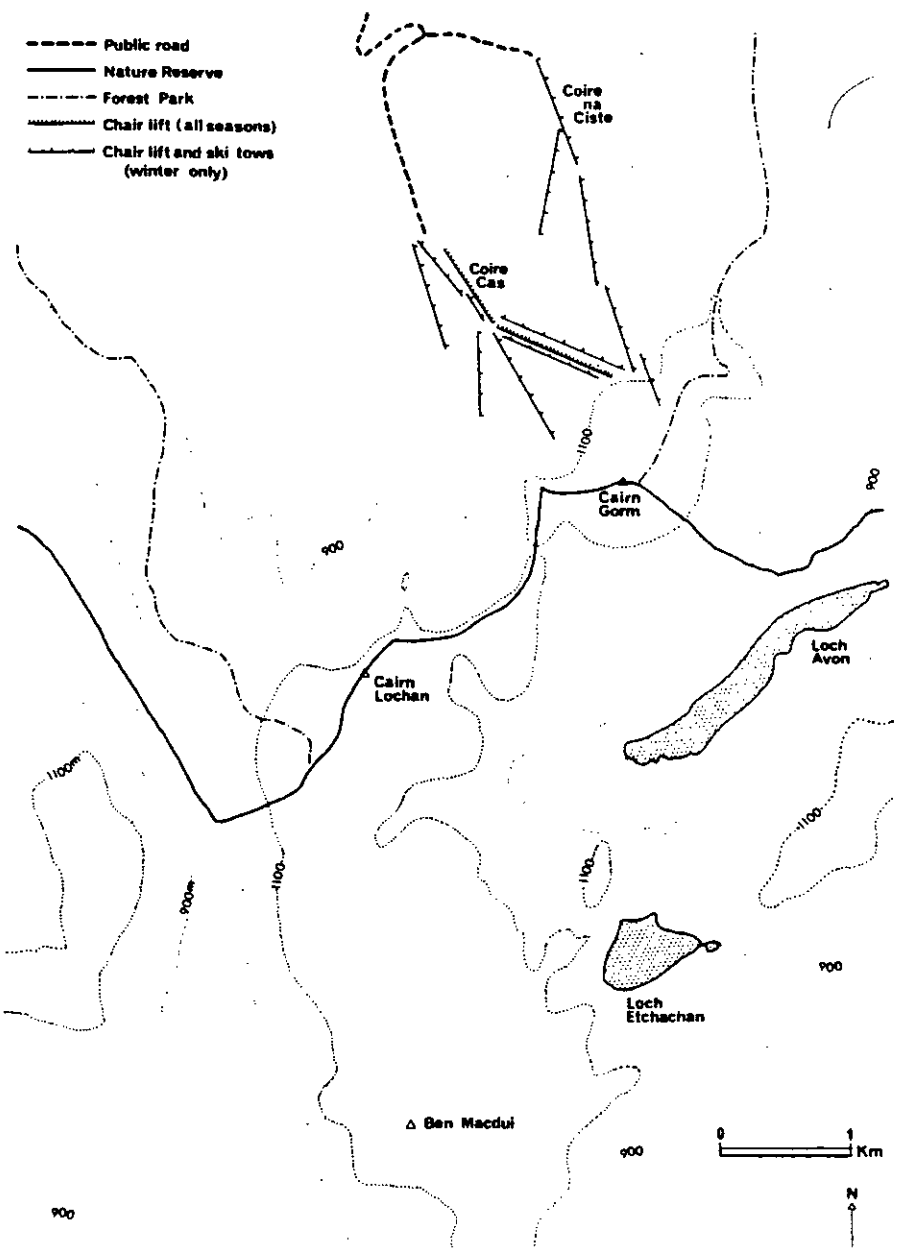

Fig. 1. Map of study area. The Cairngorms National Nature Reserve is south of the continuous line. The lines for the Forest Park mark the east and west boundaries of Glen More Forest Park; its south boundary adjoins the Reserve boundary.

After roads and ski lifts were built in 1960–61, many visitors came at all seasons, and plant damage and soil erosion occurred on the ski grounds (Watson, 1967; Watson *et al.* 1970; Bayfield, 1971, 1974). Bayfield (1979) studied recovery of natural vegetation and (1980) rehabilitation by grass reseeding.

On the nearby plateau and corries, the number and width of paths increased (Watson, 1967; Gilmore, 1975; Baugh, 1979). Trampling breaks pieces off lichens in the ground vegetation, and such lichens showed more damage within 50 m of heavily used paths (including three paths on and near Cairn Gorm) than beside little used ones (Bayfield *et al.*, 1981). However, damage to *Cladonia uncialis*, the most fragile species, amounted to only 4% at 50 m from heavily used paths, and only a tiny proportion of the total area lies within 50 m of paths.

Nevertheless Bayfield *et al.* (1981) suggested that there is probably 'widespread light damage' on heavily visited open ground such as the plateau, where people often walk off paths. In a report for proposed ski developments, Anderson Semens Houston (1981) speculated the opposite, that damage on the plateau is 'apparently confined to footpaths', and on the large areas without paths presumably 'there will be little damage to lichens but there is no data available to confirm this'. The need for a survey of damage was clear. The survey in this paper was intended to describe and measure the variety, extent, and intensity of damage in 1981, when a Public Inquiry considered proposals for new ski facilities west of the present ski grounds. The field work was done in July–August.

Names of plants follow Clapham, Tutin & Warburg (1962).

STUDY AREA

Figure 1 shows the area, which lies over granite. Nethersole-Thompson & Watson (1981) described soils, climate, plants, and conservation in the Cairngorms massif.

DESCRIPTION OF FEATURES DIFFERENTIATING DISTURBED FROM UNDISTURBED GROUND

There has been difficulty in distinguishing human from natural damage, because erosion and vegetation damage 'occur naturally at these altitudes due to severe rain, wind, solifluction and other conditions' (Watson,

1967). To distinguish the two forms of damage in the present study, people were watched near the chair lift to see human damage taking place at < 5 m range, and natural damage was found by going to places devoid of people and human footprints, at similar altitudes on ground most exposed to gales.

Every feature of proven, direct, human-induced vegetation damage and soil erosion also occurred on undisturbed ground with few or no people, except for (a) wide paths, (b) crushing, tearing and poaching marks on and beside human footprints, and (c) the sole vegetation on the most heavily visited areas being moss on the undersides of boulders. Most natural damage occurred at high altitudes and on cols on exposed slopes facing the prevailing wind during the previous winter (prevailing wind as determined from personal experience of winds on the area and observations on snow drifts there). Most human damage was on heavily used routes where numerous people were seen, and many of these routes were on sheltered lower ground. In any case, human-induced disturbed ground usually showed much more frequent and severe damage.

On undisturbed ground, torn plant matter had come mainly from that side of the vegetation clump next to the prevailing wind. Similarly, wind-blown grit lay mostly in a 1 m band on the clump's windward side, and up to 5 m to the lee of a big patch of grit. Occasionally, plants were seen being torn out and grit blown; on each occasion, plant damage and grit deposition varied with exposure and wind direction. When grit blew on to icy snow, it moved easily on it up to 100 m.

After thaws, such grit lay on underlying vegetation much more sparsely than grit moved by wind or by man-induced erosion on to snow-free vegetation. Only about 2% of the undisturbed part of the study area was affected by such sparse grit, and only on very exposed ground.

During gales on disturbed ground, fine, dark particles were often seen being blown, as well as grit. Nearby snow patches turned dirty grey after gales, whereas snow beside undisturbed ground remained relatively white. Such fine, dark particles are typical of the removal of organic matter by wind, generally leading to long-term loss of fertility (Wilson & Cooke, 1980).

On small terraces on undisturbed ground, wind-blown grit moved from the flat terrace to pile up on vegetation below the step. During heavy rain, run-off water was watched cutting small rills at right angles through terraces, but such breakdown of most terraces on a hillside occurred only on man-induced disturbed ground.

On steep slopes severely disturbed by direct trampling, part of the surface of many boulders and cobbles was pale and lacking in crustose lichens, having previously been below ground. The vertical depth of the pale part indicated the depth of soil removed. Another difference was that dry granite grit lying on undisturbed areas looked pale pink, whereas dry, freshly exposed grit from underneath was a darker pink. Deeper grit exposed by recent erosion could often be detected by its darker colour, even at 1 km through binoculars, and then checked at < 1 m range. Undisturbed ground on Cairn Gorm had some small patches of naturally dark pink or red grit, but only in a few spots on the study area.

Except in gullies, buried vegetation and topsoil lay underneath continuous loose stones and grit, often so deep that the plants had died and the value of the topsoil for vegetation recolonisation had been lost.

Some large areas, where few or no people and few footprints were seen, were disturbed indirectly because of trampling higher up. These indirect effects involved loosened grit and stones moving downhill to bury plants, and rill and gully erosion. Small patches of undamaged vegetation and soil within these areas occurred where boulders protected them by stopping grit and stones moving down from above. Damaged patches could invariably be followed uphill until one reached the origin on heavily trampled paths and other ground, up to 400 m distance away and up to 210 m in vertical altitude above.

METHODS OF ASSESSING DISTURBED AND UNDISTURBED GROUND

A scheme for scoring erosion is in Table 1. Erosion was assessed by examining the ground through binoculars or at close range. It was plotted

TABLE 1
Scoring Lateral and Linear Soil Erosion

Score	*Lateral*	*Linear*
0	No erosion noticed	No erosion noticed
1	Much grit lying on vegetation	Rills up to 10 cm deep
2	Extra bare ground or buried vegetation	Rills 10 cm - 1 m deep
3	Most of ground as in 2 above	Gullies 1 10 m deep
4	All of ground as in 2 above	Gullies > 10 m deep

on a 1:10 000 map by drawing boundaries round areas scored 1, 2, 3 and 4. The small, scattered patches of natural erosion were omitted, so the plotting produced a map of human-induced eroded ground, or disturbed ground. Disturbed ground also showed various other characteristic features described in the above section and measured on transects (see below), but in particular it showed many human footprints either close beside damaged soils and plants, or on steep slopes above them.

As much of this mapping was done at a distance, it was obviously subjective to some extent. A more objective measure was subsequently made by going to 25 points chosen randomly within each 1 km square of

TABLE 2

Mean Scores ($n = 25$) for Lateral and Linear Soil Erosion in July 1981 on km Squares of the Ordnance Survey Grid, Maximum Depth of Active Rills and Gullies, and Number of People Recorded from Interviews by Morris *et al.* (1974) on Eight Days in July 1973

km square	*Lateral*	*Linear*	*Depth (m)*	*People*
0004	2·0	1·1[b]	0·7	530
9904	2·0	0·2	0·2	381
9905	1·8	0·0[b]	0·2	473
9902	1·4	0·0	0·9	392
9903	1·4	0·7	1·0	362
9701[a]	1·3	0·0	0·0	*
0005	1·1	0·0	0·2	7
9702[a]	1·1	0·2	0·1	*
9802	1·0	0·4	1·0	290
9801	0·8	0·0	0·1	284
0003	0·7	0·5	0·2	367
9999	0·6	0·2	0·2	100
0006	0·6	0·0	0·2	3
9899	0·6	0·3	0·1	227
0002[a]	0·5	0·0	0·0	*
9800	0·5	0·2	0·5	247
9900	0·2	0·3	0·2	45
9901[a]	0·2	0·0	0·0	*

[a] < 25 points as these squares included ground outside my study area.
[b] Excluding gravel road, which had many rills.
* Included low ground outside my study area.

Fig. 2. Transect locations (numbers) and ground disturbed by man-induced soil erosion (solid). Areas with different scores could be plotted clearly at 1:10 000 scale but not when reduced as here. Paths are omitted, as well as patches of undisturbed ground in disturbed areas unless the patch covered an area of > 1 ha.

the study area, making a careful, close-range assessment of ground within a radius of 10 m from each point, and scoring lateral erosion and linear erosion separately, as in Table 1. This omitted most of the study area, between sampling points, but gave a more objective assessment at the points. It provided much of the data for Table 2, and was the basis for the illustration of disturbed or undisturbed points in Fig. 3.

The next step was to measure the frequencies of various characteristic features of disturbed ground on transects. At 14 places (locations in Fig. 2), a 200 m transect was chosen on ground that was obviously disturbed, and a paired transect on nearby apparently undisturbed ground at a similar gradient, altitude, and, as far as possible, aspect. A 0.25 m^2 quadrat was then thrown at 20 sites chosen randomly along each transect. At each site, the presence of dislodged stones, torn plants, and other characteristic features in the quadrat was noted, and percentages were estimated by eye for cover of vegetation, damaged plants, grit on vegetation, and the main plant species present.

Slope stability was assessed at eight of these pairs of transects by counting how often one's foot slipped while walking horizontally 100 steps along each slope. The eight were chosen to represent a wide variation in gradients. Gradients were measured by clinometer.

Soil samples were taken with a trowel used sideways, so that material was removed to about the same depth (approximately 2 cm) as the trowel itself when placed horizontally. Samples came from 10 randomly chosen sites on obviously disturbed ground, and from 10 on nearby undisturbed ground at the same gradient and altitude, and with about the same aspect. All samples were taken on a dry, sunny afternoon in August. Each sample was put into a polythene bag, tightly wrapped, and delivered next day to the Soil Science Department, Aberdeen University, where water content, particle size, and percentage loss of material on ignition at 550 °C (as an estimate of organic matter content) were measured.

RESULTS

Mapping of disturbed ground and counts of people

Disturbed ground (Fig. 2) covered 403 ha, 83 % in the Glen More Forest Park and 17 % in the Cairngorms National Nature Reserve. Areas with scores of 1, 2 and 3 for lateral erosion (Table 1) comprised 14, 84 and 3 % of the disturbed land in the Park and 19, 75 and 6 % of it on the Reserve.

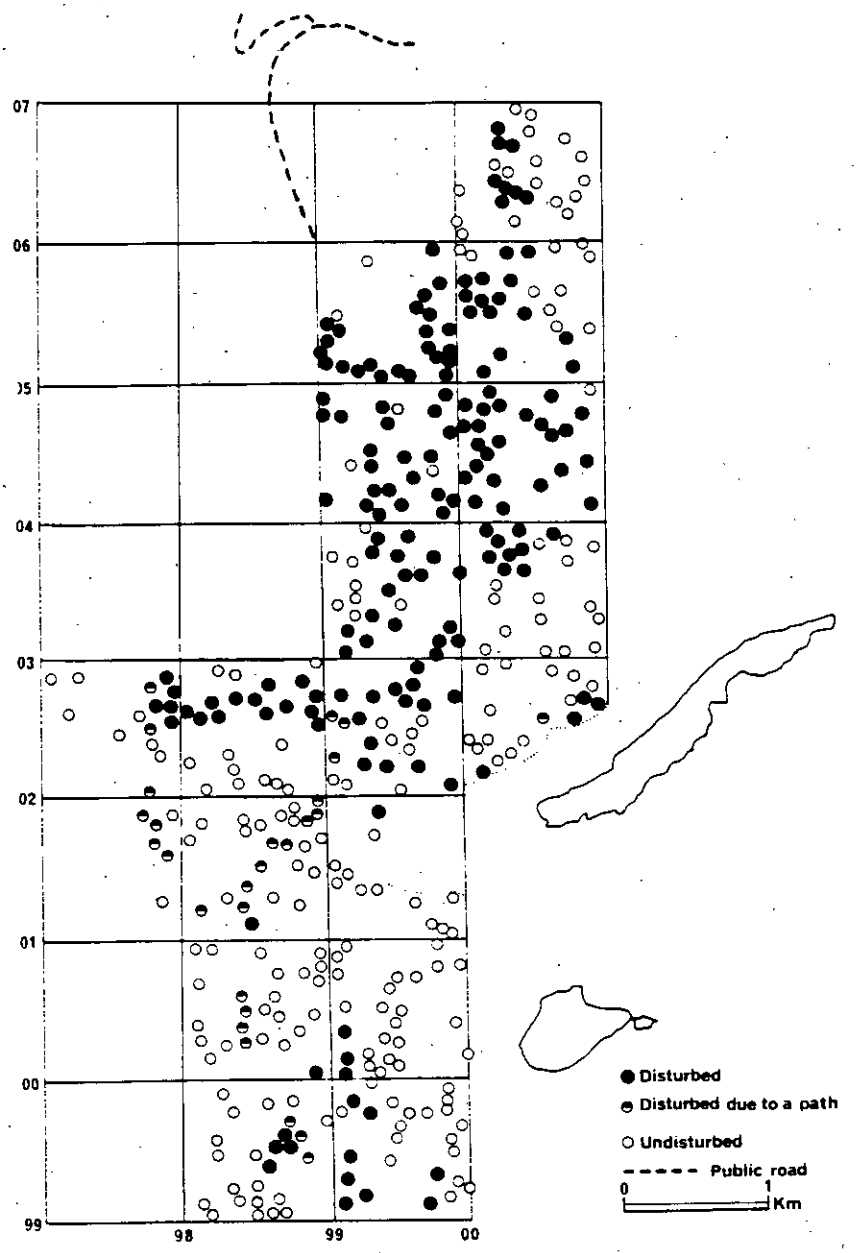

Fig. 3. Disturbed and undisturbed ground, based on 25 randomly selected points in each 1 km square of the Ordnance Survey national grid. Four squares (see Table 2) had <25 points as they included ground outside the study area, and the squares which included the public road-ends were not surveyed.

Score 4 applied only to small patches, each less than 1 ha. Disturbed land occurred mostly on and near ski grounds, but with some patches along the main visitor routes west to Cairn Lochan and south to Ben Macdui up to 6.2 km away. Data at random points within each 1 km grid square confirmed this pattern (Fig. 3).

Mean scores for linear and lateral erosion in the kilometre squares (Table 2) were not correlated. This was expected, as linear rills and gullies formed only on steep slopes, whereas much lateral erosion occurred on both gentle and steep slopes.

Morris *et al.* (1974) interviewed people to find the total number entering each kilometre square on eight days in July 1973. Their figures (Table 2) for people on the plateau and corries tallied well with my scores for lateral erosion ($r_s = 0{\cdot}72$, $n = 14$), and for lateral and linear combined ($r_s = 0{\cdot}80$); (p values are not given as interview figures for each kilometre square were obviously not independent of those in adjacent squares). The maximum depth of 'active' rills and gullies (where the bed had no vegetation) was poorly related to the number of people (r_s only 0·33), probably because gentle slopes had no deep gullies, irrespective of the number of people.

Measurements of characteristic features on disturbed ground

Transects on disturbed ground showed higher proportions of vegetation covered by grit than on undisturbed land, higher proportions of damaged vegetation (torn off, dislodged, or scuffed), a lower ground cover of vegetation (Table 3), and a higher frequency of other characteristic features such as plant burial, rill erosion, loose stones, and human footprints beside torn plants (Table 4).

Percentage cover and frequency of plant species

The worst damaged areas had no ground lichens, and other disturbed land very little (Table 5). Disturbed land had very little bilberry *Vaccinium myrtillus*, and significantly less moss, least willow *Salix herbacea*, and other species besides grasses, sedges and rushes. Grasses, sedges and rushes appeared to withstand human impact best, and lichens least, but on the worst damaged land the only plants left apart from crustose lichens on boulders were a few mosses growing on the undersides of boulders, the sole place out of reach of human trampling.

TABLE 3

Measurements on Vegetation at 14 Pairs of Transects on Disturbed (Upper Row at Each Pair), and Undisturbed Ground (Lower Row), and from Transects 15 and 16 on Undisturbed Ground, with *U* in Italics and $n = 20$ per Transect

Transect location		*Mean % of vegetation*					
		Covered by grit		*Damaged*		*Cover*[a]	
	1	32		—		47	
		3	*42*	—		57	*146*
	2	24		—		41	
		4	*10*	—		46	*188*
	3	34		—		35	
		3	*54*	—		63	*96*
	4	40		—		29	
		3	*28*	—		65	*66*
	5	29		—		55	
		3	*6*	—		65	*153*
	6	35		7		38	
		3	*0*	4	*148*	66	*97*
	7	30		4		45	
		1	*6*	0	*0*	53	*151*
	8	36		20		41	
		2	*0*	1	*23*	65	*102*
	9	53		39		16	
		5	*22*	1	*17*	53	*42*
	10	32		23		45	
		9	*10*	0	*7*	47	*172*
	11	38		14		45	
		13	*37*	2	*76*	50	*163*
	12	34		23		33	
		11	*33*	6	*56*	37	*166*
	13	31		8		45	
		3	*0*	1	*70*	57	*126*
	14	38		33		26	
		2	*23*	0	*9*	72	*32*
	15	7		0		45	
	16	2		3		61	
Overall mean and *n*	Disturbed	34	*14*	14	*9*	39	*14*
	Undisturbed	5	*16*	2	*11*	56	*16*

Means are given, as most medians for damaged vegetation were 0.

[a] All 14 pairs showed lower mean cover on disturbed than on undisturbed ground, $p < 0{\cdot}001$ (binomial test).

$p < 0{\cdot}001$ for *U* values up to 87, $< 0{\cdot}005$ for *U* up to 104, $< 0{\cdot}01$ up to 113, $< 0{\cdot}025$ up to 126, $< 0{\cdot}05$ up to 137, and $< 0{\cdot}10$ up to 150.

TABLE 4
Percentage Frequency of Occurrence of Features of Damage from Transects using Quadrats on Disturbed ($n = 280$) and Undisturbed ($n = 320$) Ground

	Disturbed	*Undisturbed*	*p*, by χ^2
Loose pebbles	58	0	
Damaged plants	37	17	
Partial burial of plants	23	0	
> 10% of vegetation damaged	19	2	
Bald scuffed patches on plants	15	0	< 0·000 5
Soil dislodged beside boot print	15	0	
Rill erosion	6	0	
Complete burial of plants	6	0	
Pale underside of boulder with no crustose lichens	6	0	
Roots exposed beside boot print	3	0	< 0·005
Dislodged cobble	2	0	< 0·05
Vegetation torn off beside boot print	2	0	< 0·05
Cobble lying on vegetation	1	0	NS

Slope stability

On gradients < 15°, my footsteps did not slip on either disturbed or undisturbed ground (Fig. 4). They slipped increasingly on disturbed areas the steeper the gradient up to 29°, but not on nearby undisturbed ground at the same gradient. The rate of slipping on disturbed ground increased logarithmically with the rise in gradient ($\log_{10}$ slipping rate versus gradient, regression equation $y = 10{\cdot}3 + 10{\cdot}8x$, $r = 0{\cdot}978$, $p < 0{\cdot}0005$). Not only were disturbed slopes unstable, but it was obvious while doing the measurements that slipped footsteps caused still further loosening of soil and vegetation.

Soil samples

Soil samples from disturbed ground had a low content of water and fine particles, and a low loss on ignition (Table 6). Disturbed soil had particles mainly > 3 mm, mostly stone-sized unweathered minerals, and very little material < 1 mm; this partly explained the low water-holding capacity. In undisturbed soils about a third of the particles were < 1 mm, and the dark colour indicated much more organic matter. The data on loss in weight on

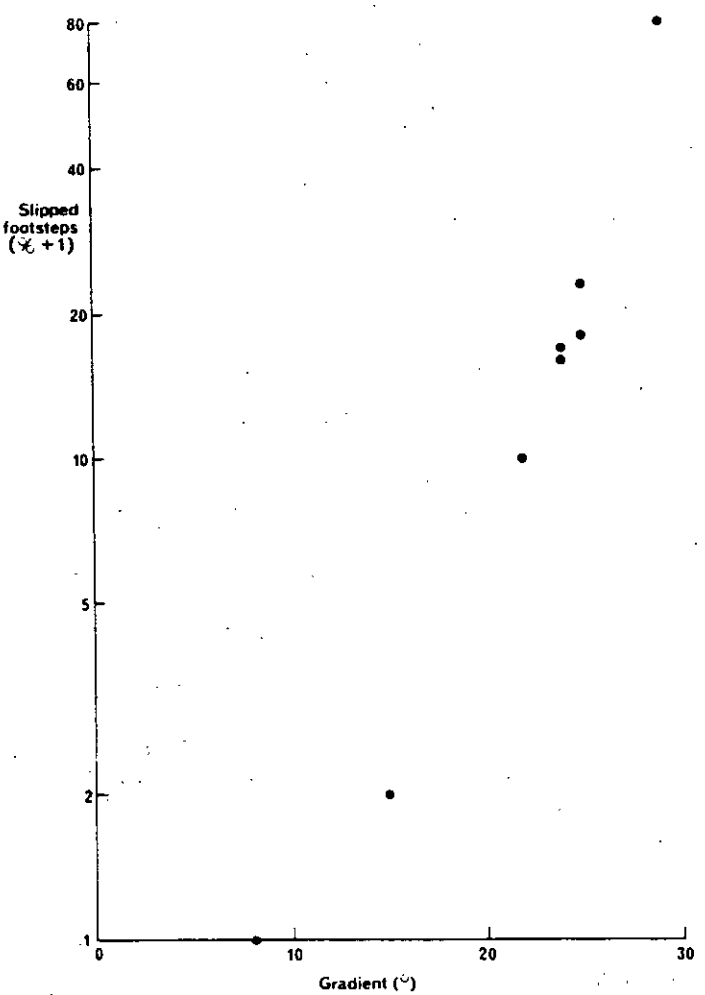

Fig. 4. Percentage of slipped footsteps in 100 steps at different gradients on disturbed ground (on transects 10, 11, 13, 3, 1, 6, 14 and 9 in order of gradient). No slipped footsteps occurred on transects on nearby undisturbed ground at these gradients (χ^2, $p < 0{\cdot}0005$ in each of the steepest five, $< 0{\cdot}005$ in sixth steepest).

TABLE 5

Percentage Cover (and Frequency of Occurrence) of Plants other than Grasses, Sedges and Rushes, at Three Pairs of Transects on Disturbed and Undisturbed Ground

Transect location		*Mean % of ground cover (frequency) of*				
		Least willow	*Lichens*[c]	*Mosses*[c]	*Bilberry*	*Other species*[d]
3	Disturbed	1·3 (9)	0·0 (0)	2·0 (10)	0·0 (0)	0·0 (0)
	Undisturbed	14·5 (17)	3·9 (15)	22·5 (19)	4·5 (11)	2·0 (4)
	U[a]	29	0	12	0	0
	p[b]	0·01	< 0·001	< 0·002	< 0·001	0·05
9	Disturbed	0·2 (2)	0·0 (0)	2·1 (6)	0·0 (0)	0·1 (1)
	Undisturbed	3·7 (9)	4·1 (14)	19·3 (20)	2·7 (11)	0·5 (1)
	U[a]	22	0	3	0	18
	p[b]	0·02	< 0·001	< 0·001	< 0·001	—
14	Disturbed	0·5 (3)	0·3 (2)	10·5 (13)	0·0 (0)	0·1 (1)
	Undisturbed	8·1 (14)	3·7 (9)	44·0 (20)	0·0 (0)	1·5 (5)
	U[a]	18	22	32	—	15
	p[b]	< 0·001	0·02	0·004	—	0·09

Means are given, as most medians were 0.

[a] The probability of the percentage figures on each undisturbed transect being larger than on its paired, disturbed transect was < 0·001 separately for least willow, lichens, mosses, bilberry, and other species, for each pair of transects ($n = 20$ per transect).

[b] Fisher exact probability of obtaining the observed difference in frequency or a more extreme difference. For other species on all three pairs of transects combined, $\chi^2 = 4·5$, $p < 0·025$.

[c] Lichens and mosses (Lichenes and Musci)—those measured were growing in the ground vegetation, and excluded those growing on rocks; the lichens were mainly *Cladonia* and *Cetraria* species.

[d] Other species—*Alchemilla alpina*, *Empetrum hermaphroditum*, and *Silene acaulis*. Grasses, sedges and rushes (Gramineae, Cyperaceae and Juncaceae).

ignition confirmed quantitatively the lower organic content of disturbed soils.

DISCUSSION

Percentage cover and frequency of plant species

Lichens, bilberry and some other species were scarcer on transects on heavily visited, disturbed areas than on lightly visited, undisturbed areas. As species composition before human impact was not measured, the

TABLE 6

Water Content, Particle Size, and Loss on Ignition in Soil Samples from Disturbed and Undisturbed Ground ($n = 10$ each)

		% water content	% of particles in size class				% loss on ignition in size class < 1 mm, as a % of whole soil
			< 0·5 mm[a]	≥ 0·5 < 1 mm	≥ 1 < 3 mm[b]	≥ 3 mm	
Disturbed	Median	2	2	2	16	80	0·1
	Range	1–3	1–11	1–3	10–31	55–89	0·04–0·44
Undisturbed	Median	15	34	7	28	36	2·4
	Range	7–23	7–42	5–11	21–38	25–49	0·8–3·6

[a] $U = 3$, $p < 0·001$.
[b] $U = 13$, $p < 0·01$.
All other comparisons, $U = 0$, $p < 0·001$.

possibility that the present scarcity of these species occurred beforehand cannot be rejected with certainty. For instance, it might be suggested that people prefer to walk on ground with little lichen and bilberry because it is easier to walk there than through thick bilberry. However, this suggestion is an unlikely explanation, because (a) all plants on the arctic-alpine ground are short, and none tall enough to make walking harder than elsewhere, (b) no transect covered continuous vegetation or boulder fields, the easiest and hardest walking, (c) the decrease in cover of species other than grasses, sedges and rushes, and the increase of bare ground since ski developments began, have been obvious to me and several others who know the area well, though not measured quantitatively, and (d) experiments show that the species of lichens, heaths and herbs which are scarce on areas with many people also suffer more damage from trampling than grasses, sedges and rushes, and recover more slowly (Bayfield, 1979; Bayfield *et al.*, 1981; Hoffman & Alliende, 1982).

Implications of soil erosion

Erosion on disturbed ground had removed much of the fine particles and organic matter in the topsoil, and so reduced its water-holding capacity. The resulting loose, dry, gravelly material provided conditions hostile to plant recovery and establishment. Loss of topsoil in mountains is serious as it contains the bulk of the nutrients available to plants for growth (Nordmeyer, 1978). One may replace lost nutrients with mineral fertilisers, but it is the organic content which contributes to the soil's aggregate stability through chemical bonding, and it cannot be replenished in this way (Morgan, 1980). Prospects for recovery of such badly degraded land at high altitudes are poor. Studies on alpine ground in Colorado indicate that it will take several centuries for severely eroded ground to recover to the original vegetation (Willard & Marr, 1971).

Rehabilitation and prospects for damage control

Damaged vegetation recovers more slowly with increasing altitude (Bayfield, 1974, 1979). Bared and partly-bared ground on ski grounds at Cairn Gorm has been rehabilitated by using fertilisers and reseeding with lowland commercial grasses (Bayfield, 1980). This reduces soil erosion

and produces a vegetation cover, and local plants native to Cairn Gorm colonise subsequently. However, the success of reseeding decreases at higher altitudes, and indigenous species colonise very slowly above 1000 m.

Reseeding has been practicable on the ski grounds because of easy access from several roads, the absence of boulder fields and steep slopes, and the concentration of damaged ground in two narrow corries. Even so, the treatments are expensive, and some have had to be paid from public funds. They would be far more expensive on the other corries of Cairn Gorm and on the plateau, because of the absence of roads, the presence of numerous boulder fields and steep slopes, and the spread of damaged ground over a bigger area. Most of the plateau lies at higher altitudes, where the worse climate and shorter growing season would ensure a slower recovery than on the ski grounds. Also, many conservationists regard artificial rehabilitation as perhaps acceptable in a ski ground that was not of high conservation or scenic value before the development, but unacceptable on a plateau of outstanding value for nature conservation, scenery and wilderness appreciation. Therefore, control or reduction of damage on the plateau appears unlikely unless the easy access by road and ski lifts can be controlled or reduced. The Nature Conservancy Council is responsible for national interests in nature conservation on the plateau, through management agreements with private landowners, but it has no control over the easy access from the ski grounds, which are owned by the Highlands and Islands Development Board.

Implications for nature conservation and other interests

The plateau between Cairn Gorm and Ben Macdui is one of the key parts of the Cairngorms National Nature Reserve for scientific importance. It is one of the most fragile parts because of its high altitude, infertile rock and severe climate, and is one of the most natural ecosystems in Britain. Human-induced damage to, and alteration of, soils and vegetation pose an obvious threat to the area's quality as a research site on natural ecosystems. They also threaten the animals that depend on the soil and vegetation, and obviously have serious implications for the interests of people concerned with scenic value, wilderness recreation, water catchment, and flood damage.

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REFERENCES

Anderson Semens Houston (1981). *Environmental impact analysis*. Glasgow, Anderson Semens Houston.

Baugh, I. (1979). *The condition of some footpaths in the northern Cairngorms*. Edinburgh, Nature Conservancy Council.

Bayfield, N. G. (1971). Some effects of walking and skiing on vegetation at Cairngorm. In *The scientific management of animal and plant communities for conservation*, ed. by E. Duffey and A. S. Watt, 469–85. Oxford, Blackwell.

Bayfield, N.G. (1974). Burial of vegetation by erosion debris near ski lifts on Cairngorm, Scotland. *Biol. Conserv.*, **6**, 246–51.

Bayfield, N. G. (1979). Recovery of four montane heath communities on Cairngorm, Scotland, from disturbance by trampling. *Biol. Conserv.*, **15**, 165–79.

Bayfield, N. G. (1980). Replacement of vegetation on disturbed ground near ski lifts in the Cairngorm Mountains, Scotland. *J. Biogeogr.*, **7**, 249–60.

Bayfield, N. G., Urquhart, U. H. & Cooper, S. M. (1981). Susceptibility of four species of *Cladonia* to disturbance by trampling in the Cairngorm mountains of Scotland. *J. appl. Ecol.*, **18**, 303–10.

Clapham, A. R., Tutin, T. G. & Warburg, E. F. (1962). *Flora of the British Isles*. Cambridge, University Press.

Gilmore, D. (1975). *Recreation—its impact and management in the northern Cairngorms*. MSc thesis, University College, London.

Hoffman, A. J. & Alliende, C. (1982). Impact of trampling upon the vegetation of Andean areas in central Chile. *Mountain Res. & Dev.*, **2**, 189–94.

Morgan, R. P. C. (1980). Implications. In *Soil erosion*, ed. by M. J. Kirkby and R. P. C. Morgan, 253–301. Chichester, Wiley.

Morris, D., Hammond, E. C. & Kessler, C. D. J. (1974). *Cairngorms National Nature Reserve. A report on the characteristics of visitor use*. Nature Conservancy Council.

Nethersole-Thompson, D. & Watson, A. (1981). *The Cairngorms*. Perth, Melven Press.

Nordmeyer, A. H. (1978). Revegetation and prospects for growing protection and production forests at high altitudes. *Proc. Conf. on Conservation of High Mountain Resources*, 264–86. Wellington, Department of Lands & Survey.

Watson, A. (1967). Public pressures on soils, plants and animals near ski lifts in the Cairngorms. In *The biotic effects of public pressures on the environment*, ed. by E. Duffey, 38–45. London, Natural Environment Research Council.

Watson, A., Bayfield, N. & Moyes, S. M. (1970). Research on human pressures on Scottish mountain tundra, soils and animals. In *Productivity and conservation in northern circumpolar lands*, ed. by W. A. Fuller and P. G. Kevan, 256–66. Morges, Switzerland, IUCN Publications, New Series, **16**.

Willard, B. E. & Marr, J. W. (1971). Recovery of alpine tundra under protection after damage by human activities in the Rocky Mountains of Colorado. *Biol. Conserv.*, **3**, 181–90.

Wilson, S. J. & Cooke, R. U. (1980). Wind erosion. In *Soil erosion*, ed. by M. J. Kirkby and R. P. C. Morgan, 217–51. Chichester, Wiley.

APPENDIX 2. DR G.R. MILLER'S NOTES ON MONITORING DAMAGED GROUND

MONITORING DAMAGED GROUND AT CAIRNGORM ESTATE

The aim of this work is to obtain accurate information on trends of change along footpaths and on other damaged ground at Cairngorm Estate. At present, two types of damage caused by walkers need to be monitored -

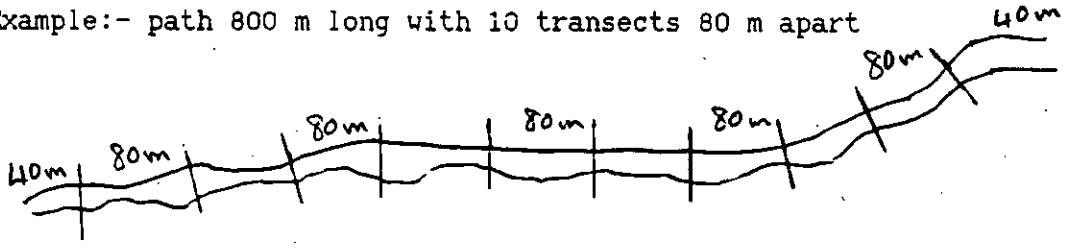
(a) along narrow, well-defined footpaths, and
(b) on broad areas lacking any clear path but where there is nevertheless much disturbance of the ground.

At a meeting at Cairngorm Estate on 17.07.91, five paths were chosen for monitoring. In order of priority these are -

(i) Second section of the Northern Corries path, from Allt Coire an t-Sneachda to Allt Coire an Lochain.
(ii) Marquis Well path from Ptarmigan Restaurant to Cairn Gorm summit.
(iii) First section of Northern Corries path from Allt a' Choire Chais to Allt Coire an t-Sneachda.
(iv) Fiacaill a' Choire Chais path: well-defined section from the summit road to the upper part of ridge and wider area of disturbance beyond to the top of the ridge.
(v) Path from beyond the western end of (i) southwards on Miadan Creag an Leth-choin.

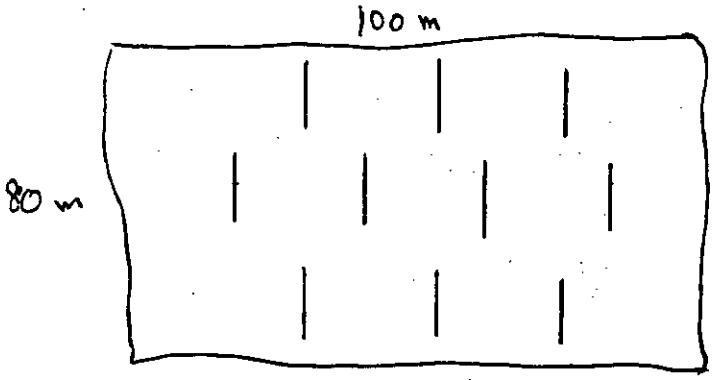
We recommend that a sixth area, the headwall of Coire Cas, should also be monitored because it is in such a bad state. These paths are some 800-1200 m long. Each should be sampled with a minimum of 10, but more usually, 15 permanently marked 10 m line transects. On a well-defined path, transects should be aligned at right angles to the direction of travel and arranged at equal distances as shown in the example below.

Example:- path 800 m long with 10 transects 80 m apart



Where the path is more diffuse, transects should be dispersed evenly over the damaged area as in the example below.

Example:- damaged ground 100 m x 80 m with 10 evenly dispersed transects



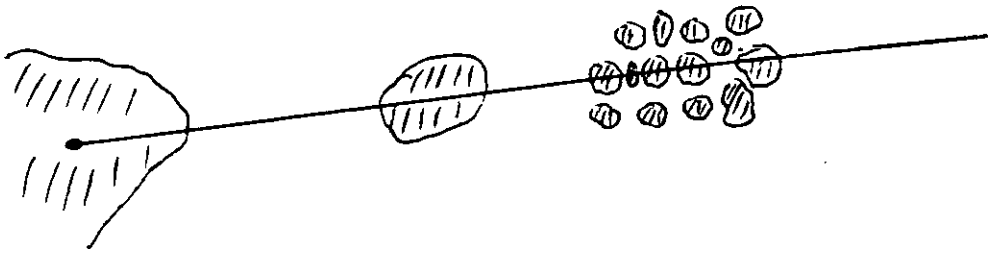
The upper part of (iv) above and the headwall of Coire Cas would be appropriate for this method.

Recommended numbers of transects for each path are -

(i) 15
(ii) 15
(iii) 15
(iv) 15 on lower section, 10 on upper section
(v) 10
(vi) 10.

Three types of ground need to be recognised and measured:
- totally covered by vegetation,
- completely bare,
- mosaics of bare and vegetated patches.

At each transect, a 10 m tape should be stretched between the permanent markers. The lengths of each type of ground intercepted by the tape should then be noted to the nearest 1 cm on standard record sheets. In the case of a mosaic, the percentage of bare ground traversed by the tape should also be estimated by eye. An example is shown below.



Transect section (cm)	Veg	Bare	Veg/ bare	% bare
0 - 40	✓			
40 - 92		✓		
92 - 112	✓			
112 - 131		✓		
131 - 191			✓	40
191 -				
etc				

MONITORING RECORD SHEET

Path: ..... Transect no. ... Date .....

Record each patch of ground crossed by the transect line by entering the measurements for the start and end of each section and by ticking the appropriate column below:-

VEG = totally covered by vegetation
BARE = completely bare ground
VEG/BARE = mosaic of vegetated and bare ground

For VEG/BARE, estimate by eye the percentage of bare ground in the section.

Transect section (cm)	VEG	BARE	VEG/ BARE	% bare	Transect section (cm)	VEG	BARE	VEG/ BARE	% bare

APPENDIX 3. DETAILED DESCRIPTIVE NOTES ON PATHS

The paths below are listed in the order in which they appear in Section 11, where the main problems are usually noted. The following notes are mostly on a more detailed level, forming an impartial assessment of path condition, for each path usually made during a single walk but in some cases on two or more visits. They are given mostly unabridged from the original notes, except where extra information on location or other matters is warranted to increase intelligibility.

Sometimes the notes include detailed suggestions for new improvements and sometimes suggestions where past improvements have not worked as well as they might. These suggestions should not be taken as criticism but as factual impartial comments to help future works; everyone is learning, including the writer.

Comments are made on whether the path overall is deteriorating, or improving, or broadly staying steady in condition; these are summarised by giving scores at the end of each path description respectively as (-), (+), and (=), in parentheses. It would be rather too subjective to score for different rates of deterioration or improvement, say (+), versus (++), versus (+++). However, decisions as to whether a path or area shows diagnostic signs (Watson 1985) of deteriorating from human impact or improving by natural recovery, on a simple minus or plus basis, can be made fairly accurately by an experienced observer. The comment that a path overall shows signs of recovery does not necessarily mean that it has stopped widening and is narrowing. For example, if people spread out far more to cause braiding, the old path might show recovery even though more ground is affected, but this would be obvious on the inspection visit and would appear in the notes. Generally, signs of recovery in path surface condition and vegetative growth go along with narrowing, not widening.

This Appendix includes some paths that are not in Section 11 because they do not pose major problems. A map showing most paths is in Fig. 2.

1. Direct path from Top Station to Cairn Gorm summit

Most notes in Section 11. Some reseeding was done in 1981 on the west side of the path about half way up to the skyline, using netting to hold the ground surface and discourage walkers from trampling there. The netting was torn badly within the first winter. The relics of this reseeding can still be seen, but it gave poor success, certainly not enough to justify further treatment on a larger scale. In any case, there is little point in reseeding unless the ground can be kept largely free from further trampling. What is more important here is to aim for a hard path surface that will withstand heavy pressure, combined with enough obstacles on adjacent ground to discourage walkers from straying there. Generally (=) when inspected in 1990-92, but the bare trampled grit at the sides of the boulder path suffered considerable fresh erosion including rills during heavy rain combined with a rapid thaw of deep fresh snow in mid May 1993. As a result, it was definitely (-) in summer 1993 compared with 1992, though still (+) compared with summer 1981.

2. Top Station by Marquis' Well to Cairn Gorm summit

Following the diversion of most people to the above direct path in the

mid 1970s, use of the Marquis' Well path declined greatly. Bayfield (1986) found that, after widening sharply from 1970 to 1975, it narrowed between 1975 and 1985. Most notes are in Section 11. There has been some discussion about the possibility of a circular route using this path and linking it to the direct path. However, if this were implemented, the Marquis' Well path would deteriorate rapidly, and really needs a hardened surface if it were to withstand heavy trampling and its consequences. (+), but (-) in summer 1993 as compared with 1992, due to heavy rain and a quick thaw in May 1993, though still (+) compared with 1981.

3. Top Station to Ptarmigan Bowl

All notes in Section 11. (+)

4. Fiacaill a' Choire Chais down to about top of Fiacaill Tow

All notes in Section 11. (=)

5. From about top of Fiacaill Tow down to zigzag road

All notes in Section 11. (=)

6. Down east side of Ridge Poma

Some notes in Section 11. First section up from bottom is peaty, up to ½m of peat gone, leads down to reseeded areas. Higher up beside the tow, the surface is gravelly and better, but there are some parts with loose stones and gravel. (-) on bottom part, generally about (=) higher up.

7. Northern Corries path to first corner

All notes in Section 11. (=), but (+) since before the repairs, and (+) in September 1993 (following repairs in June 1993) compared with 1992.

8. Northern Corries path from first corner to Allt Coire an t-Sneachda

This path widened considerably between 1981 and 1986, and in 1986 was eroding in some places (Lance, Baugh & Love 1989). Measurements by Bayfield et al. (1988) also showed widening between 1985 and 1988. The reports of the Footpath Management Project by Aitken (e.g. 1985a, 1988) give details on the repair works, and as they are highly relevant, they are reproduced below (Appendix 12).

In autumn 1990, first section, rocks inserted in such a way as to speed up water flow, not reduce it. Next part, some peat at side, being kicked and washed down on to path. Flat part generally good, but people are walking at the sides and churning the peat there; needs obstacles from boulders. Some drains above path level and wide peat band between them and path, so not working as well as they might, but divert some surface runoff. Bits of plastic matting sticking out often. At one place, boulders and turf had collapsed to block a drain, leaving a pool and wet path bside it. New path has some long wet bits, one set of drain stones not at the best place. Old parts adjacent showing recovery of surface and vegetative growth. Rocky parts past corner, churned-up peat between the rocks, not enough gravel. Older sections of side paths with smooth surfaces still being used, not enough obstacles, need more boulders to block access. (=), slightly (-)

since path repairs were finished, but (+) compared with years before repairs. Later notes added in September 1993 following further repair works in June 1993 would give a classification of (+) since 1992.

9. Upper path to Allt Coire an t-Sneachda

Widened considerably between 1981 and 1986 (on average by 0.6m), and in 1986 the surface was eroding in some places (Lance, Baugh & Love 1989). Between 1986 and 1990 "it showed no change in overall width, but the number of secondary tracks increased and the width of bare ground significantly declined. Evidently more walkers were using the less-trampled sides of the path and avoiding the previously eroding central portion" (Lance, Thaxton & Watson 1991). Bayfield et al. (1988) also found widening between 1983 and 1988. This path was monitored by the Cairngorm Ranger Service in the mid 1980s-1990.

In autumn 1990, a few wet wide boggy parts, but path surface was mainly on gravel, though much of it rough and loose. Showing a little recovery of vegetative growth in summer and autumn 1990, and up to autumn 1992. As compared with autumn 1992, the peaty parts showed some deterioration in September 1993 after a summer and autumn with unusually wet ground conditions. Some notes in Section 11. Generally (=), but peaty parts (-) in September 1993 compared with 1992.

10. Allt Coire an t-Sneachda to former Jean's Hut

Widened greatly between 1983 and 1985, and again between 1985 and 1988 (Bayfield et al. 1988). The eastern path goes up the west side of the burn at first (this is described as a different path below), but the main western one heads south away from the burn. The west path is wide and fairly good, but rough, loose and eroding on fairly steep parts on gravel. At a steepish step about 30% of the way up, there are large boulders where the peat has eroded out; the surface here is good. There are small wet peaty stretches, especially in a hollow. Further on, the east path joins it. Some stretches by a pool are very wet and boggy. There is then a stretch of flattish boulders which are resistant to trampling, and finally a short part on gravel amongst grass, near the site of the former Hut.

Although there are a few poor wet parts and loose rough parts, the path was showing recovery in surface condition and vegetative growth in autumn 1990 and 1992 (+). East branch - some wet peat at southern part, but fairly good on the whole, though one steep gravelly part among boulders poor, with 50cm depth of gravel gone; generally shows recovery (+).

11. Allt Coire an t-Sneachda to Allt Coire an Lochain

Bayfield et al. (1988) found that this path combined with its extension to Allt Creag an Leth-choin widened a little between 1981 and 1983, between 1983 and 1985, and between 1985 and 1988. In this Study I have separated the two parts of it (nos 11 and 12), as their condition was so different.

In 1989, boulders were inserted as stepping stones up the first peaty bank east of the burn. In autumn 1990, still a large area of bare trampled peat on first steep slope, but useful repair works were done here in late 1990 (see Section 11). After first hillock, flat, in reasonable condition with gravel path. Then steep short rise on peat between big boulders;

here, almost 1m thickness of peat gone. Much of peat left was smooth in autumn 1990, but had been made partly amorphous by trampling, and so is eroding in rain and wind. Gravelly sections quite wide and loose, but far better than the peaty ones. First peaty slope (+) due to repair works. Part beyond is generally (-), tending towards (=), but (-) in September 1993 as compared with 1992, following a poor summer with the hill unusually wet.

12. Allt Coire an Lochain to top of Allt Creag an Leth-choin

West of the crossing of Allt Coire an Lochain, rough in some places and wet in others, gradually becoming narrower to the west and gradually improving in condition (=). Beyond where a path heads south to Miadan Creag an Leth-choin, the surface improves, smoother and drier, and vegetative growth shows clear signs of recovery between here and Allt Creag an Leth-choin (+).

Below the crossing of Allt Coire an Lochain, a path goes down the burn to the north, to the path coming up Allt Creag an Leth-choin from the Allt Mor; it shows recovery (+). From the crossing of the main Northern Corries path, two small paths run up the west side of Allt Coire an Lochain. Their condition is fairly good, though there are a few wet and rough parts; generally there is recovery, and much recovery on deer sedge and mat grass, but less on heather over gravelly soil (+). Another small path runs up the east side of the burn, condition similar, also recovery (+). At its bottom end, this connects with a faint path which has developed from this point on Allt Creag an Leth-choin round to the Chalamain Gap, roughly on the contour line. It is still in good condition though slightly rough in places, generally (=), but tending in places towards (-).

Further up Allt Creag an Leth-choin, past where the Northern Corries path comes in from the east, two paths go up the burn, with one on each side, some recovery (+). Path higher to east nearly all showing recovery (+). Lower down Allt Creag an Leth-choin, several paths run along the gravelly hillocks on west side, showing recovery (+).

The general recovery of paths in the Allt Creag an Leth-choin area fits with counts of people by Mr Jo Porter (some data in Watson 1981, Supplement 2). A set of counts in the 1970s showed 57% in Coire an t-Sneachda, 18% in Coire an Lochain, 22% on the paths (including the main and subsidiary eastern Northern Corries paths), and only 5% in the Allt Creag an Leth-choin area. My own experience is that numbers using the Allt Creag an Leth-choin route from the Allt Mor were higher in the 1950s before the road was made to Coire Cas. Similarly, numbers going on the Northern Corries main path beyond Allt Coire an Lochain and up Allt Creag an Leth-choin to the plateau and Ben Macdui were higher in the 1960s and 1970s than in the 1980s and 1990s. This used to be regarded as a major route to Ben Macdui. Subsequently, the path up the north nose of Miadan Creag an Leth-choin (next paragraph) became more important.

13. Up north ridge to Miadan Creag an Leth-choin

Quite good but eroding. Too steep and direct in many places, up to 20cm depth of soil gone, many small washouts of grit off path on to vegetation. In dwarf heather zone quite good, as it's on a well drained nose, but eroding, some loose bits, two paths in places, some washouts of grit at

side, up to 30cm gone, too steep in places here too. Steep bit in woolly fringe moss, some erosion, one long rill 50m. Higher up there are three paths, one near edge recovering, middle one some recovery, west one in main use and showing widening. Higher up, condition is better, gradient a lot less. (-)

14. Goat Track

All notes in Section 11. Now (=), tending to be slightly (-), but (+) compared with before repairs, was strongly (-) before repairs.

15. Miadan Creag an Leth-choin to Loch Coire an Lochain

Top part very steep, eroded, rutting, with grit and stones kicked out and down to the side. Lower part showing some recovery in vegetative growth and path condition. Some notes in Section 11. (+)

16. Slanting path west of 15

Top of slant eroding and steep, most of slant O.K. and showing some signs of vegetative recovery. Generally a little recovery except where steep and gravelly. Some notes in Section 11. (+)

17. Miadan Creag an Leth-choin to Cairn Lochan

Bottom part moderately good, but one small eroded section with much loose grit. Higher part wide, eroded and rough, with much loose grit and stones, and some grit flow on to vegetation. (=)

18. Plateau north rim

All notes in Section 11. (+)

19. Forest edge car park at Sugar Bowl to reindeer enclosure

Short path to road, eroded down to 30cm by water runoff from tarmac road, so path is acting as a main drain for the road, needs a barrier to prevent runoff going on to path. In autumn 1990, beyond the road, drain blocked by vehicle tracks on top side, should not have allowed a vehicle to damage a bog like this. Wet, muddy, not draining because of blockage by bridge. Plastic matting showing in places. Big turf of heather dug out by machine and dropped at side on top of vegetation which it will kill, could have been used. Heap of old posts. Steps - stones are too round. Flat bit by old tree, edge broken - stones rolled down. Stones across, big one slopes downhill, drain not working well, filled up. Steeper bit below is eroding. Boulders at edge good but path is going, no boulders on it. Zigzag good boulders, but eroding, needs boulders across. Further up, not enough boulders, people walking to side of them. Banks well built up.

Last part to bridge, stones facing out, wrong way for reducing water flow and avoiding slips by walkers. Also, people walking on downside of some boulders towards edge of bank, drain largely filled. Old former Clach Bharraig bridge and concrete lying on island, should be removed.

Path up to reindeer enclosure, stones put in and grit, but wide peaty bit had trampling at side - stones too small for easy walking, so people go to

side. Top part needs more cross drains, lateral water movement from long drain at side is too small for peat. First repaired bit of gravel path too low, peat on either side washing and falling on to it. Gravel has too high a clay content at one place, leads to poor drainage and puddling. Tree on this side has old string and wire on the bottom, should be removed. Reindeer enclosure, heap of unsightly wire and old posts near gate, and another heap further south. (=), but (+) compared with 1970s and early 1980s.

In autumn 1990, some further notes on the same path. Wooden steps on steep part east of bridge break rhythm, too regular, and spacing incorrect, also look very artificial. Rock path would be better, also wood very slippery in ice, frost, and snow. First bit beyond bridge, boulders set into path face downhill, wrong way for easy walking and for reducing water flow. Drain on flat part, edge falls away on top side, stones rolling, no clear edge delineated by boulders or other obstacles like further up. Below path, Sphagnum-dominated turves laid on well drained edge, completely the wrong vegetation type for such a dry site. Upper part of steep brae, new drain dug on top side, ends in a 60cm vertical drop, leading to splash and loosening, collapsing bank, too much bare ground in drains, with no rocks, iron pan broken by diggings immediately above.

Notes made later in August 1993. At top of steep part from bridge up the west side, a former path branch to the left was eroding badly, and has been stabilised by inserting boulders. These face outwards, so making foot slipping more likely and not reducing water flow. There's a wet peaty part at the turn by the pine tree at the top of the more gently-angled path just to the north. (+) in August 1993 compared with 1990.

20. Reindeer enclosure to Caochan Dubh a' Chadha

In autumn 1990, first part poor, up to 20m width of bare peat and up to 40cm thickness of peat gone, 20cm gone in many spots. Good along heather edge, poor on deer sedge. Along ridge quite good, but braided, path tending to move south on to peat. Peat eroded down to gravel higher up. Bits on deer sedge poor, often 10-15cm thickness of peat gone. Along south edge of escarpment quite good, but much braiding on gravel and some roughness, people forming new paths at side and former main path recovering.

Steep slope down to Caochan has been repaired. One stone drain too low in middle. Some unnecessary drainage of peat. Turves too shallow, leads to poor growth. Many gaps left between turves, leads to plant roots and soil drying. All gaps should be filled with peat or mineral soil, peat best if available as here. Any square edges sticking out should be evened off by packing peat or soil against the turf's edge of exposed peat or soil. Some peat divots left on vegetation, which they'll kill.

People still cutting across zigzag corners, not enough boulders or other obstacles. Especially at first zigzag, needs blocking at bottom and above all at top. Some parts too steep for gravel, which is eroding, zigzags better on a lower gradient, i.e. fewer zigzags but traversing further out. Boulders inserted into path nearly all put in the wrong way, increase water flow rather than reduce it (i.e. boulders tend to face downhill). One drain, not enough boulders - break out. One shallow drain in gravel is pointless. Vegetation turves dug out to get peat divots from underneath,

turves not put back. Generally too much steep gravel and too many peat slopes at the side. (=), but (+) compared with 1970s, (+) mainly due to repairs on steep slope east of Caochan, but slight natural recovery too.

The following notes were made on a visit after the 1991 repairs, heading east from Caochan. On 200m steep brae to ridge east of Caochan, first 100m wider, south-east side of path is taking many people, edge not clear and shaved peat too easy to walk on. At foot of next 100m, eroded grit from a drain goes 10m downhill and spreads up to 4m wide over the vegetation, needs more drains higher up. Also, bare surface too wide, up to 2m wide, former paths still present on west side.

High, level part on south edge of escarpment, 200m at edge of steep escarpment, former 2-3 paths on west side recovering greatly. Eroded hollows in places, much grit washed downhill, water flow needs breaking in hollow and at edge, generally O.K. but needs watching. Path shouldn't be allowed to go further out, and the few places where edge is broken should be stabilised with a rock each. A few peaty damp patches, but quite good on the whole. Further on, path is well back from steep edge. A few peaty patches. The 2-3 former paths to north are recovering.

Along last part before path turns north, old former path below, at edge of steep slope, is recovering well. At corner, path goes to edge of gravelly patches, needs watching so that stones at edge of path don't move down to break the edge of the steep slope; path is very close to it at one point.

Beyond corner, cross drains armoured with boulders, side drains longitudinal, gravel on path, big improvement. Lower path being used in places, sometimes not clear where main path is, needs a few more boulders as obstacles; boulders inserted for this elsewhere on the path have worked there. The peaty part on either side needs a boulder or two to deflect people, and similarly on the vegetation at the side.

Where path comes above the Allt Mor, gravelly hillock was used for fill for path, very clever and neat! Gravel on sides is covered with peat in small lumps, mixed with soil and grit, not a good mixture. Last 100m above path from reindeer enclosure, path has longitudinal drains in the peat, and stones on the path, and boulder cross drains, big improvement. Part below on path is drier. New short-cut path for 10m, stones face downhill, not easy to walk on and doesn't reduce water flow enough. This problem applies to all paths repaired on the Estate, including the direct path from Ptarmigan Restaurant to Cairn Gorm and the early repairs below Fiacaill a' Choire Chais. Overall rating undoubtedly a big improvement due to the repairs, but minor improvements would help raise standards and reduce the likelihood of future trouble. (+)

Note added later, in September 1993. Further major repairs were made in June 1993 on the section from the corner down to the reindeer enclosure. The following notes were made in August 1993, starting at the top of the steep brae above the bridge. Side path to upper gate has wet churned peat in places. New section of main path good, peat dug out and used for filling eroded holes, some sods of vegetation open at the sides, need loose peat packed into gaps to prevent drying out. On the first steep section, boulders had been inserted, facing downhill, and so were not reducing water speed enough and were making walking more difficult. There were some patches of bare peat at the sides of the path, and footprints

were in it, not enough obstacles to keep people in the middle of the path. Result is that peat from the side is mixing with the path gravel. Imported gravel is good quality with sharp-angled stones mainly of mica schist.

Some steep sections don't have boulders, even though they're steeper than one part that had boulders inserted. On the part near the edge of the bank to the east, the path is still 3m wide, but well drained. Last 200m to the top flattish part, gravel path is narow, less than 1m of gravel, flat peat at sides is mixing with the grvael due to people walking on the bare peat. The ditches dug in the peat at the side are up to 2m from the path edge. One wonders about the effectiveness of this, given that good drainage in peat applies only within ½m of the drain, and mostly within 30cm. Certainly they are catching surface runoff, but could do more.

On the last flattish part to the top, path width down to 30cm in one place, with bare peat sloping up steeply on either side. One gets the impression that the workers were running out of material and decided to spin out the little that was left over a long section, rather than doing one part properly and leaving the rest undone. At the corner is a stretch of wet gravel mixed with peat, not enough gravel deposited. Also, there is too long a distance before the next cross drain, so the surface is eroding. Geotextile with black plastic ribbing and grey plastic matting was showing at one point. Some sods are upside down, and some gaps in inserted sods are not filled with peat, so the edges of sods and roots are exposed. Not good handling of sods and soils there. (+) compared with 1992.

21. Caochan Dubh a' Chadha to Chalamain Gap

Repaired up to first hillock 1990, and up to second and last hillock 1991.

In autumn 1990, on first part, fresh peat divots piled up higher than before, at the sides. Path only 45-50cm wide in places, too narrow. Drains dug across, with stones. Longitudinal drains are at the side. Some drains unnecessary. Many drains unnatural-looking, straight with neat stonework almost like a suburban garden. Path up to 30m wide formerly, on bared peat. On the slope beyond, boulders set into the path are speeding up water flow, boulders face downhill. Beyond, path up to 40m wide on bare wet peat! Up to ½m depth of gravel has eroded away on one deep path. The only good part is on a flat stretch where grit washed out from steeper braided sections higher up has made a good surface on top of vegetation.

Too big boulders used for many drains and crossings of small burns, not used on old stalkers' paths, as dangerous for ponies. Gap between boulders is up to 40cm wide and deep. Even tiny burns have big boulders added like this. Looks artificial and incongruous in such wild surroundings. Makes crossing very easy in summer, but the gaps would be risky in deep winter snow, e.g. if a walker put a foot on a snow-filled gap between boulders.

In autumn 1990, (-) for top part, (+) for bottom repaired part.

Notes added later in December 1991. Soon after Caochan, several places where stones were wasted, many are in the heather or on the peat, but otherwise first part quite good. Second part big improvement, but the brownish grit has much clay and is porridgy when wet, leading to puddling. Small lumps of peat rolling down and washing in from the peat at the side are on the gravel path and mix with it, creating further puddling. Some

bootprints seen in peat at the side. Gravel too rounded, rolls under boots, easier to walk on dry peat at side on way up, even though stones easier on way down than on way up. In a few places, braided side paths are well blocked by a vegetated mound or boulder. The last part to the second hillock had been only partly finished, on my visit in December 1991. Geotextile was showing there, and sticking into mid air at one place; stones were on it but not fine gravel.

There is an east and a west path on one section. East one badly eroded, up to 1m thickness of peat washed away. Beside it, a fairly new path takes a more easterly line higher up and then heads towards the Gap. The best path is the west one, but it is strongly braided up the hillock. Where east one first breaks off, added boulders would block it off. Beyond the hillock, path is braided up to the steep bit, then a few different routes up among the rocks. Near the top of the unfinished part, a few vegetated sods that had been dug up were lying upside down.

Another more important drawback is that boulders were inserted facing downhill, instead of being angled horizontally or at a slight angle facing inwards to reduce water flow and make easier surfaces for walking. Just west of Caochan, foxglove growing at side of path, and heather seedlings colonising the bare peat well. Massive flat-topped boulders inserted into the burn make it effortless to step over, arguably too easy; looks a bit artificial in such a place, and seems unnecessarily expensive. (=), but (+) compared with 1970s.

22. Caochan Dubh a' Chadha by burnside to below reindeer enclosure

In autumn 1990, this former stalkers' path had eroded to form a little watercourse in places. Path very wet and widening on peaty parts, but deer sedge colonising the bare peat, a sign of recovery. About half way down the old path is a peaty depression where moss and common cotton grass have colonised. Wheelmarks of mountain bikes here, filled with water; there's no doubt that bikes on wet parts leave a deeper mark than a boot, and what's more, a linear mark which becomes a channel for water movement. There's much standing water in places. Path better where it comes nearer burnside, but still some wet peaty bits. Generally rough, with many bogs, path there wide and churned up. A few parts as good as the former old stalking path used to be. Some collapsed banks close to the burnside. Very rough where the big landslide came down. Recovering generally. (+)

An old branch path from the confluence of Allt a' Choire Chais with the Allt Mor slants up the east side of the Allt Mor to the prominent gravelly ridge below the old zigzag ski road. It was used mainly before the ski road was made, and is recovering. (+)

23. Coire na Ciste restaurant to top of chairlift

First steep slope very poor, 100m length of bare peat, width mostly 5m but up to 10m. Peat wet and very acidic, bog asphodel and deer sedge clumps. Some recovery of hill vegetation. A few wheel marks of mountain bikes. Peaty band gets narrower towards first pylon. Beyond first pylon, two paths, up to 40cm thickness of peat gone, lower path showing recovery. Marks of mountain bike wheels on terrace and beyond. Two paths to second pylon, and one beyond it. Path beyond to foot of Aonach Tow mostly peaty, narrow. Generally (=).

Beyond the bottom of the upper chairlift, path continues roughly along line of chairlift, on well-drained ground, fairly good condition, slightly rough and loose in a few places and two paths at times. Generally (=).

24. From Coire na Ciste car park up burnside

Paths up both sides of burn below landslip. There's a footbridge on the burn near the car park.

In autumn 1990, path up east side recovering in places on lower part, but wet parts poor and churned up, wheel marks of mountain bikes as well as walkers, some big loose stones. At one spot, green plastic matting laid, good plant growth coming through it, but looks out of place. Below there, path recovering. Generally (=) in autumn 1990. Upper part to the crag of Creagan Dubh on coarse grit, very loose (=). Some patches of bare loose grit in this area naturally, but have increased with human impact. In 1992, some repairs done in places since autumn 1990 on path to fenced alpine garden, stone drains, gravel added to path surface, path built up above the spot where the burn had washed it away (+).

Paths to chairlift station peaty in places and rough, now approximately stable though in active use (=). Beyond, showing recovery (+). Paths from burn to first pylon and from burn to top of fence on west side narrow but peaty and rough (=).

On west side, wooden steps to footbridge, slippery in ice and wet conditions, break rhythm. Beyond, path is on loose stones with much bare peat, too steep. Path to stile in forestry fence shows wheel marks of mountain bikes, wheel marks slipping on the steep traverse. (=)

25. Beside White Lady Chairlift

All notes in Section 11. (+)

26. Beside White Lady Tow

All notes in Section 11. (+)

27. East of Allt na Ciste to forest edge

All notes in Section 11. (+)

28. Clach Bharraig to Ptarmigan Restaurant

Bayfield (1986) found that this path, very wide in 1975 when first measured, had narrowed greatly by 1980 and continued to narrow up to 1985. Most notes in Section 11. (+)

29. Paths from path 28 down to Coire Cas car park

All notes in Section 11. (+)

30. To Scottish Ski Club Hut

All notes in Section 11. (=)

The following were not included in Section 11:-

31. North of Sron a Cha-no

This path has appeared since the road and chairlift were built. Not heavily used, and still fairly narrow, but wider and braided on gravelly parts, where there are some loose stones and grit, and small washouts. A few paths come off the ridge down to the high tree plantation, all narrow and in fairly good condition, but too straight and direct, and so showing some roughness and erosion. Below the plantation, wheel tracks from a vehicle lead downhill. (=)

32. North from Allt na Ciste to Ryvoan

Fairly good condition, some wider wet spots in boggy patches but some good parts on well drained gravel. The path goes round the west side of Lochan na Beinne, and at the lochan's south end joins a set of wheel tracks leading south to Allt na Ciste near the car park below Coire na Ciste. (+)

33. To top of Creagan Dubh from Allt na Ciste

Too straight and direct. Not heavily used, and still narrow, but lower parts go straight up damp vegetation of heather and deer sedge on fairly thick peat, so path is wet and acts like a drain, in frost can be a long ribbon of ice. Some deer sedge growing and recovering. Needs drains. Upper part on heather is on thinner peat, some loose gravel and stones, too steep a line. Beyond the top, the path continues on gravel, straight uphill; generally fairly good, but a little roughness, loose grit and erosion, and some braiding, with several faint paths in places. (=)

34. Up Allt Coire an t-Sneachda

A path up west side and one up east side, from crossing of main Northern Corries path. Main use is on east one, peaty, but fairly good in places, very wet and boggy on east side of crossing, then better except on wet peaty sections where peat is breaking and going downhill, producing a very wet morass. Some erosion and looseness on gravel. Beyond where path divides, east one fair recovery, west one some recovery. Generally showing recovery (+). Path up west side similar in condition (+).

35. From Fiacaill a' Choire Chais ridge into Coire an t-Sneachda

Several paths traverse this slope; they start at zigzag road above Mid Station, and go to Coire an t-Sneachda. Typical walkers' paths on granite gravel, rough in places with stones and some loose gravel, and with churned peat in the rather few wet spots. However, generally they take dry routes. One path has obviously been disused for years, and has recovered almost completely, with a total vegetation cover of sedges on wet parts, and an almost total cover of heather and sedge on dry parts where there are only small patches of bare grit left. Generally (=), but a few (+).

36. Old paths from the north to the lower and middle parts of Coire Cas

These were made by skiers walking to Coire Cas before the road was made in 1960. They have very seldom been used since, and I have seen nobody on some of them. Now markedly narrower and smoother, with recovery from strong growth of heather and deer sedge. (+)

37. Up Allt Creag an Leth-choin from confluence with Caochan Dubh a' Chadha, to where burn steepens at foot of Lurcher's Gully

Northern part was a stalkers' path in mid and late 1940s, in good condition. Later, walkers extended it southwards. In autumn 1990, peaty, wet and rough in places, up to 40cm of soil gone, but a few parts as good as before. A few collapsed banks by the burnside, especially at two small landslips, where the going is rough. Generally recovering. (+)

38. On Miadan Creag an Leth-choin south end

Short path extending into mat grass, an extension of the path from Lochan Buidhe along the west flank of Cairn Lochan. Path narrow and in good condition, as mat grass very resilient, but some grit washed down from the poor loose section on west side of Cairn Lochan where it is on Rothiemurchus Estate. (-)

39. Caochan Dubh a' Chadha to Eag a' Chait and Lochan Dubh a' Chadha

First main part peaty, wet, widening in wet parts, but recovering in drier places. Top ridge to Eag, still quite good, recovering. On the whole recovering (+). Branch to Lochan similar (+).

40. Old path from forest edge east of Allt Mor to road to Coire Cas

Below junction with path from car park at Sugar Bowl, old path from Glen More overgrown with vegetation at the side and lower down on the path itself. About 50m down, path ends at a collapsed bank caused by a landslip undercut by flooding of the Allt Mor. (+)

Above junction with path from Sugar Bowl car park, improved surface, but steeper parts mainly rough, consisting of loose cobbles due to lack of drainage maintenance in the 1950s and 1960s. Some little banks collapsed. No drains, but vegetation growing strongly in from sides. Above the topmost trees, big heather turves about 1.5x1.2m in size had been dug up and turned over to lie upside down. Top part steep and loose with no drains, but recovering. (+)

Path to viewpoint hillock from old zigzag ski road is recovering, with lichens, grass and common cotton grass growing. (+)

Old path from zigzag road to start of Sugar Bowl path, shows much recovery. (+)

41. Across neck of Fiacaill Coire an t-Sneachda

Was a former red deer trail from Coire an t-Sneachda to Coire an Lochain. Greatly loosened and roughened by walkers, too steep and direct to be a good path for walkers. Damage especially great on descent. Considerable erosion, movement of loose grit, stones and boulders. Approximately steady in condition in recent years, but still potentially serious problem if walker numbers were to increase greatly. Useful for rangers to request walkers to avoid this route, and explain problems of damage. (=)

APPENDIX 4. INSPECTION AND MONITORING REPORTS ON THE SKI AREA

Early-summer inspection at Cairngorm ski centre 1990

The area was visited on 28 May along with Mr Tom Paul and Mr Tim Whittome of the Cairngorm Chairlift Company. Because of the mild winter and early spring, virtually all snow had gone, and the weather was clear and sunny, so conditions for viewing the ground were excellent.

The past winter was exceptionally mild, windy and snow-free, and was a poor skiing season at the centre. Nevertheless the snow cover was better than at Glenshee and the Lecht. The snow season began unusually late, well into the New Year. Although there were some heavy snowfalls and big storms, including one that would normally have been sufficient to provide good skiing for weeks, these were usually followed by massive thaws and heavy rain, accompanied by gales. However, some late snowfalls provided spring skiing when the other centres in the east Highlands had closed.

Although some damage to vegetation and soils occurred because of use by skiers and piste machines in conditions with thin and incomplete snow cover, particularly on the lowest ground in Coire Cas, this was counter-balanced by the general under-use of the hill on the many days when the facilities were all closed because of insufficient snow, or when only some runs could be opened. The result overall was that the hill suffered little fresh damage as a direct effect of usage over the last winter.

The state of the hill has also been helped by the fact that the spring was unusually early, dry and warm, and so plants grew very early. The general lack of snow in late spring allowed plant growth to be early in snowy spots where growth in an average year would not start until late May or June. The result overall was that during the inspection the hill looked unusually well for such an early date in the summer.

The only areas of appreciable fresh damage due to usage last winter were in the lower part of Coire Cas below the mid station. Some bare patches of peat had extended in the flat small basin above the Hump in the upper part of this section, due to trampling by skiers. Similar bare patches were obvious at the bottom of the slope near the bottom station, again due to trampling by skiers, and some smaller patches showed worn vegetation. Snow cover was often thin or incomplete in these lower parts, and the bare patches were caused by skiers skiing down on narrow strips of snow at the foot of the runs, or walking downhill on the last slopes at the foot. There were very few signs of fresh damage by piste machines, so their use must have been carefully controlled. Compared with the Lecht and Glenshee Ski Centres, which were also inspected by the writer in late May, fresh damage by pisters and skiers was on a much smaller, more localised scale. This reflected the generally better snow cover last winter on the Cairngorm ski grounds than at the other two east-Highland centres.

It was agreed that the Company would reseed all these bared patches. Any patches of freshly worn vegetation would be given a light dressing of manure to help growth by the hill plants.

During the visit, some areas were inspected where the main damage to be seen in 1990 is a result of actions taken many years ago. One was the worn ground around the Ptarmigan Restaurant, another the bare ground and erosion beside the path to Cairn Gorm summit, a third the spreading bare ground east of the Restaurant, a fourth the road up Coire Cas to the Restaurant, and a fifth the peaty ground near the Coire na Ciste car park. Some suggestions were made for rehabilitation there, but detailed recommendations will be made later, following the Environmental Baseline Study of the HIDB's Cairngorm Estate by the writer. Two areas of fresh damage in 1990, as a result of past actions many years ago, were the loose grit washed on to vegetation and soils below the path from the Ptarmigan

Restaurant to the Marquis Well, and the sloughing off of a patch of reseeded gravel on a steep road bank below the big bend in the road up the upper part of Coire Cas. Both events occurred during spring thaws, and the site up the Marquis Well path is one where loose grit has been washed down in most past springs. Recommendations for both these two areas of fresh damage will come after a full examination during the Environmental Baseline Study.

Summary. The skiing season was poor because of the exceptionally mild, windy winter, and some damage to vegetation and soils occurred due to trampling by skiers, and to a much lesser extent machines. However, the damage was localised and very small in extent, mainly in the bottom part of Coire Cas where snow cover was poorest. Rehabilitation measures for the freshly damaged ground were agreed. Hill plants and reseeded grass started growing very early because of the unusually warm, dry, snow-free spring, and the result is that the hill looked very well for such an early date in the summer. Two areas of fresh damage that occurred at the time of the 1990 spring thaws were an indirect result of actions taken many years ago. These were examined, as were other areas of damage that have been present for years. Recommendations for rehabilitation in such cases will come following the Environmental Baseline Study of the HIDB's Cairngorm Estate by the writer.

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Early-summer inspection, Cairngorm ski area, 1991

After a useful discussion with Mr T. Paul and Mr T. Whittome, I visited the ski grounds with Mr Paul on 17 June during heavy rain. This was a benefit in showing better where excess water was going and so indicating solutions.

Unlike the previous two poor skiing seasons, last winter was good. The season lasted from November to May, and downhill skiing with facilities was possible for six months. There were fewer skier days and fewer skiers than in the previous top year. This was attributed to the two consecutive bad years having a run-on effect, and the run-on effect is expected to go in the opposite direction this next winter following a good skiing season. Easter was early in 1991 and had poor weather, both of which resulted in fewer people than would otherwise have been expected. Also, the season ended prematurely due to rapid spring thaws, and later snowfalls in May came too late to bring large numbers. The premature end to the season helped prevent excessive damage to the ground, which is often a problem on the lower parts of all Scottish ski areas in springs without heavy snow cover.

The hill showed fewer signs of fresh damage than in spring 1990, as expected from the better snow cover. The patches of bared peat at the foot of the runs immediately above the bottom of Coire Cas near the bottom chairlift station were again showing bare. Reseeding in 1990 had only partly been successful, and in autumn there were bare patches due to failure of the grass to germinate, partly as a result of dry conditions. Some of the reseeding had survived the winter. This should be lightly manured, and bare patches reseeded. Bare patches where the peat is thick should have a lime treatment in addition. Reseeding work on these peaty bumps should be done now, while ground conditions are wet, so that the grass seeds can germinate before the peat dries out.

A few similar bare patches in the wet hollow above the Hump in lower Coire Cas were smaller than in 1990, and will be reseeded again.

A few open cross drains on the gravel road up Coire Cas have become clogged, leading to run-off going down the road. These drains will be opened up, and a few new ones opened where there is too much of a fetch for run-off to build up.

As in 1990, the main inspections and discussions on the hill involved past damage. This will be an important part of the Environmental Baseline Survey of the whole Cairngorm Estate, being done currently by the writer. Detailed recommendations for reinstatement will be made there. However, some useful practical measures can be taken now in a few instances. For instance, the sharp-angled chips that I suggested last summer for the immediate pedestrian surrounds of the Ptarmigan Restaurant have proved successful, and should be used for future works of that kind. Over the years, a rill has developed down one of the steeper parts under the White Lady chairlift, and water velocity in this rill should be reduced by placing stones into the rill here and there, and similarly in a rill on a former trackway near the top of the Coire Cas tow, beside the big bend in the road. A few man-made ridge-tops below the top chairlift station had become bare due to exposure following the removal of snow fencing. Reseed after fencing these off from sheep. As the ridge tops are so exposed, some extra humus should help plant establishment, using a thin layer of fibrous peat broken up and sprinkled on top. Loose amorphous peat should be avoided as it will be liable to blow away in gales.

Monitoring the ski grounds will be a part of the Baseline Survey, and the sites to be monitored will be chosen this summer by Dr G.R. Miller and

myself after discussion with the Chairlift Company Manager, the ranger Mr Neil Baxter, Mr A.D. Walker (soil scientist) and Mr Keith Bryers of Highland Enterprise. The methods to be used have already been agreed in principle by Dr Miller and myself after inspections of the hill with Mr Baxter last autumn. The first quantitative annual monitoring checks will be set in place at permanent sites this summer, and the monitoring work will be done by Mr Baxter this autumn in cooperation with myself.

Dr Adam Watson, 24 June 1991.

MONITORING AT CAIRNGORM SKI AREA, AUTUMN 1991

Background

Independent annual inspections of ground condition at Cairngorm ski area began in 1990, following an initiative by the Highlands and Islands Development Board (owner of Cairngorm Estate) and agreement with the Cairngorm Chairlift Company (which leases the ski area). The HIDB had asked Dr Adam Watson to carry out an environmental baseline study of the estate, concentrating on severely damaged ground on and off the ski area, including footpaths. Permanent marked locations were set up for this in summer 1991, the first annual measurements were made, and measurements using the same methods each year will provide hard evidence on whether ground condition is improving, worsening or staying the same.

As at Glenshee, most of the human-induced damaged ground on the ski area was caused by construction operations many years ago, and on the wider Cairngorm Estate by long-term heavy usage by people, mainly walkers. This long-term damage will be measured annually as the main part of HIE's annual monitoring of their Cairngorm Estate's ground condition. Monitoring of the Cairngorm ski area will concentrate, as at Glenshee and the Lecht, entirely on fresh damage caused by skiing operations in the previous winter.

Procedure

As at the Lecht and Glenshee, it has been agreed that the writer will go with key Company staff each year on an early-summer inspection of fresh damage caused during the previous skiing season. The visit will be made after the main thaw, when nearly all ground is snow free. The purpose is to inspect fresh damage and discuss its origin, and agree on rehabilitation measures for that summer, to be done by Company staff. Shortly after this inspection, the writer will send a typed report on the inspection, to the Company, which will eventually send an agreed report to HIE and other relevant organisations.

After the end of the growing season, the efficacy of the rehabilitation measures will be checked by an annual monitoring check of those areas of fresh damage identified in the early-summer inspection. The detailed check will be made by the Chief Ranger, supervised by the writer, who will subsequently send a typed report to the Company. Other assistance may be used by the writer if necessary, and in 1991 Mr Richard Smith did some work. The first check was in late 1991; it was not done in 1990, as the methods to be used for the main HIE survey (and for the ski-area monitoring) were not finally decided until summer 1991.

Methods

As freshly damaged ground in early-summer 1990 and 1991 due to pisters and skiers was on a much smaller, more localised scale than at the Lecht or Glenshee, it was decided to concentrate on the main patches of freshly bared ground. Measuring damage on entire towlines and pistes as

at the other two centres would now be pointless on the Cairngorm ski area's towlines and pistes because there is too little damage there to measure with any reliability. The main patches in 1990 and 1991 were in lower Coire Cas, on peaty hummocks where snow cover is thin and where skiers cause most of the damage. The other main area, in 1991, was due to new construction work on the upper extension of the M1 tow below the Ptarmigan Restaurant. In late 1991, these areas were roughly mapped, the sizes of the damaged areas were estimated approximately by eye, photographs were taken from fixed points and will be repeated in future from the same positions, the percentage vegetation cover (or conversely the percentage of bare ground) was estimated visually, and notes were made on colonisation by native hill plants.

Top of M1

Excavations and other work here were done in late summer 1991. Some former man-made ridges were removed. The steep gravel bank on the east side of the new dismounting ramp was covered with topsoil turves brought in from low altitudes. Some reseeding was done. Inspection in October revealed that some fertile humus lay below the infertile granite grit on the ramp and nearby banks. In early summer 1992 this should be raked carefully and reseeded, after all pebbles, stones of 25 mm and upwards have been removed.

Lower Coire Cas

The patches of bare peat here are mostly opposite the Day Lodge, between the burn and the first line of snow fencing to the west. There are also some bare peaty patches more than half way up the lower chairlift, in a hollow beside a side stream west of the metal sewage tank and beside a hut for the small Shieling Tow. Between the main bridge over the burn between the top of the car park and the hut for the Car Park Tow, there are some damaged patches. Some of these had become worse due to insufficient delineation of ground to be protected, but after the early-summer inspection in 1990 the Company took measures to make the delineation clear and to reseed. Lastly, the ground at the ramp and bottom of the recent tow from beside the Day Lodge and up the slope to the east was inspected.

The next section is on reseeds opposite the Day Lodge, with No. 1 at the bottom and No. 24 at the top (data from R. Smith). The sites of the patches, their vegetation cover (percentage of ground covered by vegetation), and the main species of hill plants present are shown in Table 1. Vegetation cover, over and above the percentage for native plants, is due to reseeded grass. Other hill species noted by the writer on the partly bare peaty patches were:- cotton grass *Eriophorum angustifolium* colonising bottom reseeds, along with *Dicranum* moss, a little *Agrostis canina*, and broad-leaved sorrel. A few mountain hare droppings were seen on reseeds opposite the Bottom Chairlift Station, where many heather seedlings were growing. A little cowberry (*Vaccinium vitis idaea*) was also found, and a green foliose lichen growing on the

Table 1 Reseeds opposite Day Lodge

No.	Size	% Vegetated
1	4 x 1 m	30%, trace JS
1	2 x 2 m triangle	70%, trace NS
3	10 x 1.5 m	70%, 5% JS
4	12 x 2 m	70%, trace VM
5	3 x 3 m	50%, trace JS
6	9 x 2 m	80%, 5% JS, trace NS
7	5 x 1 m	25%, trace VM
8	4 x 1 m	20%
9	2 x 2 m	50%
10	3 x 1 m	30%, trace VM, CV, M
11	2 x 2 m	20%, trace CV
12	5 x 4 m	30%, trace M, JS, VM
13	3 x 2 m	70%
14	3 x 2 m	50%, 20% VM, 10% CV
15	7 x 3 m	60%
16	15 x 3 m	60%
17	10 x 2 m peaty bank	80%, trace JS
18	7 x 2 m	70%, 30% VM, 15% EN
19	13 x 4 m	80%, 30% E, trace V, CV, S
20	7 x 5 m	15%, trace CV, SC, E
21	10 x 3 m	50%, 5% CV, 5% SC, trace M
22	4 x 3 m	10%
23	track c. 1.5 m wide for 20 m	30%
24	large patch	70% vegetated, 60% SC, trace CV, M

JS = *Juncus squarrosus*
NS = *Nardus stricta*
CV = *Calluna vulgaris*
M = Moss
VM = *Vaccinium myrtillus*
EN = *Empetrum nigrum*
SC = *Scirpus cespitosus*
E = *Eriophorum*

bare peat. Opposite the gate above the Bottom Station, the reseeding success was poor, and the little vegetation present was mainly a thin crust of dark moss which often grows on reseeded peat where the grass seeding has largely or entirely tailed. This patch is on thicker peat, where an addition of lime in summer 1992 should accompany fresh reseeding; some heather seedlings were present.

Six patches beside the bottom of the Shieling Tow are described in Table 2.

Four patches near the bottom on the Car Park Tow were also inspected. A triangle 20 x 15 m beside the bottom hut had 90% vegetation cover. A 10 x 5 m patch uphill on the other side of the track had 80% cover. A 25 x 20 m triangle beside the vehicle track and towards the bridge over the burn had 95% cover, with 5% *Juncus squarrosus* and a trace of *Nardus stricta*. A small 2 x 2 m patch within that triangle, beside the track, had only 50% cover. The above cover values were due to reseeded grass except for the 25 x 20 m triangle.

At the bottom of the tow on the other side of the car park from the Day Lodge, inspection in December 1991 showed that the rehabilitation carried out had resulted in a high cover of reseeded grass on bare patches, and a highly successful recovery of turves of native hill vegetation which had been carefully dug out and replaced on the steep bank.

No quantitative estimates were made in summer and autumn 1990, but it was visually obvious that the patches of bare peat in lower Coire Cas were in better condition in early summer 1991 than in early summer 1990. The reseeding cover was also obviously greater in autumn 1991 than a year before, and the many seedlings of native hill species that have colonised is a good sign, especially the development of the tough clumping species heath rush, deer sedge and cotton grass. These withstand further trampling and other human impact better than the reseeded grasses, and better even than the heather that was there before.

Experience at Glenshee and the Lecht shows that reseeding of bare peaty patches gives poor results for a few years, as has happened in lower Coire Cas. However, continued fertilising and reseeding, with lime also on thicker patches of peat, leads eventually to a better reseed and invasion by native species. The end result can be a complete vegetation cover of tough wiry clumps of native hill species. This is the aim at Cairngorm ski area. Fresh damage by skiers can set recovery back, but the aim is to increase the summer recovery by substantially more than the previous winter's loss, and so get a complete, resistant vegetation cover as soon as possible. Extra intervention techniques will be used in summer 1992 experimentally, in an attempt to speed up this process.

Table 2 Reseeds half way up Chairlift

No.	Size	% Vegetated
1	3 x 3 m	15%, trace *Carex* sp. and M
2	6 x 1 m	15%, trace CV
3	6 x 3 m	70%, 5% NS, 15% M, trace SC
4	2 x 2 m	90%, 15% NS, 70% M, trace VM, JS, SC
5	3 x 3 m	50%, 30% M, 10% CV
6	8 x 10 m triangle	75%, trace JS, SC

It should be understood that all these damaged patches are on easy gradients where there is no risk of serious erosion and hence no threat to the hill. The objective is to rehabilitate the damaged patches primarily for amenity reasons, because they are in areas seen by large numbers of people.

Dr Adam Watson

January 1992

Cairngorm Ski Area, early-summer inspection 1992

I visited the area on 23 June with Tom Paul and Tim Whittome of the Chairlift Company and Dave Carstairs of Scottish Natural Heritage's Aviemore office. This was the first annual inspection visit attended by a member of NCC (now SNH) staff. It was agreed that this was a useful addition, as it has proved to be for some years at Glenshee, and that Mr Carstairs will come on future visits.

The previous winter was exceptionally snow-free and the skiing season extremely poor, as was also the case at other ski areas. Some Cairngorm pistes were very little used. Much snow fell at high altitudes in April and early May, but since then the weather had been unusually warm, dry and sunny. Plant growth at the time of our visit was therefore further on than usual, but ground conditions had been too dry for reseeding.

Fresh baring of ground and vegetation damage as a result of skiers, pisters and other operations to do with skiing during the previous winter were not found except at several places in lower Coire Cas and at one small spot in lower Coire na Ciste. These were all local pressure points where skiers had trampled on small bare patches of peat, mostly at the very foot of Coire Cas opposite the Day Lodge (details below).

During the visit, an opportunity was taken to familiarise Mr Carstairs with the thinking that has developed since the first summer inspection in 1990, and it may be useful now to describe this briefly here. On the 1990 inspection it was clear that most of the problems of ground condition on the ski area were a result of construction operations and other activities done many years ago, along with a continuing problem of ground disturbance due to walkers. Fresh vegetation damage and fresh baring of ground due to downhill skiing and associated operations during the previous winter were of relatively little importance, and were of no importance as threats to the hill by rapid run-off and soil erosion. It was agreed that they were important in terms of amenity, as they were on the lowest parts of the hill that were seen by most visitors, and hence should be tackled by reseeding and other work; this has been done annually by the Company since, and the bare patches have become better vegetated each year. At the same time, it is generally being agreed that bare ground caused by long-past operations and continuing trampling from walkers, and path deterioration caused by walkers, should be rehabilitated with help from other bodies. The Countryside Commission for Scotland have stated that they would be prepared to help with such works, and this commitment now rests for Scottish Natural Heritage to deal with. The present report differs from previous ones in that it describes not only current problems of fresh damage from the previous winter, but also the background that will be useful for tackling these longer-term problems in future.

On the 1990 inspection I suggested that loose rounded stones rolling on to vegetation below, as on the walkway around the Ptarmigan Restaurant, should be replaced with sharp-angled stones that interlock when trampled upon. This was later done at the Ptarmigan, and has been successful in solving the problem, as well as forming a better surface to walk on. I also suggested that the key principles for reducing erosion and vegetation damage on gravel roads and paths were to i) cut the width of bare ground to the minimum width necessary for vehicles etc to use the track, ii) have good cross-drains on steep sections, diverting into safe watercourses, and maintain them, iii) use sharp-angled stones on steep road surfaces, rather than rounded granite grit, iv) put rocks into large drains so as to reduce water speed, and v) when rocks are used on paths, place them so as to reduce water speed to the maximum and not leave a relatively smooth

surface as on the granite path to Cairn Gorm summit. A good operational guide is to see where surface run-off water goes in heavy rain or thaw, reduce the water speed by bends, rocks, waterfalls and other obstructions (as in a burn), and divert the water into safe watercourses. We agreed that the most revealing visits are in heavy rain, when it is easy to see where extra drains are needed and where other problems are developing. The annual inspection visits have involved good detailed discussions where each of us has learned from the experience of the others, from examination and observation of case problems on the ground in front of us, and from the results of new methods tried out on the hill at Cairngorm and other Scottish ski areas. This combined thinking has also been applied to the new ground works carried out by the Company (see below).

Ptarmigan Restaurant area. In front of the restaurant, below the walkway, isolated boulders that were put there many years ago when the foundations were excavated have had a raw, artificial appearance, so it was decided to remove them. The holes should be reseeded, with some soil added to the larger holes. The grassy ground there should be raked to remove the loose stones lying on the vegetation, and small pieces of broken cement removed.

Towards the Ptarmigan Tow. Many visitors in summer walk out to a snow patch at the top of the hollow beside the tow, using a gravel track for much of the way. For the future, it would be useful to narrow this track and keep the track to the horizontal parts, avoiding having it on a cross slope. I suggested that it might be useful to consider a circular route coming back to the Ptarmigan Restaurant at a higher level, so as to reduce the numbers of people wandering about off the path after it ends.

Marquis' Well path. The intention for the future is to narrow it down and reduce water flow as described above, perhaps as part of a circular path up to the summit of Cairn Gorm by the granite path and back down by a different route past Fuaran a' Mharcuis using the Marquis' Well path. As a result of less use by people, there has been considerable colonisation of the bare grit by moss and other plants. Reseeding of the banks lower down, below the top of the Ptarmigan Tow, has been reasonably successful, although it could now do with a repeat treatment. Ideally the entire track should be reseeded, after future ground works have been completed. As usual in the main spring thaw, some grit had been washed off the path and nearby patches of bared ground on to ground below the path, including some local deposits on vegetation. The amounts involved were much smaller than in most past years.

M1 extension. The turves and reseeded ground on the ramp at the top had survived the winter well. On the day of our visit the reseeded grass had not started to grow, but on 17 July there was a good green sheen of new growth there and the turves were growing well. It was agreed that loose stones and heaps of sand and gravel at the top end of the disturbed area on the new ramp would be removed. Near the top station of the new M1, drains have been made and lined with turves, which is a new idea from the Company. These drains should be photographed as a record. Drains subject to frequent water movement would be unsuitable for turves, which would tend to die out, but the drains at the top of the M1 are subject only to occasional water flows. If the turves do survive, they should reduce water speed and erosion of the drain surfaces. There is plenty of evidence on Cairn Gorm that reseeding and natural colonisation of bare grit by native hill plants are more successful on damp ground, including drains that hold water only occasionally. Big stones and boulders lying on top of vegetation should be removed, and could usefully be put into gravel-surfaced drains to reduce water speed. Most turves of vegetation had been put back on the

ground carefully, but a few were upside down on the date of our visit, which was during the period when works were still going on; these will be put back right way up. Any patches of bared ground that still occur as a result of the ground works in this area should be reseeded. In many spots there where the surface is of granite grit, slight digging with the finger showed that this grit is a thin layer lying on top of darker, more fertile topsoil, which has been buried by the construction works. Such places should be raked to expose some of the underlying topsoil, before reseeding.

Last summer, one of the big, longitudinal earth ramps was removed. Originally this was bulldozed so as to catch drifted snow behind it, in an area that lacks good natural snow-holding. The ramp was then reseeded, but the grit along the top of the ramp was too exposed to wind and drought to support vegetation well, so it tended to stay bare. Moreover, better understanding of the use of snow fencing and pisters has removed the need for earth ramps, so it was agreed that this one should be removed. The vegetation on the ramp was carefully dug out as turves, the boulders forming the inner core of the ramp were removed to help form a French drain lower down the vehicle road, and the remaining gravel was covered with the turves. Any bare ground left will be reseeded, after loose stones have been removed. It was agreed that removal of the earth ramp had proved very successful, and the area now looked more natural.

Upper part of vehicle road. Considerable erosion of the grit surface of the road had occurred in the upper section during the main spring thaw. On the upper section, drains had been constructed shortly before our visit, on each side of the road. The intention is to provide better drainage of the road but also to contain walkers on to a good, narrow, central line on the road, instead of having them walking frequently on the edges as in the past. The edges of the road are now far better defined. Reseeding on these new open drains was done after our visit, and was starting to show well on 17 July. Cross-drains on the road have also been dug. At a point where the road had eroded to bedrock, the road surface has been raised by adding new gravel taken from the old earth ramp.

At the corner at the top of the traverse into the upper part of Coire Cas, the outer edge of the road has been raised to prevent eroded grit being washed off the road on to vegetation on the downhill side. The raising involves a drystone wall with a little cement to keep the top together, and snow fencing is to be added on the outside of the wall. New drains have also been constructed, and Arthur McCabe of the Company staff reckoned that these were working well, after inspecting them on a wet day.

On the main part of the traverse, all snow fencing on the outer edge had been replaced by 17 July. The deep trench eroded on the inside part of this section of the road has been elevated to provide a better, more level surface for vehicles and walkers. The main elevation involved filling the trench with a great quantity of spare boulders from the earth ramp and other parts of the new construction works, thus forming an effective French drain at the same time, to reduce further erosion of the road. Cross-drains have also been dug at intervals to remove water going down the road and to divert it into the French drain.

On the hillside above the traverse, and particularly at a point about half way along the traverse, there is evidence of soil deposition from erosion starting much higher up. This has been a problem for years, and during detailed examination of the entire hillside in 1981 I found that it was caused by small numbers of walkers traversing the steep hillside much higher up, after coming up the chairlift and lower part of the granite path to Cairn Gorm, but then moving off the path as a short cut to the plateau,

and as a short cut on the return route. Tom Paul agreed that walkers were the cause, and said that unfortunately this route was described in a book by E. L. Cross, even though this route was not a path at all, and that this had led to increased numbers. The sediment movement downhill as far as the road does not occur on parts where the hillside above contains stretches of large boulder scree, as the scree higher up acts as a sediment trap.

Headwall of Coire Cas. On the inspection visit I noticed four fresh small landslips in the central steep part of the headwall; these were not there during the middle of the winter and probably occurred during the main spring thaw. They occurred on an area with greatly increased bare loose ground as a result of walkers going on to this steep slope, which always had much bare ground because of the short growing season at this long-lying snow bed. I will examine the landslips in more detail later this summer, and the transect markers put in by Neil Baxter as part of the monitoring of ground for HIE may also show the effects when the field work on the transects is done later this summer.

Lower part of vehicle road. On the first long steep part below the big bend, we agreed that it would be useful to narrow the width down to the minimum, and to indicate the sides of the road better with drains, so that walkers stay on the central part. On the section that has been reseeded, the big bank is looking quite well but could do with some more seed. Most of the small cross-drains have filled up with eroded sediment from higher up, and need opening up, as far down as the "105". At the big bend we crossed over to look at the top of the Coire Cas tow track; near the top of it there is a bare area that is unnecessarily wide. The intention is to narrow it down by reseeding in due course, but there is no risk of serious erosion as the gradient is so low.

Near tower 6 we had a discussion about the unsuitability of Cairngorms granite grit for binding on a road surface, and the need for sharp-angled gravel and grit to produce a better and more lasting surface that binds together, is less likely to erode in rain, and is less likely to roll and loosen under the impact of walkers and vehicles. The Company will also try out a type of quarry dust that may be useful for the top surface.

Between towers 6 and 7 the road has widened out considerably. This should be brought in by reseeding, additional drains, better surfacing, and possibly marking the central part of the road with coloured tape on each side.

On the zigzags there is some water erosion on the road. The intention is to use drains to narrow the road down and encourage people to walk on a central section with improved walking surface. At the western end of the top zigzag where the path heads up to Fiacaill a' Choire Chais, we looked at slippage on the roadside bank due to walkers taking different lines when coming off the hill. Tom Paul had constructed granite steps with boulders at the end of the zigzag, and people tended to use this on the way up, but it was agreed that walkers on the way down tend to spread out and use a variety of routes. This could be solved by having one, visually obvious, good path, and by perhaps putting obstacles such as boulders on this path at points where subsidiary paths spread out going downhill.

At the bottom of the Coire Cas Tow, there has been quite a lot of water running down the road to the burn just above the last tower before the turn-around of the Car Park Tow. This needs attention by better drainage. The path going through underneath the bottom station of the Coire Cas Tow has been narrowed down using grass turves, and the grass in these was growing quite well.

Paths from car park to Fiacaill a' Choire Chais. Several paths have proliferated here, especially on the lower, heathery part of the hillside; the paths converge higher up, below the top of the Fiacaill Tow. Some of the ground on these lower paths is black, churned peat, as the paths take fairly straight lines and go through wet ground with thick peat as well as drier ground. It was agreed that this multiplicity of paths is caused largely by walkers taking different routes when coming downhill.

Bare peaty patches on pistes in lower Coire Cas. These occur mostly in a wet hollow above the old "Hump", and also opposite the Day Lodge. In autumn 1991 they looked better than they have done for years, due to reseeding and colonisation by native hill plants (see monitoring report for autumn 1991). In early summer 1992 they looked far better than they have ever done at that season in recent years, partly because the lower pistes were little used but mainly because of the better ground cover of vegetation at the start of the winter. Some patches showed no obvious vegetation damage or increased bare ground at all. Others were affected, and should be reseeded. On the wettest patches above the Hump, where water was showing even during the dry spell when our inspection visit took place, it would be useful to get rid of most of the water by digging surface drains with a spade, up to 2-3 inches deep. This has proved very effective on the thick wet peat at the Lecht in drying out the wettest surfaces of bare peat and aiding in the success of reseeding and colonisation by hill plants.

Dr Adam Watson, 10 August 1992

CAIRNGORM SKI AREA INSPECTION AUTUMN 1992

Introduction. Dry weather in late May and June prevented good growth on reseeded ground and prevented new reseeding. However, rain in early July allowed new reseeding to take place and the wet late summer and autumn provided very good conditions for growth of reseeded grass and indeed for colonisation of bared ground by hill plants. The sunny warm June resulted in excellent heather flowering, even at high altitudes. The seeds from these heather flowers will have been spread abundantly in the autumn, and this is likely to lead to larger than usual numbers of seedlings in 1993.

The main quantitative monitoring in 1992 was done on the small peaty bared patches in lower Coire Cas. As noted in the inspection report for early summer 1992, these looked better in early summer than they had ever done at that season in recent years, and the recently disturbed ground at the top of the extended M1 Tow looked in good condition as a result of careful ground works and reinstatement. I decided, therefore, that it would be unnecessary to do quantitative monitoring of these areas this autumn. A careful eye will be kept on them, and if in future there is a trend for the worse, they can be measured again. The present report is therefore based on inspection alone, without any need for quantitative measurement. This reflects the fact that ground conditions have been improving for several years and that new operations are being done to an increasingly high standard.

Ptarmigan restaurant and top of M1. The holes where boulders were removed in summer, below the viewing parapet, were reseeded, after the deepest holes had been partly filled with soil. The reseeding had done very well, and the shelter and higher moisture in the holes had probably helped grass growth. The larger loose stones that had been lying on the vegetation had been raked up and removed, and bits of broken cement also.

Above the top of the M1, the loose stones and small heaps of spare sand and gravel had been removed. The reseeded grass on the mound at the top of the tow had a very good ground coverage and was beginning to be a firm sward. It shows the best success by far for any reseed done above 1000m on Cairngorm ski area since the first reseeds were done in the 1960s.

The turves laid in the drains had all grown well, and very little washed grit was lying on them. So far, then, the turves have clearly reduced scouring of the drain surfaces, partly because turves that would be difficult to wash away are lining the drain rather than easily erodible grit, and partly because the plant leaves in the turf would be expected to intercept runoff water and sediment, and so reduce both of them. The small amounts of sediment on the turves can certainly not be attributed to little rain, as the late summer and especially autumn were much wetter than usual.

The few turves left upside down at the time of the early summer inspection had been put back, right way up. Most of the big stones and boulders lying on the vegetation there in early summer had been placed in drains to reduce water flow, and any patches of bared ground of ½ square metre or more had been reseeded. The 1992 reseedings had taken very well, despite the great wind exposure on the ridge below the Restaurant.

Vehicle road. The work done in early summer, described in the summer report, has greatly improved the surface on the upper part of the road down to the big bend near the top of the Coire Cas Tow. This has also greatly reduced erosion and sediment flow down the road itself and from the road on to the donwhill slope where it had periodically washed out on to vegetation.

The surface on the lower part of the vehicle road has been improved by better cross drains and main drains, better surfacing on the road, and

reseeding of the sides. The turves defining the edges of the narrowed path underneath the bottom station of the Coire Cas Tow had grown well over the summer, and showed no signs of dehydration. It remains to be seen whether this would be the case in a dry summer.

Bare peaty patches on pistes in lower Coire Cas. The barest of these had been freshly reseeded in summer 1992, while others with a fairly good grass cover were not reseeded. The fresh reseeding showed good growth. On the patches opposite the Day Lodge, dwarf cornel seedlings had colonised the damp edges of the bared patches and had grown well in 1992. This is an interesting and attractive species which is not abundant, but previous observations at the Lecht indicate that it can become commoner than usual on lightly disturbed pistes on thick peat, where reseeding and fertilisng has been done. Blaeberry and cowberry had also colonised well, and there were numerous heather seedlings. Heath rush and Eriophorum angustifolium were colonising and both had produced many seeds in 1992. Sorrel and cloudberry were also colonising.

The biggest patch with bare peat was about 3 x 1m; vegetation cover was 40%, mostly reseeded grass. However, heath rush, heather and other colonising plants round about had produced many seeds, as had some of the grass reseeded in 1991. Another big patch near the foot occupied about 5 square metres and had about 35% vegetation cover, mostly reseeded grass but with Dicranum moss and heather seedlings colonising.

The "island" where the vehicle track runs west of the bridge over the burn showed a strong growth of clover and invading heath rush. Heath rush and Eriophorum angustifolium (see also two paragraphs up) are both tough tussocky hill species which withstand human trampling and machines far better than reseeded grass, and they are therefore a very good sign.

Coire na Ciste. The first 100m of steep slope from the bottom building uphill beside the chairlift is in a poor state, with wet bare churned peat up to 10m wide and mostly about 5m wide. This was caused originally by people walking on the vegetation above thick wet peat. This is a vegetation type that very readily suffers damage and destruction, as is most obvious at the Lecht. The short slope at Coire na Ciste has been like this for over ten years, and it is not obviously getting materially worse. There is no risk of severe erosion as the peat is mostly fibrous and not amorphous, and there is not a serious amenity problem as the area is seldom used in summer. It will be discussed with the Management during the 1993 early summer inspection.

Along the bottom 120m of the Aonach Tow are a half dozen patches of mostly bared peat on a pressure area where snow cover is sometimes thin or patchy. The biggest patch is about 3 x 2m. There is no erosion risk and the area is seldom seen by summer walkers. This will be discussed with Management in 1993. If it is decided to reinstate, the methods should follow those practised successfully on the similar patches opposite the Day Lodge.

Dr Adam Watson, c/o Institute of Terrestrial Ecology, Hill of Brathens, Glassel, Banchory, Kincardineshire AB31 4BY. 28 December 1992.

APPENDIX 5. REVIEW OF MONITORING

The problem sites fall into five categories for monitoring:-

Category	
0	no check needed
1	recommended action needs checking after action implemented, but no monitoring needed thereafter (e.g. removing rubbish or posts).
2	recommended action will ease but not solve problem, so monitoring recommended by a check every 2 - 3 years, not entailing detailed quantitative estimates; colour photographs useful on each check at same time of year, taken from same positions.
3	as in 2, but annual check; also colour photographs as in 2.
4	damage serious but so diffuse and covers such a big area that difficult to assess reliably without quantitative monitoring by annual visual estimates; also colour photographs as in 2.
5	quantitative monitoring by annual measurements at fixed marked sites; also colour photographs as in 2.

Monitoring at a given site could be changed from Category 3 to 2 if ground improvement were sufficiently good. Similarly, Category 2 sites might in future be considered for Category 3 monitoring if damage were to become more serious. In this way, monitoring would be flexible and could be changed to meet future conditions that may arise.

APPENDIX 6. LIST OF MONITORING PROPOSALS

Site number*	Category of monitoring×
1	0
2	3
3	2
4	2
5 - 8	1
9	0
10	2
11 - 18	3
19	3, ?4
20	5
21	3
22	5
23, 24	3
25, 26	5
27, 28	2
29	3
30	2
31	5
32	3
33 - 40	2
41	3
42	2
43, 44	3
45, 46	2
47 - 50	3
51	2
52, 53	3
54, 55	4
56 - 59	3
60	5
61, 62	3
63	2

* See Section 11 and Fig. 4 for more details
× See Appendix 5 for explanation

APPENDIX 7. SUMMARY IMPLEMENTATION TABLE

Problem	Priority Individual	Priority Overall*	Treatment	Timing	Responsibility
1	IV & E	-	0	none	Co
2	IV & D	3	reseed	95	"
3	V & C	3	reinstate	post 95	"
4	IV & C	3	sign	94	HIE
5	V & V	3,+	discuss	discuss	"
6	IV & B	2	fill	94	"
7	V & C	-	0	none	"
8	V & C	3	reinstate	95	"
9	V & C	-	0	none	"
10	IV & D	-	0	none	"
11	IV & C	1	repairs	annual check	Co
12	V & B	1	rationalise	"	"
13	V & B	2	reinstate	post 95	"
14	V & B	2	rationalise	"	"
15	IV & B	1	repairs	annual check	"
16	IV & C	1	"	"	"
17, 18	V & B	1,+	"	"	"
19	IV & B	1	discuss	discuss	CO & HIE
20	III & D	1	fill rills, monitor	94	"
21	V & B	3	narrow	post 95	Co
22	IV & C	2,+	monitor	annual check	HIE & Co
23	III & C	1 2	signs repairs, monitor	94 annual check	Co & HIE
24	IV & D	3	sign	post 94	Co & HIE
25	V & D	3	repairs	annual check	HIE
26	V & D	3	"	"	"
27,28	V & C	3	0	check every 2-3 years	"
29	V & C	2	repairs	?95	"
30	V & D	-	0	check every 2-3 years	"
31	IV & C	1	monitor	annual check	"
32	III & C	1	?sign	"	"
33-35	IV & C	0	0	check every 2-3 years	"

Problem	Priority Invididual	Overall*	Treatment	Timing	Responsibility
36	IV & C	+	discuss	discuss	"
37-39	V & D	-	0	check every 2-3 years	HIE
40	V & C	-	0	"	"
41	IV & C	3	repairs	discuss	Co
42	V & D	-	0	check every 2-3 years	?HIE
43	IV & C	-	0	annual check	Co
44	IV & C	3	fill rill	"	"
45	V & D	2	repair	94/95	HIE
46	IV & C	-	0	"	"
47	IV & C	2	add rocks	?95	Co & HIE
48	III & C	1	repairs	discuss	Ski Club
49	IV & C	2	"	"	Co
50	IV & C	3	reseed	96	"
51	V & B	-,+	?reinstate	discuss	"
52	V & D	-	0	annual check	"
53	IV & C	-	0	"	"
54	V & D	1	reseed	annual check	"
55	V & D	1	reseed	"	"
56	V & E	0	0	annual check	"
57	IV & C	0	0	"	HRC
58	IV & D	3	repair	"	Co
59	II & B	1	signs	94	HIE
60	I & D	1	repair, signs, monitor	94 94 annual	?HIE
61,62	IV & D	-	0	annual check	HIE

* - no action needed
+ discussion needed before action taken

APPENDIX 8. DETAILED SPECIFICATIONS FOR REDUCING DAMAGE (FROM WATSON 1990a, APPENDIX 6)

This Appendix is taken a) from the specifications for rehabilitation of disturbed ground on the Glas Maol Tow at Glenshee Ski Centre, copied as Appendix 9 in Watson (1988), and b) "Specific recommendations" after Watson & Walker (1987) on possible alterations at The Hump in Coire Cas.

a) Specifications for rehabilitation of disturbed ground on the Glas Maol Tow.

1. Surplus stones over 2" to 3" in size from the foundation pits should be disposed of. These could be removed from the site or placed along the foot of the snow fencing. On the lower slopes they could perhaps be buried. After some considerable discussion, it was agreed that, in view of the nature of the ground, the least environmental disturbance would be caused by the use of a suitable vehicle to remove the stones from the line of the tow for disposal elsewhere.

2. The concrete bases of the pylons should be flush with the restored land surface. There was some uncertainty, however, as to whether the bases should be soiled over or not. It was eventually agreed that it was desirable, but not essential, that this should be done. It was noted that, at the Lecht, Moray and Gordon District Councils held different opinions over the need for soiling over. After the meeting, however, Dr Watson gave further thought to the question of whether pylon bases should be covered over with soil and then revegetated. He decided that it would be unwise to cover them and further discussions with builders have confirmed this view.

Pylon bases should be open for inspection as part of normal maintenance and safety checks. If cracks occur, they can be dealt with easily, but only if they are visible! Covering up pylon bases would prevent visual inspection, and hence would cover up potential hazards. The importance of this outweighs the aesthetic argument for covering them. The aesthetic argument is not very strong anyway, as the main intrusion on the landscape is due to the pylons and snow fences, not the pylon bases.

Since there are strong safety reasons for not covering up pylon bases with soil, Dr Watson recommended that this should on no account be done to the Glenshee pylon bases --- this recommendation was subsequently accepted by all parties.

3. Before the areas around the pylon bases were reseeded, they should be smoothed out. Abrupt changes in slope and dwarf retaining walls of stones should be eliminated.

4. To improve the chances of re-establishing vegetation, peat (preferably from deposits re-worked by water) should be incorporated with the spoil from the pylon foundations in cases where the spoil was all gravelly and hence very infertile (yellowish to orange in colour). There would be no need for this if the spoil had some topsoil in it (tinged brown or blackish).

5. The areas of bare and eroding peat at the foot of the Tows had originated naturally and pre-dated development. A succession of mild winters could lead to problems but these would be picked up as they arose by the monitoring programme. They could supply the peat required in 4.

b) Specific recommendations (after Watson & Walker 1987)

1. The likelihood of successful reinstatement during late summer or autumn is poor. It is recommended that excavation be done in spring. Provided that weather and ground conditions permit, the completion of earthworks should be aimed at late April for the Devil's Elbow area and mid June for the highest sites. Reinstatement should be completed by 2-3 weeks later. This is very important because of the poor water-retaining qualities of the subsoil, and because it would allow the maximum growing season for plants.

2. In view of the damage ensuing to vegetation underneath stockpiled soil and vegetation, all stockpiles should be placed on strong plastic sheeting. Such a procedure would also make it easier for the operators to move the remnant stockpiled material quickly, without loss of material, and without damage to the underlying vegetation. Precautions against wind damage to sheeting must be taken. Stockpiled soil should be stored if possible on excavated ground, not on intact nearby vegetation.

3. Where vegetation is stripped and where its cover allows the removal of complete turves, it should be handled and stockpiled with great care. Although the thickness will vary from site to site, a minimum of 6 inches should be aimed for in the peaty hollows, but substantially less in exposed places. Further details on depth and on the precise methods for optimum storage of turves will be available from the writer and Mr A.D. Walker in combination.

4. In all excavations, the utmost care should be used in stripping the site in three stages, a) the topsoil and immediate subsoil should be stripped very carefully because they are so thin, and should be stored separately, after the contained boulders and big stones have been removed, b) the depths of the upper soil horizons to be stripped vary according to the nature of the soil present, and hence must be identified continuously in the field by a competent supervisor, in order to maximise the potential of the material present, and c) the remainder of the subsoil should be monitored continuously and an attempt made to pick out large boulders individually and withdraw them temporarily prior to their final deposition. The separately-stockpiled soil horizons must be replaced in reverse order.

5. The maximum use should be made of vegetation and soil on site. This includes careful stripping of vegetation and soil from areas of infill. Because of the acidic and highly podzolised soils on much of the site, it is inadvisable to import ex-arable topsoil which invariably has a higher pH and a radically different cation exchange capacity, structure and texture.

6. The use of grass species eminently suited for lowland grass production is not recommended for the hostile environment at Glenshee Ski Centre. As endemic hill species are now commercially available, their use is strongly advocated. Many of the topsoils at these mid altitudes have a highly organic top. It would be advisable, therefore, to ensure the presence of similar high organic contents prior to reseeding. This could be best achieved by using acid peat from nearby deposits. It would be preferable to use peat turves stripped by means of dragline. If the peat were excavated vertically rather than horizontally, then careful identification of the precise nature of the peat deposit would be necessary.

6. In future, to aid re-instatement around pylons, the turf down to 6 inches and the subsoil down to 12 inches should be separately stored on polythene sheets until replacement. Debris from the foundation pits should be stored on areas from which the turf had been temporarily removed. The roots of turves in storage and after replacement should not be exposed and thus subject to drying out and, on replacement, soil to be packed and brushed into all joints.

7. Nardus and Deschampsia flexuosa seeds were now available commercially and should be used where all other attempts at re-instatement had failed. Mr Watt stated that serious consideration should be given to using Nardus seed initially on upper reaches of the Glas Maol Tow where establishment will inevitably be difficult and this should not be considered only as a last resort.

8. Damage caused by the snow fences diverting and concentrating the passage of sheep along the slope should be reduced by opening the snow fences where these crossed the more heavily used former sheep tracks.

It was agreed by all present that these improvements should be implemented. Mr Rothwell remarked on how little damage the Fionn Choire Tow had caused.

APPENDIX 9 ENGLISH AND LATIN NAMES OF SPECIES

Plants

Common bent	Agrostis capillaris
Velvet bent	A. canina
Sheep's fescue	Festuca ovina
Mat grass	Nardus stricta
Sweet vernal grass	Anthoxanthum odoratum
Wavy hair grass	Deschampsia flexuosa
Tufted hair grass	D. cespitosa
Stiff sedge	Carex bigelowii
Deer sedge	Scirpus cespitosus
Hare's tail cotton grass	Eriophorum vaginatum
Common cotton grass	E. angustifolium
Heath rush	Juncus squarrosus
Woolly fringe moss	Racomitrium lanuginosum
Hawkweed	Hieracium sp.
Cloudberry	Rubus chamaemorus
Dwarf cornel	Cornus suecica
Rosebay willow herb	Chamaenerion angustifolium
Foxglove	Digitalis purpurea
Bog asphodel	Narthecium ossifragum
Alpine lady's mantle	Alchemilla alpina
Dwarf cudweed	Gnaphalium supinum
Starry saxifrage	Saxifraga stellaris
Common sorrel	Rumex acetosa
Heather	Calluna vulgaris
Bell heather	Erica cinerea
Crowberry	Empetrum nigrum agg.
Blaeberry	Vaccinium myrtillus
Cowberry	V. vitis idaea
Broom	Sarothamnus scoparius
Scots pine	Pinus sylvestris

Animals

Red deer	Cervus elaphus
Mountain hare	Lepus timidus
Ptarmigan	Lagopus mutus
Dotterel	Charadrius morinellus

APPENDIX 10. ASSESSMENT OF SNOW LIE FOR GROUND PROTECTION (FROM WATSON 1990a, p. 62)

The best way to assess useful lines for possible future tows, pistes and snow fences is to use the operators' experience by trial and error of the success of different kinds of ground in the past, along with detailed ecological and topographical experience of snow-patch vegetation, snow patches and snow drifting. Detailed inspection of the ground in spring and summer by people with both kinds of experience, working together and discussing the problems fully in the field, has been found useful at the Lecht.

It has often been stated that Scottish ski developers should collect data on snow lie on places likely to be proposed for future developments, and indeed that this is essential information, without which planning applications should not be considered. These statements have been made by several individuals or groups opposed to particular developments on environmental grounds, and the report on the "Environmental Design and Management of Ski Areas in Scotland" (ASH Environmental Design Partnership 1986) recommends that ski operators in Scotland collect data on snow lie as a routine job. In the writer's view these statements are misguided when applied to Scottish conditions, even though they have been found to be important in the Swiss Alps and elsewhere.

Snow lie in Scotland is notoriously variable, and can change greatly from day to day, and even from morning to afternoon on days with strong winds and powder snow. Even if one did set out to measure snow lie, the measurements would entail serious difficulties of statistical sampling if the data were to be used for reliable generalisation. Moreover, the question would still remain: what would the data mean in terms of useful snow for skiing? Much store has been put on the Snow Survey of the Meteorological Office as a source of data on snow lie at high altitudes, for assessing ski developments (e.g. Anderson Semens Houston 1981). However, the Snow Survey data on snow lie on the hill were shown at the Lurcher's Gully Public Inquiry to be of no value as a guide to skiing conditions on the hill (Dunlop 1981; Watson 1981). Even if a useful, sound method could be devised, one would still have the snag that the data would relate only to those days or seasons when measurements were made. Snow lie in Scotland varies much between winters, and it is possible to get runs of two or three snowy winters, or two or three mild ones. Hence, even if a good method could be devised (which has not yet come about for assessing Scottish snow conditions for possible ski developments), the measurements would have to be done for 4-5 years to provide a reasonably reliable guide to typical or average conditions. This is unrealistic.

In contrast, the vegetation shows the hill plants' long-term response to typical or average conditions. It is a far more reliable guide than the most sophisticated measurements of snow lie, particularly when used in conjunction with experience of the behaviour of drifting snow and the occurrence of snow patches in relation to the topography of the area.

APPENDIX 11. PHOTOGRAPHS SHOWING CHANGES IN PROBLEM SITES AND PATH REPAIRS

Photographs of the same spot in different years can be valuable in showing whether sites with damaged ground show obvious deterioration or improvement or no material change. I suggested in May 1993 that it would be useful for this report to reproduce some photographs of damaged ground in earlier years, along with new photographs of the same places taken at the same season in 1993. This was agreed.

Mr T. Paul had taken the main set of photographs in June-July 1975. He went on the hill in June-July 1993 with prints of the earlier photographs so as to find the locations, and then took new photographs there. These pairs of photographs provide an important record showing visually obvious changes on the ski grounds.

Mr K.S. Bryers took photographs of paths before and during repairs. Special visits to retake photographs of paths after repairs were not made in 1993 as on the ski area. By chance, however, the same view of one site had been taken both before and during repairs. Other photographs during repairs are valuable in showing the scale of the repair work. It should be noted that ground condition along heavily used paths is generally far better some months or years after repairs than it was during repairs. This is because of natural and human-induced revegetation of formerly bare areas on either side of the main central band of the repaired path.

1

Wide stretch of churned-up wet peat at the start of the Northern Corries path, September 1987, prior to repairs.

2 Same location looking in the opposite direction as 1 in July 1988. Much of the peat has been excavated and black geotextile matting is being laid by the path repair team, with broken-up local rock placed on top. Finally the surface is finished with a layer of fine well-drained gravel.

3 & 4

A helicopter is used to transport heavy material to remote sites, as here on the path to Chalamain Gap, west of Caochan Dubh a' Chadha in August 1989. Each skip carries 750kg of material. The road to Coire Cas can be seen going up the far hillside above the helicopter in Photo 3.

5

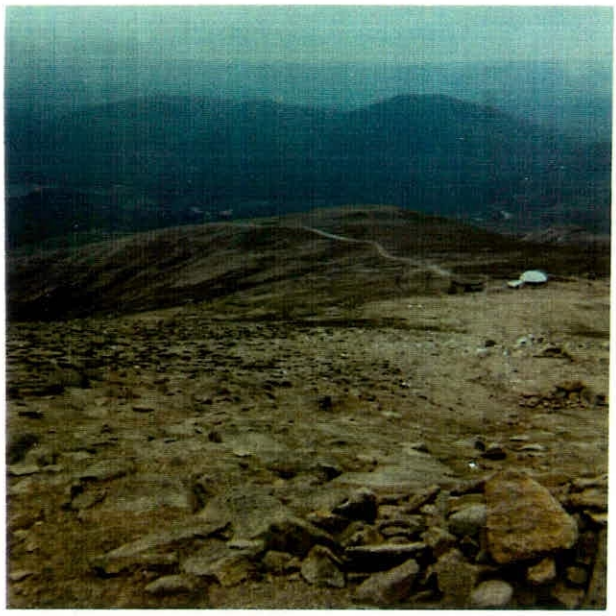
Looking downhill from lower section of White Lady piste, mid 1975.

6 Taken slightly above 5, July 1993, shows (a) marked revegetation in foreground, (b) disappearance of a pale track (horizontal line beyond the stony ground in the 1975 photo), (c) revegetation around building second from left and (d) around the Scottish Ski Club hut on far right, including disappearance of track above right building, (e) revegetation of tow track and other tracks from top of building second from left down to the lower part of the sinuous road to the car park and (f) of bared area above building second from left. Note that the largest landslip on the Allt Mor (top right, behind car park) shows no obvious change.

7

Shows direct path from Ptarmigan restaurant to Cairn Gorm summit, mid 1975.

8 Shows same view June 1993. Note the narrowing of the bared ground by the path, and better vegetation cover, especially on the lower slope. 1975 photo shows white quartzite boulders on either side of bottom end of path and thin reseeding there and on either side. 1993 photo shows good cover of vegetation in same place (some of quartzite boulders have been removed to allow skiers to pass in winter).



9

Looking down direct path to Ptarmigan restaurant, mid 1975.

10 Same view, July 1993, illustrating major vegetation recovery mainly due to channelling walkers and to a lesser extent reseeding. Biggest recovery is seen under the two buildings on the 1975 photo. Old path to Cairn Gorm (left of chairlift top station) is far less obvious in 1993 photo, due to less usage by people. Very pale strips beside old path are snow fencing, not there in 1975.

11

Reseeded area east of and about 200m below top of Fiacaill tow, July 1975. A typical bulldozed area one year after it had been reseeded, showing thin grass cover and much bare grit.

12 Same location, July 1993, with complete revegetation and much invasion by mosses and hill grasses despite this area being subject to heavy pressure each year as it is on a main piste. The boulders in the 1975 photo are black due to bitumen emulsion which has disappeared in the 1993 photo. On the original print more bare ground is evident below the skylining pylon in the 1993 photo due to use as a path.

APPENDIX 12. DETAILED NOTES BY DR R. AITKEN AND MR K. WILSON ON PATH AND DITCH REPAIR WORKS

where we had little advance confidence in the efficacy of purely manual management techniques, has greatly encouraged us in contemplating the other problem sections of the Coire Lagan path.

(iii) Small team trial

20. The stimulus to set up a trial operation of a small mobile team of path workers arose partly from the Project's experience of maintenance management during 1984. The two-person unit used in that approach seemed appropriate to small-scale maintenance work, but less so to substantial path repair or restoration tasks, which called for rather larger manpower. Additional impetus was generated by observation and discussion of path management in National Parks south of the border during September and October this year (detailed later in this report): much of the best work there is being done by small teams whose expertise derives from several years' continuous, shared experience in path work.

21. In mid-October, therefore, the Project engaged on short-term contract a team of three relatively experienced workers, each of whom had been involved as a volunteer on our Scottish Conservation Project tasks this summer. They were equipped with a hired Transit van and a range of simple hand tools from Project stock and from Scottish Conservation Projects at Doune, and directed on to four paths of diverse type in a six-week period. Based mainly in climbers' huts and outdoor centres, the team worked largely to outline specifications drawn up in advance and modified in the light of experience when I visited them at intervals of about a week.

22. The Cobbler: as an introductory exercise the team spent a few days on the Buttermilk Burn path in a maintenance management style, tidying up the sites worked on in August by clearing out drains, laying more gravel and stepping-stones, and further defining the approaches to the problem areas.

23. Cairn Gorm: with the permission of the Highlands and Islands Development Board and the approval of the Nature Conservancy Council, we undertook an experimental approach to the section of the Northern Corries footpath between Coire Cas and the Allt Coire an t-Sneachda. This almost horizontal cross-slope path on heather, peat and granite boulders is typical of many problem paths in the eastern Highlands, with downslope migration occurring as path roughness increases under trampling. Over a length of about 300m we cleared a line through the area of damaged ground, shifting boulders and heather to obstruct the downhill edge of the path. The technique proved effective enough in dry conditions to encourage us to pursue it further on this site and perhaps elsewhere, as on Lochnagar; but thorough draining will be needed to maintain a reasonable walking surface on the cleared substrate. Heavy snowfall brought work to an abrupt end, but allowed us to see that the new path line remained clearly visible under snow, an important consideration when this path receives heavy winter use.

24. Coire Lagan: as on the Cobbler, the main emphasis in returning to the Coire Lagan path was on tidying-up and reinforcing the summer's work, and on clearing drains of the first clogging accumulations of dead Molinia. However, the team continued the re-definition of the Terracettes path for some distance downhill from its previous lower end, and also clarified the path alignment on a rib above the previous limit of operations.

25. West Highland Way: partly to find a sheltered site for team operation at the end of November, and partly to help demonstrate a structured, pre-specified approach to long distance route maintenance, the team spent

Cairn Gorm

17. We had an existing commitment to return to the Northern Corries footpath on the Highlands and Islands Development Board estate, where we had previously worked with the team in 1985 and 1986. While we were on that site, however, we were invited by Board staff to assess the prospects for improving another path on their estate. This was the first section of the path which leads from the "Sugar Bowl" on the Coire Cas access road to the reindeer enclosure on the western side of the Allt Mor, then onwards through the Chalamain Gap to connect with the main Lairig Ghru route. This path is used daily during the summer to take visitors to see the reindeer herd, and was falling to a standard below that required for the safe passage of casual visitors.

18. Inspection showed that this was an eminently practicable subject for work by the team, with the additional advantage of being highly accessible. The Board agreed to contribute £2000, the notional cost of two-and-a-half weeks of team work, towards the repair of the Reindeer path. We were thus able to work alternately on the two paths, partly in response to weather conditions. As in 1986, accommodation for the team was made available by courtesy of the Cairngorm Chairlift Company at its hostel in Aviemore.

19. Northern Corries path: the team spent about 45 work-days on the Northern Corries path, making a total project input of 100 work-days in three visits since 1985. As at the Cobbler, there was work to be done on this path to consolidate our past improvements as well as to extend them westwards to the Allt Coire an t-Sneachda. The main work, as before, comprised the clearing of boulders and revetting of the outer edge of the path, with the aim of formalising a single defined route through a wider zone of damaged ground, but on the peatier sections towards the burn we were also engaged in cobbling and building cross-drains. The Tirfor again proved its value.

20. Previous project reports have outlined the restrictions placed on our path improvement techniques at this site by the Nature Conservancy Council under its SSSI designation. The limitation on winning gravel locally from the burn, or by opening a small borrow-pit, proved a greater handicap than before as we worked over the soft ground close to the Allt Coire an t-Sneachda. Consent has been given for the importation of appropriate gravel, but getting it to site from Coire Cas is beyond the project's resources.

21. Similarly, the prohibition on reseeding has prevented us from effectively defining and consolidating our improved path line. The cultivar grass mix used by the project would certainly be much less appropriate in this environment than at most of our other sites. We did undertake some trial transplantation of local sedges at the path edges, but this technique is highly labour-intensive, and while a good proportion of plants do seem to survive the process, their spread is necessarily very slow compared to a sown sward. NCC staff are considering low-level fertiliser treatments to encourage recovery and spread of local vegetation.

22. The net effect of these restrictions is to leave us with a sense that our work on this path is incomplete, and that its demonstration value is much less than it might have been in different circumstances. That is the more regrettable because the Northern Corries path is a good representative example of a class of Scottish hill path problems in heather-and-boulder terrain, particularly on granite. This remains the highest-altitude path on which the project has worked (650m), though ironically it is also one of the more accessible.

23. Reindeer path: the project's first "contract job" on the reindeer path offered a sharply contrasting proposition: a well-defined set of varied problems of slope and drainage, with no shortage of local materials and no restriction on their use. The total length of path under consideration is only about 500m, involving an almost flat section across a fluvio-glacial terrace, a benched descending traverse to cross the Allt Mor, and a corresponding rising traverse up the other bank. Nonetheless it encompassed a notable variety of small-scale management issues: an ageing geotextile section with drainage and surfacing problems on the terrace top, four flights of elderly and battered wooden steps on the two descending traverses, and badly gullied short-cut lines down the very steep scarp of the western terrace. The standard of path required for the specific main user group, of mainly car-borne tourist visitors, was also rather higher than our norm on mountain paths.

24. The distinctive characteristics of the site made it relatively easy to assess the work needed with a fair degree of accuracy. It thus provided a valuable training exercise in estimation and specification both for myself and for the team members. As is often the case, however, adverse conditions after we had started work - in this case very heavy rain showers - revealed that part of the problem of the site could be traced back to drainage problems well outwith the immediate path environment originally surveyed and costed for repair.

25. Apart from resolving minor drainage and surfacing issues, we were largely involved in problems of path slope. We rebuilt the main flight of wooden steps down from the eastern terrace edge in timber. This was our first project venture into wooden steps, and amply confirmed what field observation of other sites had shown, that it is far from easy to construct high-quality, tidy and effective steps, and that local site conditions need to be taken very much into account. We took out the other three flights: two we re-graded with revetments, reducing the path gradients, and one we rebuilt as a short zig-zag. We had the benefit of good local stone for revetting, and some prospects of tree regeneration to contain the new line. On the face of the western terrace we undertook stone-banking and revetting of soft path edges and of a very active gullied short cut, which we also re-seeded. Two more stone-lined cross-drains completed our work, though further re-seeding of this site will be needed in the spring of 1988. Both HIDB staff and the Reindeer Company expressed general satisfaction with the team's work.

DETAILED NOTES ON PATH REPAIRS, BY THOSE WHO DID THE WORK

The first sheet below is a summary prepared by Dr R Aitken, covering all repairs in 1985-92. The other sheets are detailed descriptions of path repair works, prepared by Pathcraft Ltd.

CAIRNGORM ESTATE PATH WORKS: 1985-1992

CFMP = Footpath Management Project experimental team;
SCP = Scottish Conservation Projects interim team;
PCL = Pathcraft Ltd Team
Early teams had 4 rather than 5 members; so team-weeks before 1987 represent smaller inputs.]

Northern Corries path

1985	28.10-07.11	FMP	2 weeks	
1986	25.06-04.07	FMP	2 weeks	
1987	11.08-19.08	FMP	2 weeks	(with Reindeer path)
1988	22.06-21.08	SCP	9 weeks	
1989	10.07-28.07	SCP	3 weeks	
1990	29.10-09.11	PCL	2 days	(with Coire na Ciste works)
1993	09.08-03.09	PCL	4 weeks	

Reindeer path (Sugar Bowl-reindeer enclosure)

1987	11.08-19.08	FMP	2 weeks	(with N.C. path)
1991	21.10-01.11	PCL	2 weeks	

Chalamain Gap path

1989	31.07-25.08	SCP	4 weeks
1990	09.07-28.09	PCL	7 weeks
1991	03.06-06.09	PCL	9 weeks
	10.10-18.10	PCL	2 weeks
1992	06.01-17.01	PCL	2 weeks
	29.06-04.09	PCL	10 weeks
1993	14.06-09.07	PCL	4 weeks
	12.07-04.08	PCL	4 weeks

Goat Track path

1989	04.10-08.10	PCL	1 week

Coire na Ciste path works

1990	30.10-11.11	SCP	12 days	(with Allt Coire an t-Sneachda works)

SCP FOOTPATH MANAGEMENT PROJECT

Pathworks - Northern Corries, Cairngorm
OS Sheet 36 GR 986053

10-28 July 1989

REPORT

Accommodation

The Cairngorm Chairlift Company Staff House in Aviemore provided the base for the nine weeks of the teams work programme for HIDB in the Cairngorms. It again proved adequate, with proximity to facilities making up for congestion in the kitchen. During the teams stay it became apparent that the building would not be able to accommodate Team II during their three week stint on the Lairig Ghru and an alternative was sought, to the relief of both SCP and CCC staff.

Work

The main worksite was the approach to the burn crossing from the East and the exit from the crossing, up the steep peat bank to the West. This work is summarised on the attached site plan. In addition further general improvements to path line, surface and drainage were undertaken between the SSSI boundary and the main site. 10 kg of Deschampsia flexuosa seed was applied with NPK 1:1:1 fertiliser to bare area along the path length to and including the peaty exit from the burn crossing.

The standard of work was generally good, although questions remain about the formality of the stepping stone exit from the burn crossing. The developing vegetation cover of Deschampsia in the bare areas, particularly below the path, is very encouraging and bodes well for our sustained use of this technique. Some experimental heather notching was carried out and will be monitored. Dry weather again made drainage issues difficult to identify.

Future Work

This path is now approaching the care and maintenance stage. The main input over the next few years should be on the seeding, ground restoration front.

User Numbers

Highest Day	Lowest Day	Ave/Day	Total
88	10	38	573

Work Days Achieved

Team + SCP staff - 78

User Comments

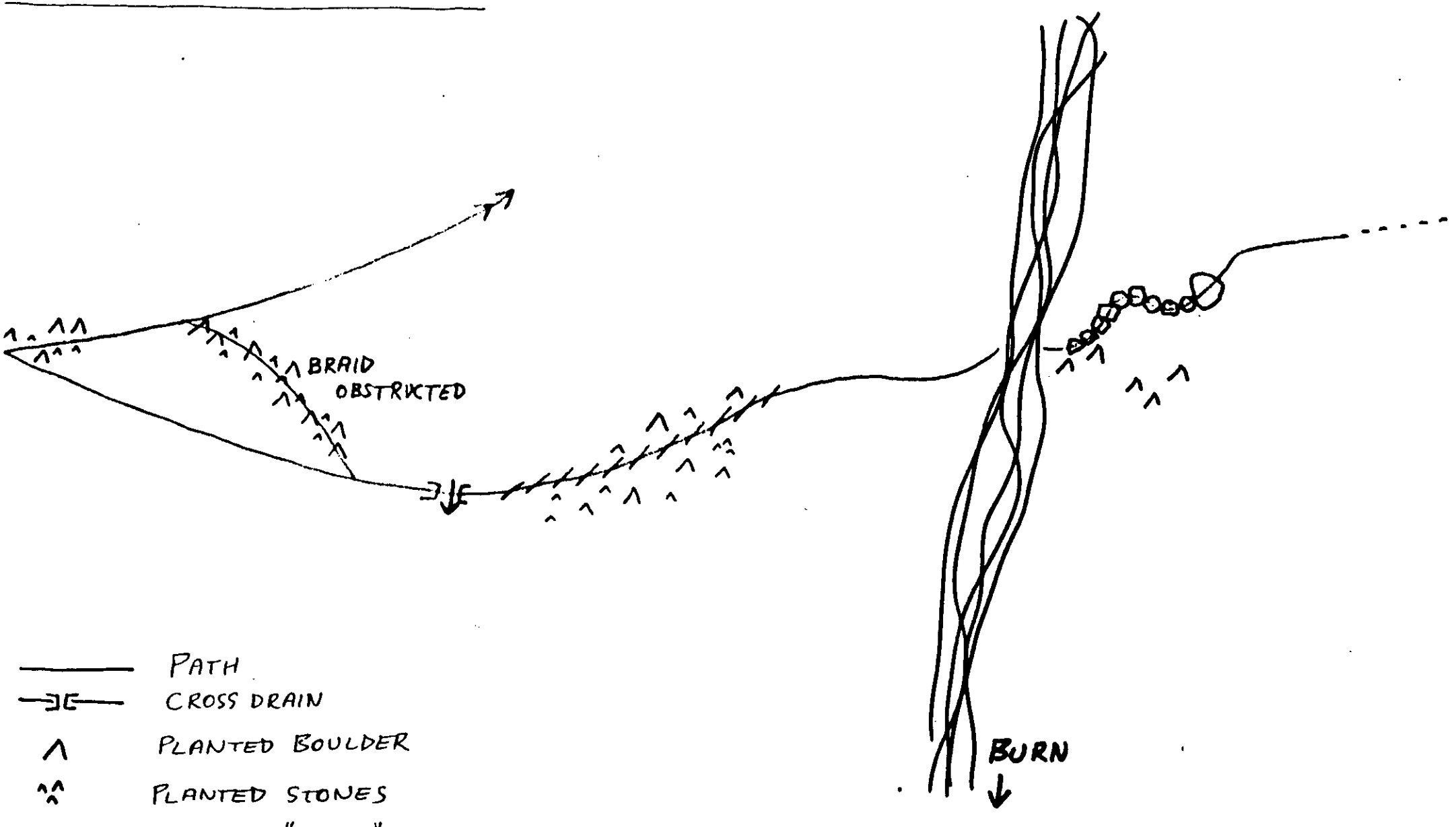
All favourable.

K. Wilson
Project Manager

CP FOOTPATH MANAGEMENT PROJECT

PATHWORKS N. CORRIES 10 - 28 JULY 1989

SHEET 36 G.R. 986 053



Pathworks - Goat Track Cairngorms
OS Sheet 36, GR 992 028

4-8 September 1989

REPORT

Accommodation

Cairngorm Chairlift Company Staff House.

Site Access

HIDB arranged team use of the Coire Cas Chairlift to and from the middle station, for the five work days. This route in was used each day, followed by a walk over the Fiachaill a'Chorie Chais into Coire an t-Sneachda to the site. On the first day the team used this route for exit but subsequently found it easier to follow the burn out of the corrie, descending to the N. Corries path, saving time and effort.

Weather

No time was lost due to weather which was in the main overcast and, at this altitude, cold. On two mornings access was effected in very low visibility due to cloud cover. Fortunately the route in is well supplied with continuous landmarks, i.e. the Fiachaill ski tow, snow fences and the pro-tallus rampart within the corrie. This is, however, a safety issue to be considered in regard to any future worksites in high remote areas.

Work

The work undertaken, with PDO consent from NCC, is summarised on the attached site plan. Particular points of note are: the extreme looseness and mobility of disturbed "soil", leading to concern over re-stabilising rates and possible accelerated erosion in disturbed areas; the life expectancy of any drystane work in an area under snow/ice for probably 4 or 5 months each year.

It is very much to be hoped that the low key pre-emptive approach on this site is successful, as more intensive works would be difficult to justify on a wilderness high site of this nature.

Similar future work of this type would be better programmed in August to take full advantage of local seed supplies for ground restoration work. The seed heads collected on site during these works, mainly D.flexuosa, had already shed the majority of their seed.

Future Work

Initially the site should be monitored with regard to both the effectiveness of the work and its acceptability to the public. Further low key works may be considered valuable to further consolidate the zig-zags and to promote revegetation.

User Numbers

Highest Day	Lowest Day	Ave/Day	Total
15	0	7.6	38

User Comments - All favourable. The half expected critical comments did not occur.

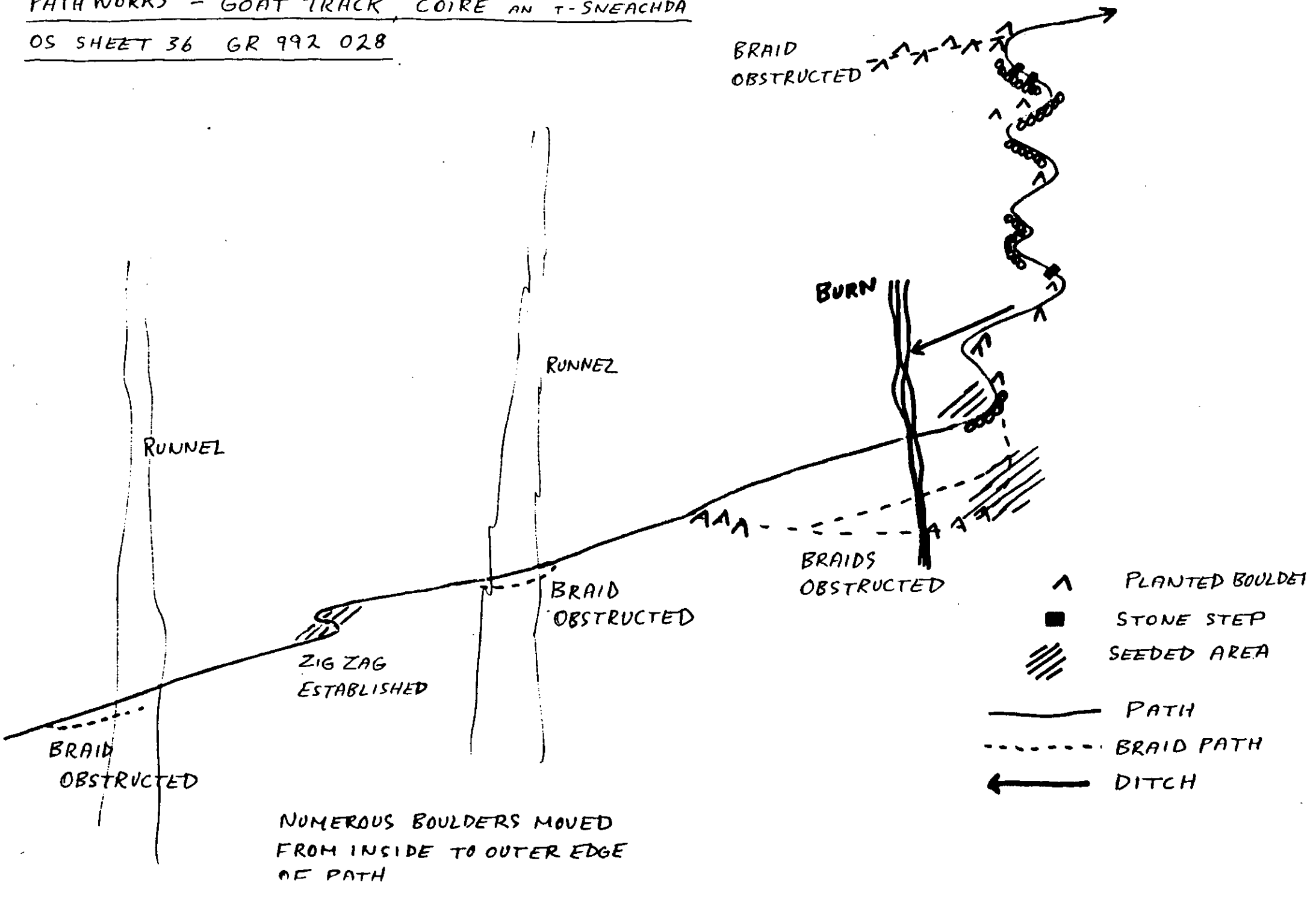
Workdays Achieved - Team and SCP staff 24.5

K. Wilson
Project Manager

[redacted] PATH SURVEY SHEET

PATH WORKS - GOAT TRACK COIRE AN T-SNEACHDA

OS SHEET 36 GR 992 028



Pathcraft Limited
70 Main Street, Doune, Perthshire. FK16 6BW
Telephone 0786 841915 Fax 0786 65359

4 December 1990

PATHWORKS. Coire na Ciste & Allt Coire An T'Sneachda
Cairngorm 29 October to 9 November 1990

REPORT

Accommodation — CCC Staff House Aviemore. As usual for work in this area the CCC staff house proved highly suited to our needs.

Weather — Generally cold and windy with periods of rain.

Work — The works undertaken are summarised on the attached site plans. The boulders selected movement at the Allt Coire An T'Sneachda by Jonathan Stacey were of such a size that three full team days were required to move them as opposed to the intended two days. However the reduction of a days work on the Coire na Ciste path did not present a problem.

Future Work — It will be very interesting to note the effectiveness of the Allt Coire an T'Sneachda works in spring 1991, fingers crossed until that time.

Future use of the Coire na Ciste path will identify the need for further works, if any.

Work Days Achieved — 48

User Numbers — None Recorded.

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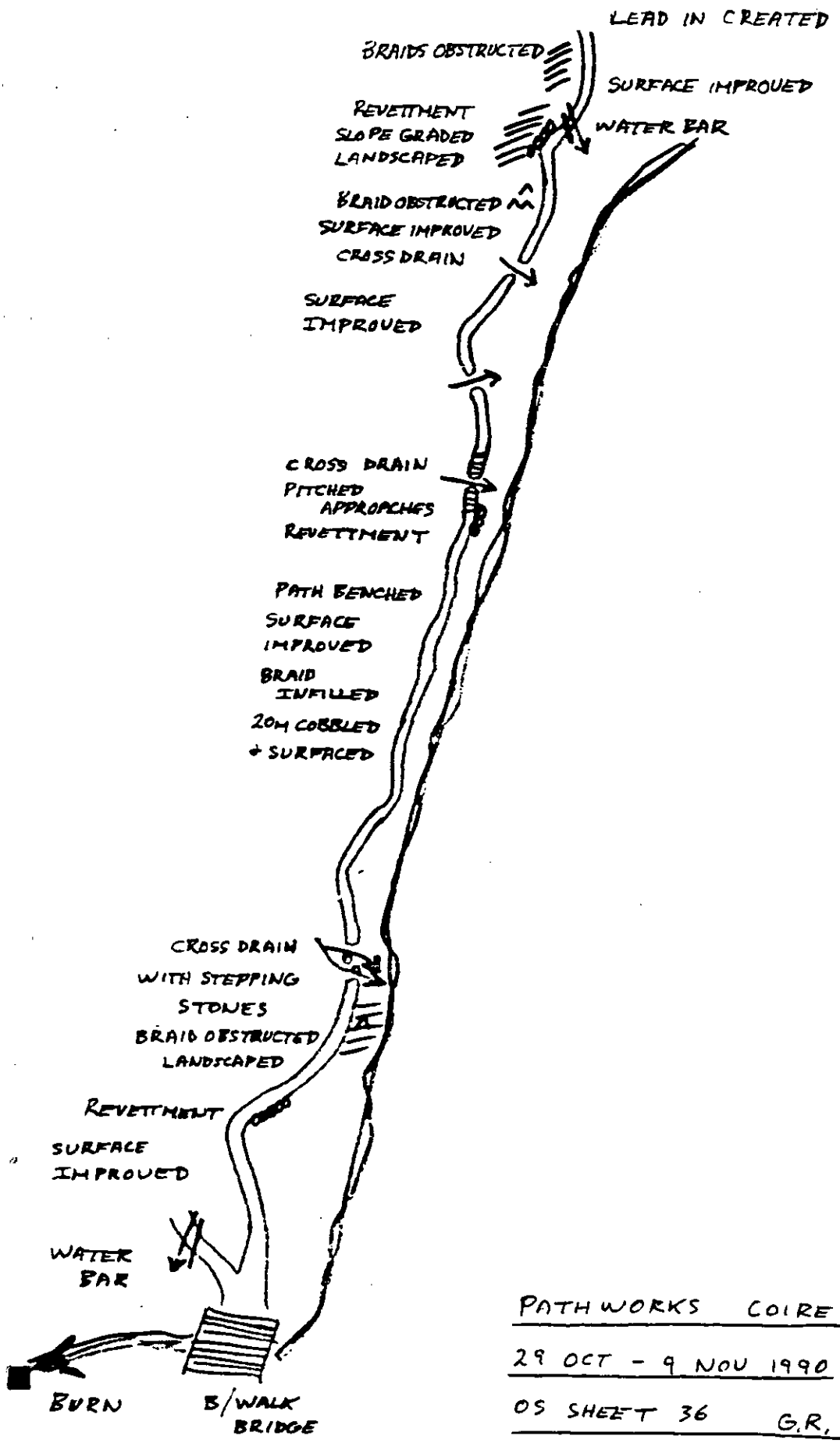
70 Main Street. Doune, Perthshire. FK16 6BW
Telephone 0786 841915 Fax 0786 65359



PATH WORKS COIRE NA CISTE CAIRNGORM

29 OCT - 9 NOV 1990

OS SHEET 36 G.R. 999 072

PATHCRAFT LIMITED
Balallan House, 24 Allanpark, Stirling, FK8 2QG
phone: 0786 51819 fax: 0786 65359

PATHWORKS SUGARBOWL TRAIL OS 36 GR 983 072
21 OCTOBER - 01 NOVEMBER 1991

REPORT

ACCOMMODATION Mrs Betty Warne, Kimberley, Nethy Bridge, PH25 3ED (0479) 82476. Not overspacious and requiring us taking one bed, however other than this, very suitable.

WEATHER The first week of the Contract period was fine, dry and not cold allowing good progress to be made. Wet weather before our arrival was still draining off allowing drainage issues to be observed. The second week brought two days of heavy rain and colder conditions but did not seriously slow work progress. Daily details are carried on Appendix A to this report.

USER NUMBERS User numbers are presented on a daily basis on Appendix A. The (possible) response of the public to weather conditions on 28 and 31 October is marked.

WORK The works were undertaken to a high standard and are summarized on the attached site sketch Appendix B. In addition to the Contracted work a section of 12m pitching was installed at the tight zig zag at the base of the river terrace, which had been degenerating recently.

WORK DAYS ACHIEVED 50

USER COMMENTS All favourable.

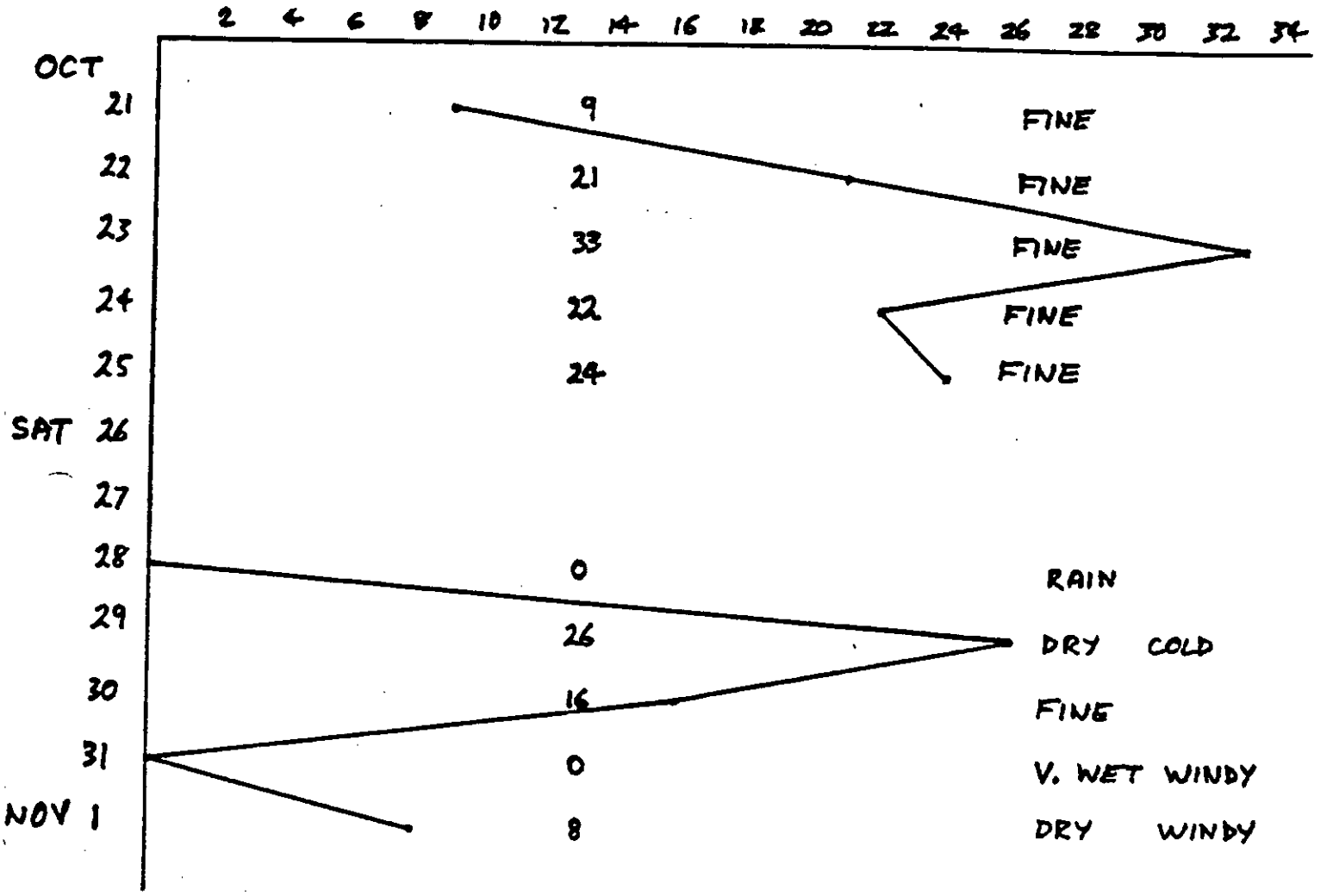
K J Wilson
Operations Manager

cc Dr R Aitken

Pathcraft Limited
Balallan House 24 Allan Park STIRLING FK8 2QG
phone: 0786 51819 fax: 0786 65359

APPENDIX A

PASSAGES ACROSS SITE



PATHWORKS – SUGARBOWL TRAIL OS 36

21 OCTOBER – 01 NOVEMBER 1991 GR 983 072

HIGHEST DAY	33
LOWEST DAY	0
AVE / DAY	15.9
TOTAL	159

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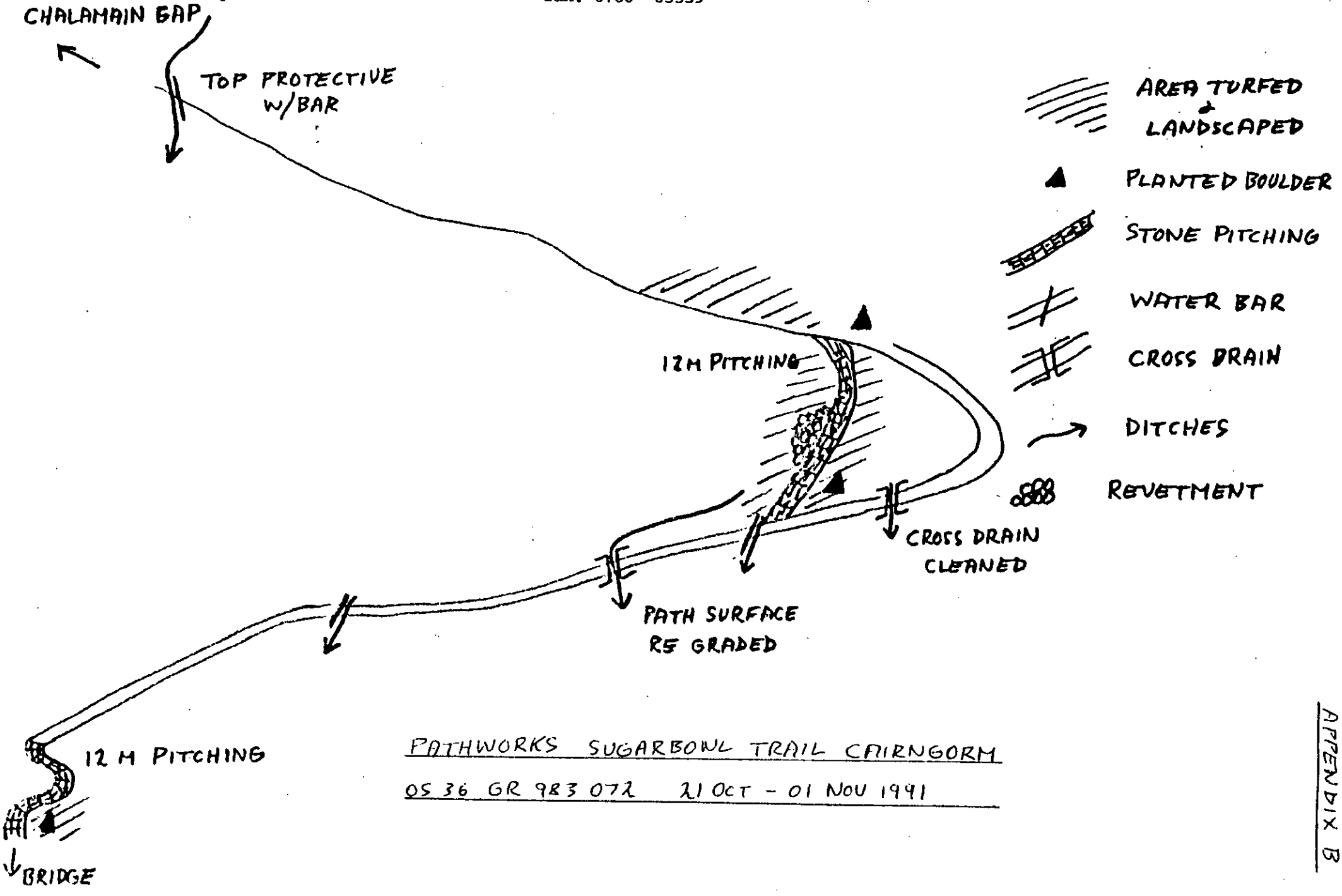


PATHWORKS SUGARBOWL TRAIL CAIRNGORM

OS 36 GR 983 072 21 OCT - 01 NOV 1991

APPENDIX B

Pathcraft Limited
Balallan House 24 Allan Park STIRLING FK8 2QG
phone: 0786 51819 fax: 0786 65359

Chalamain Gap Path - Cairngorm Estate

6 - 17 January 1992

OS 36 GR 969 057 to 971 059

REPORT

Accommodation Kimberley, Nethybridge. This is a self-catering wing of a family residence and was first used in late 1991 as team accommodation and proved well suited although somewhat up-market and therefore expensive for our needs.

Weather Two full working days were lost due to snow during the first week of the contract, however excellent working conditions prevailed during the second week allowing the time lost to be made up.

Appendix A is attached and carries brief reports on the daily weather conditions experienced.

Work The works undertaken are summarised on the attached site drawing, Appendix B, they can now be split into two areas of effort:-

A Repair of path section which was washed in very wet conditions during October & November 1991.

B Installation of a beefed up drainage system to cope with the recurrences of weather conditions as in A. This included a top cross drain above the damaged area to shed water south into the burn and an extended drainage system within the damaged area, shedding water downslope to the north of the pathline.

The was-out problem was not associated with the areas of ground water seepage that had caused concern during the original path building in summer 1991 but rather was caused by surface flow from, (We surmise,) rapid snow-melt above the site area. Sufficient protection of the path from such an occurrence had not been established originally.

Future Work The site should be carefully monitored to assess the effectiveness of the remedial works in extreme conditions.

Work Days Achieved 40

User Comments None were recorded.

User Numbers A record of user numbers is presented on appendix A to this report and provides further evidence of the popularity of this particular route.

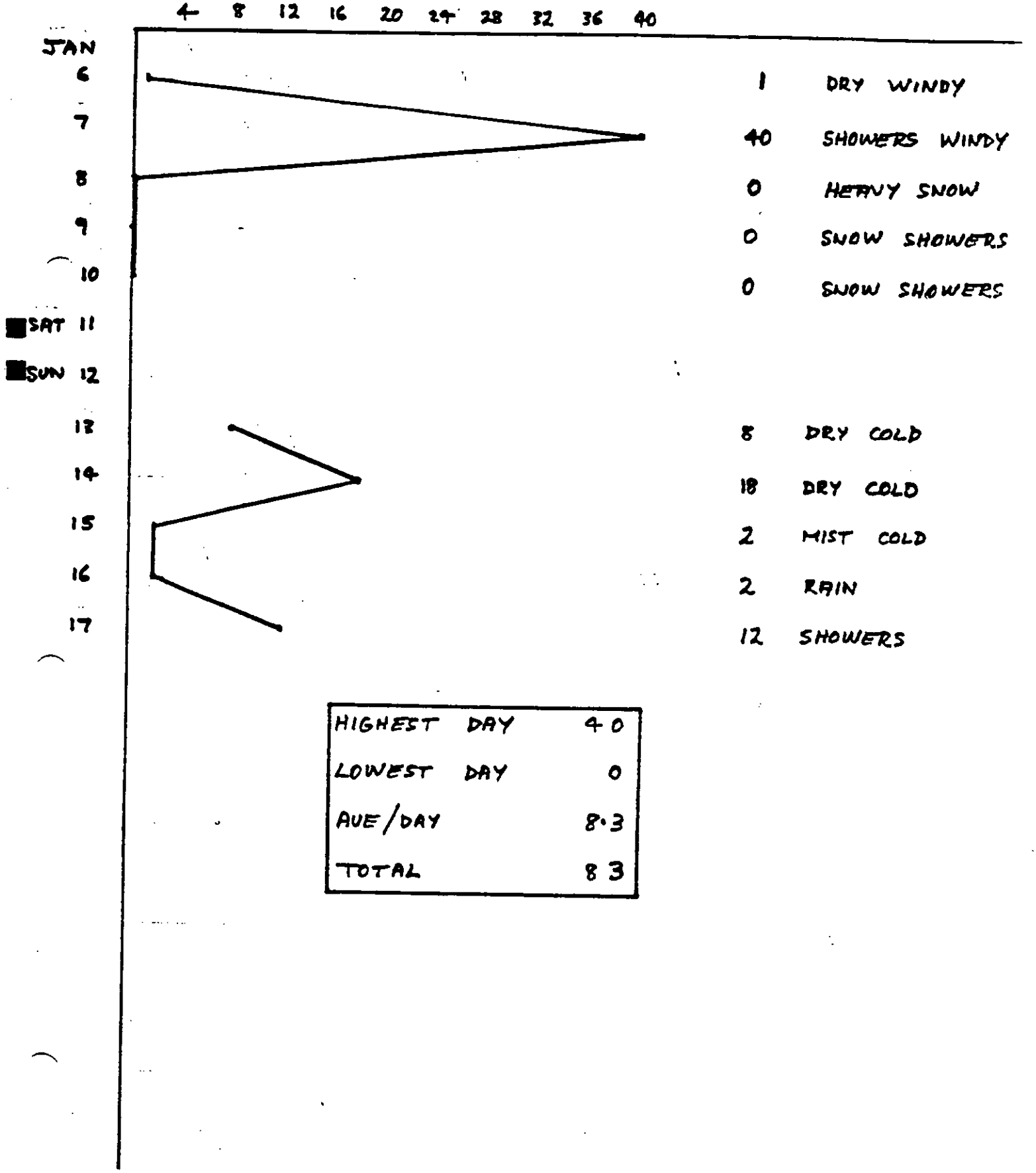
K J Wilson 060292

cc: Dr R Aitken

Pathcraft Limited
Balallan House 24 Allan Park STIRLING FK8 2QG
phone: 0786 51819 fax: 0786 65359

Appendix A.

Chalamain Gap Path - Cairngorm Estate
Remedial Works
6 - 17 January 1992
OS 36 GR 969 057 to 971 059



HIGHEST	DAY	40
LOWEST	DAY	0
AVE/DAY		8·3
TOTAL		83

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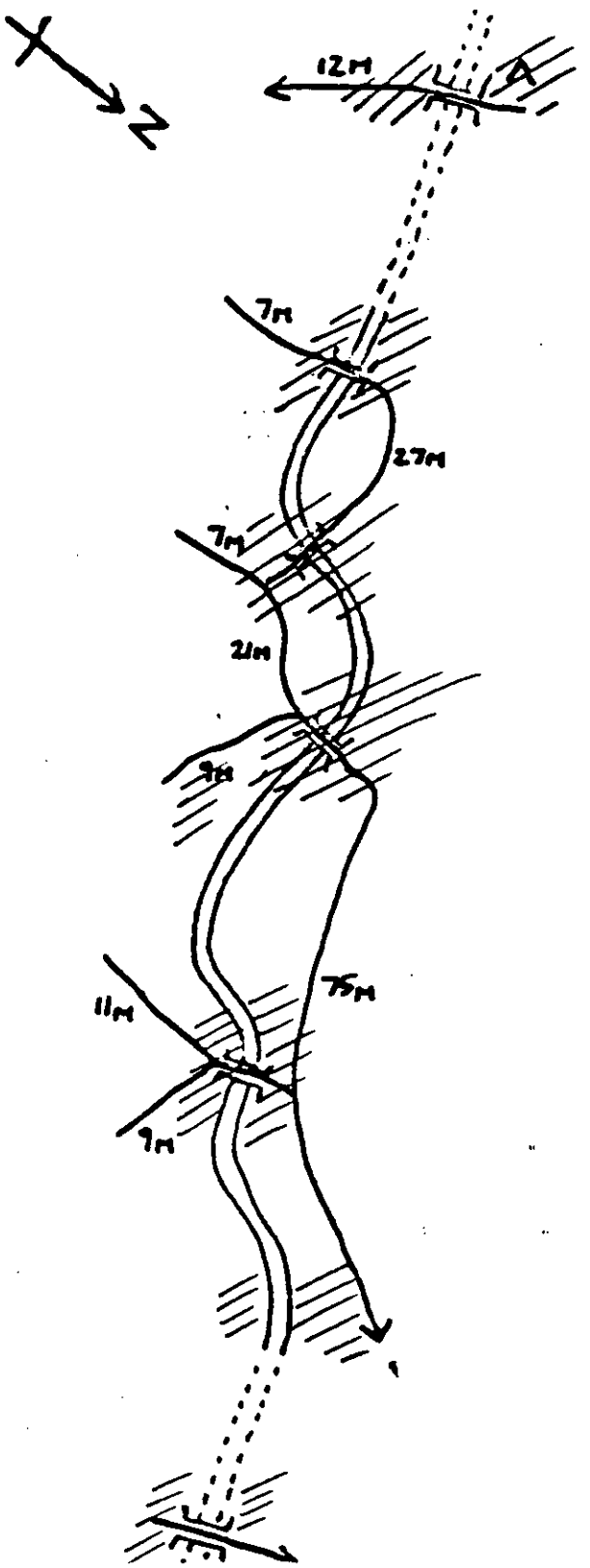
Appendix B.

Chalamain Gap Path - Cairngorm Estate
Remedial Works
6 - 17 January 1992
OS 36 GR 969 057 to 971 059



TOP SITE PROTECTION CROSS DRAIN + DITCH SHEDDING WATER INTO BURN.

PATH RESURFACED

4 CROSS DRAINS INSTALLED

166M DITCHING TO SHED WATER TO NORTH SIDE OF PATH

LANDSCAPED AREAS

ADDITIONAL CROSS DRAIN BELOW MAIN SITE

Pathcraft Limited
Balallan House 24 Allan Park STIRLING FK8 2QG
phone: 0786 51819 fax: 0786 65359

Pathworks - Chalamain Gap Path
OS 36 GR 983 067 - 976 065
29 June - 04 September 1992

Report

Accommodation:- Mountaineering Council of Scotland club hut - Mill Cottage. Highly suitable in terms of facilities and location. Perhaps rather large and antiseptic for a long stay and has the disadvantage of other users, although at this time of year this was not excessive. Recommended for future use.

Weather:- Over the first six weeks of the contract weather conditions were generally fine allowing rapid progress to be made on the site. However the final four weeks were a different story with the team battling against some miserable conditions on this very exposed site. The rain of the final weeks did allow for the checking and improvement as necessary of the path drainage. A daily record of weather conditions is carried on Appendix A to this report.

User Numbers Appendix A also carries a record of user numbers over the working days of the contract period. The average figure shows a minimal increase over the same period in 1992. Twenty-four as opposed to twenty-three.

Work The works undertaken are summarised on the attached site drawing, (Appendix B) and were carried out in a diligent and efficient manner. The immediate effect was the creation of a single clear pathline through the braids of the pre-existing damage zone. The transformation in the peaty flush areas is particularly marked.

As was expected on this site, the location of suitable surfacing materials was difficult. In all, five borrow pits were opened within the damage zone providing a little good quality material and larger quantities of a lower quality material, ie very fine with a high peat content.

The extreme weather conditions at the end of the contract fully tested the installed drainage which coped well. However a question mark was raised against the ability of the surface over approximately 100 metres at the west end of the site to withstand these conditions. This was the poorest material obtained from borrow pits and was only used because there was no alternative. Monitoring will be necessary to asses the longer term effectiveness in this area.

Work days achieved 245

User Comment All highly favourable.

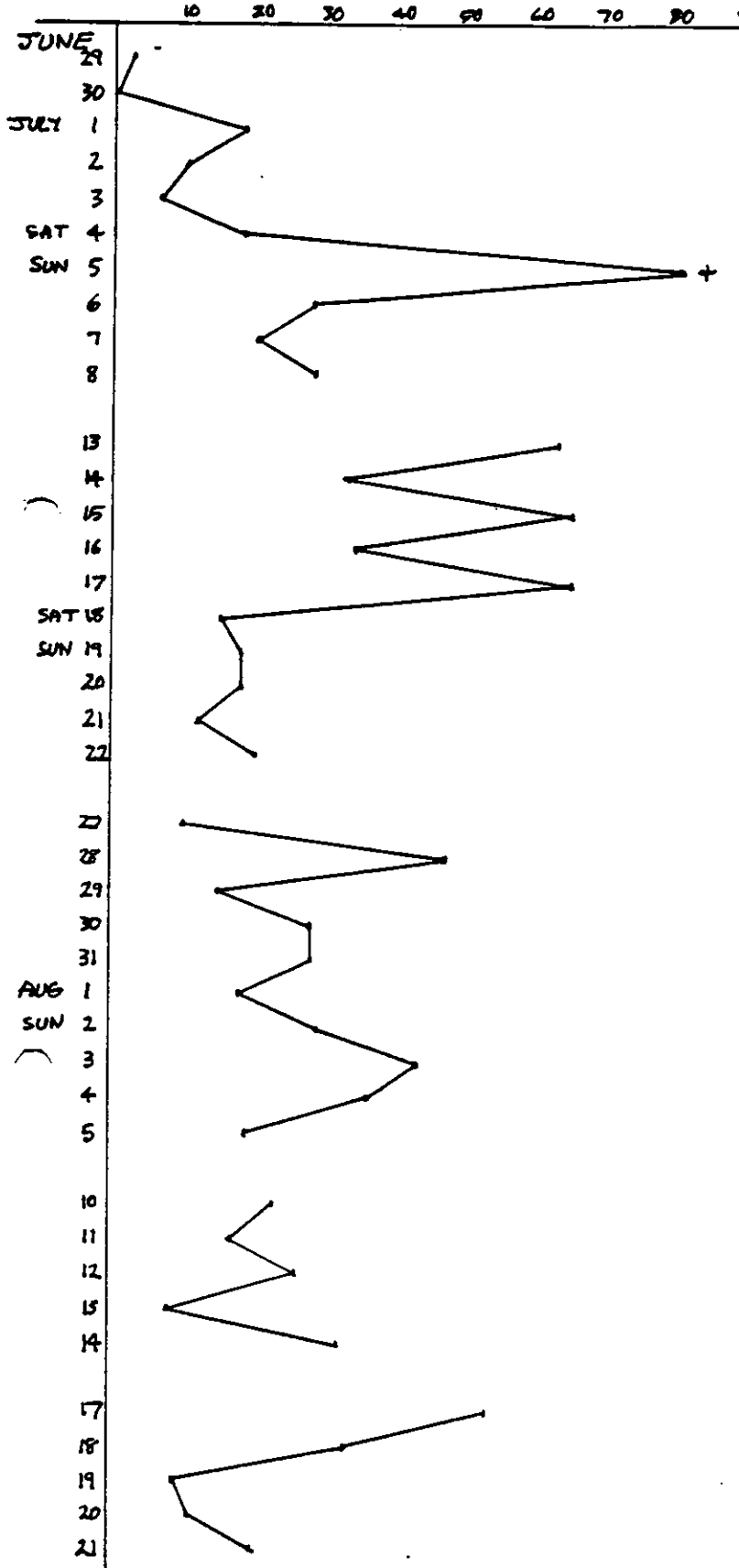
K J Wilson
Operations Director 9 September 1992

APPENDIX A

PATHWORKS CHALAMAIN GAP PATH CAIRNGORM

OS 36 GR 983 067 – 976 065 29 JUNE – 4 SEPT 1992

PASSAGES ACROSS SITE



2		FINE
0		FINE
18		OVERCAST DRY
10		OVERCAST DRY
6		DRIZZLE
18		DRIZZLE
80+		FINE
28	ARMY	DRIZZLE
20		SUNNY HUMID
28		SUNNY HUMID
63	ARMY	WET WINDY
33		OVERCAST DRY
65		BRIGHT → RAIN
34		DULL SHOWERS
65		SHOWERS
15		V. WINDY SHOWERS
18		V. WINDY BRIGHT
18		OVERCAST
12		V. WET → SHOWERS
20		DULL BRIGHT SPELLS
10		HEAVY SHOWERS
47		BRIGHT FRESH
15		DULL LIGHT SHOWERS
28		DULL LIGHT SHOWERS
28		SUNNY FRESH
18		HEAVY SHOWERS
29		BRIGHT COLD
43		DULL HEAVY SHOWERS
36		DULL LIGHT SHOWERS
19		BRIGHT V. WINDY
23		FINE
17		V. WET → BRIGHT
26		V. WET → SHOWERS
8		V. WET WINDY
32		FINE
53	SCHOOL GROUPS	RAIN → BRIGHT
33		BRIGHT COLD
9		V. WET → BRIGHT
11		BRIGHT V. WINDY
20		FINE

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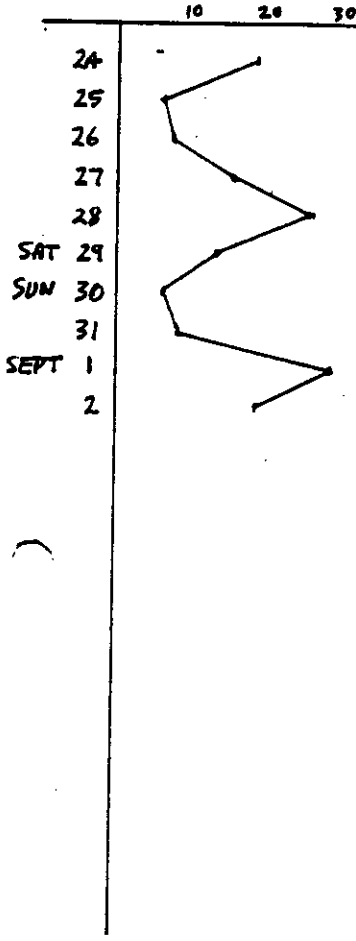
CONTINUED

CONTINUED

PASSAGES ACROSS SITE



18	BRIGHT	SHOWERS
6	BRIGHT	SHOWERS
7	BRIGHT	SHOWERS
15	RAIN	→ SHOWERS
25	RAIN	
13	DULL	SHOWERS
6	V. WET	WINDY
8	RAIN	WINDY
28	RAIN	WINDY
18	SHOWERS	WINDY

HIGHEST DAY	80
LOWEST DAY	0
AVE/DAY	24
TOTAL	1202

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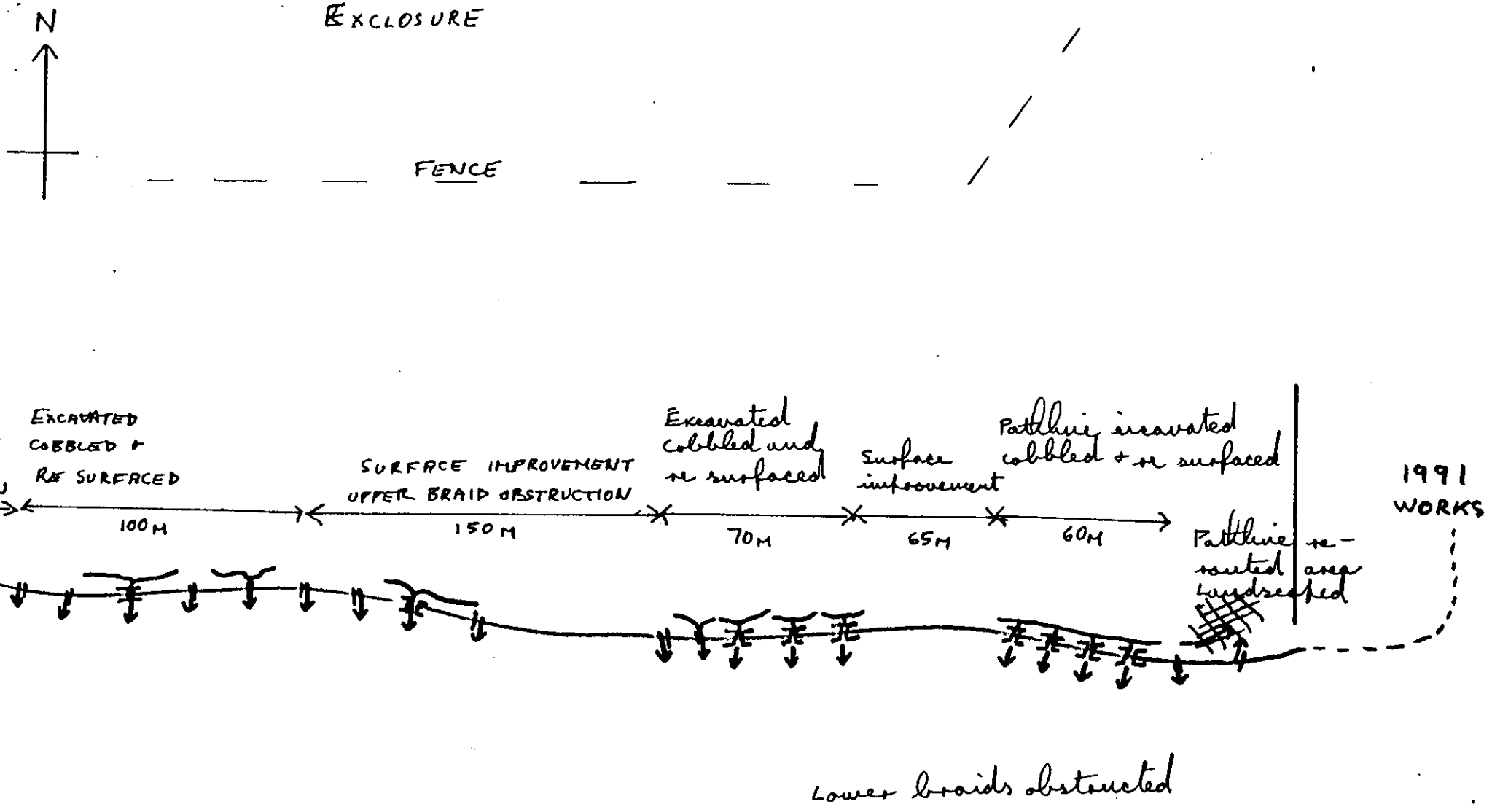

PATHWORKS CHALAMAIN GAP PATH OS 36 GR 983 067 - 976 065

29 JUNE - 4 SEPT 1992

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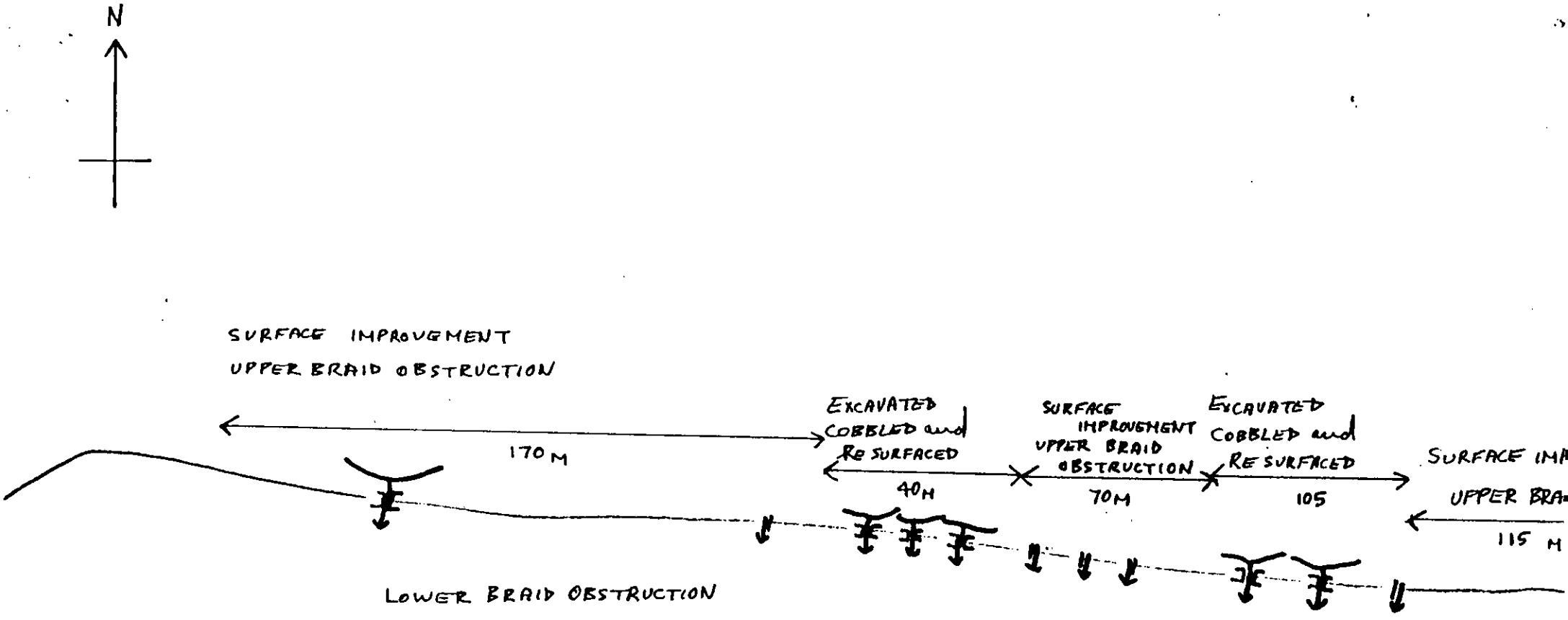
APPENDIX B



X DRAINS	15
WATER BARS	15

PATH LENGTH WORKED 945 M as per site records - equates to 945 paces.

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APPENDIX 13. GRASS RESEEDING MIXTURE AND AREAS TREATED IN RECENT YEARS

The composition of the grass seed mixture currently (1993) in use is as follows:

	Per cent
Lamora perennial ryegrass	5
Mondial perennial ryegrass	10
Dawson slender creeping red fescue	10
Artist slender creeping red fescue	20
Biljart hard fescue	20
Fertilia fine leaf sheep fescue	25
Carmon creeping bent	5
Highland brown top	5

One load of the hydroseeder, which covers 1/3 acre, contains the following:

Grass seed mixture	- 34 kg
Composted seaweed (Alginure)	- 94 kg
Fertiliser (ICI Longlife 6:9:6)	- 94 kg

GRASS RESEEDING

A summary of reseeding carried out in the period 1987-93 taken from the Ranger's diaries is as follows:-

1987

June. Hand seeding and fertilising:
- Verges on zig-zigs
- Patches in Trainer area
- Peat areas on Northern Corries footpath and areas on either side of Ridge poma

Fertilising:
- Both sides of summit path to top of fenced area
- Areas around Top Station and Ptarmigan
- Areas around and opposite Day Lodge
- Peat areas at bottom of Fiacaill Ridge poma
- Verges on track 105 (from lower end of traverse down east side of Coire Cas)

July. Hand seeding and fertilising:
- Areas around Middle Station and Sheiling
- Bottom of Coire Cas tow track
- Unimog tracks on M2

August. Hand seeding:
- Banks around Sheiling

Hydroseeding:
- Verges from Top Station to Bottom Station
- Verges on old zig-zag road from Sugar Bowl
- Verges along road below Cas car park

1988

July. Hand seeding and fertilising:
- Old get-off ramp half way up Car Park tow track

Hydroseeding:
- Steep bank and verges on 105 down to opening to Coire Cas
- Roadside below Cas car park
- Below Sheiling tow on road under Lower Chair
- All verges on road from Middle Station along zig-zags
- Flat area and banks two-thirds up traverse
- Top one third from Top Station to traverse
- Lower part of 105 to Cas gun barrel

August. Hydroseeding:
- Old roads at top of Cas

Hydroseeding and fertilising:
- Around Sheiling, Middle Station and bottom of Cas track

1989

May. Reseeding and fertilising:
- Areas opposite Day Lodge
- Around Sheiling (nets removed from steep banks)

Hand spreading and fertilising:
- Various combinations on areas on Lower slopes and either side of Ridge poma track, for tests

Soil samples from limed areas:

1992

May. Turfing:
- Around Cas gantry
- At Middle Station below chair

Returfing: at top of M1 after extension (by outside squad)

June and July. Spreading soil:
- Around Cas gantry
- Bank along edge of Cas car park
- Area on bank at verge below Cas car park on road

Hand seeding and fertilising:
- Area at Cas gantry
- Bank in Cas car park
- Areas on Lower slopes
- Outside Top Station from where rocks were taken to build retaining wall at top of traverse
- Areas at M1 track not reached by hydroseeder
- More seed, with gypsum, on area at Cas gantry

Hydroseeding:
- Areas from old get-off ramp on M1 to new ramp
- Areas around track and along road to Top Station
- Down traverse to 105

Fertilising: areas opposite Day Lodge and Lower slopes
Turfing: in drainage channels at top of M1 poma
Watering: area at Cas gantry with hose in dry spell

September: Repairs to bank: on old zig-zag road (with SNH assistance)

1993

June and July. Hand seeding and fertilising:
- Top of M1 poma down to old get-off ramp (twice)
- Areas at Cas gantry
- Areas opposite Day Lodge on Lower slopes and queuing area at Car Park tow
- Patches in Trainer area to bottom of tow
- At queuing area and unit at bottom of M1 poma

Fertilising: Gypsum at top of M1 and down to old get-off ramp

Hydroseeding:
- Areas on old zig-zag from Sugar Bowl
- Verges on road from Bottom to Middle Station
- At Cas gantry and below Chair at Middle Station

August. Hand seeding and fertilising:
- At steps on zig-zags to Fiacaill path
- On path at White Lady tow hut (after spreading soil)

June. Hydroseeding:
- Bottom of Day Lodge poma
- Road between Bottom and Middle Stations
- Old road below Trainer tow, under Lower chair

July. Hydroseeding:
- Banks and verges in Ciste car park
- Verges on road from Bottom to Middle Station.
- Bank leading from Middle Station to M1 poma
- Bottom of Coire Cas and around Middle Station.
- Areas on zig-zags and 105
- Verges on road below Cas car park
- Banks in Top car park

Hand seeding and fertilising:
- Peat areas around bottom of Ridge poma track

1990

June. Hand seeding and fertilising:
- All patches in Trainer area and lower slopes to Day Lodge
- Top ramp of Coire Cas tow track
- Areas at bottom of Ridge poma
- Experimental work on either side of Car Park tow track and on track, with various combinations of seed, fertiliser and composted seaweed (Alginure)

July. Fertilising:
- Areas on summit path
- Bank on road below Cas car park

August. Hand seeding and raking:
- Areas along summit path

September. Hand seeding and fertilising:
- At steps on zig-zags
- Around Car Park tow hut and queuing area
- On patches on lower slopes

1991

June. Hand seeding and fertilising:
- Lower slopes and around Car Park tow hut and Ridge poma track, get-off area and queuing area

July. Hand spreading Alginure and pre-seeder:
- Trainer area and lower slopes

Hydroseeding:
- 105, traverse, zig-zags and Lower road

Spreading fertilisers with hydroseeder:
- Bottom of Day Lodge poma
- Verge on roadside below Cas car park

Hand seeding: area on Car Park tow track
Hand spreading of Alginure: areas around Ridge poma track

August. Hand spreading of lime:
- Peat areas at Ridge poma

Fig. 2. Large-scale map

Locations for monitoring at fixed sites ((i), (ii), etc as in Section 7)
Problem sites (1, 2 etc as in Section 11)

Figure 2.
Location of Problem Sites
showing roads, car parks and vehicle tracks (black), buildings, ski lifts (pink), snow fences (dashed black)and footpaths (green, based on 1988 aerial surveys).
Arabic numerals (red) show the location of problem sites, and Roman numerals (brown) those being monitored at fixed transects.

Map prepared on GIS by Arthur McCabe, CCC Ltd.