JAMES RENNIE BEQUEST

REPORT ON EXPEDITION/PROJECT

Expedition/Project Title: 'Tambopata Trails' ....

Travel Dates: July & August 2004 ....

Location: Tambopata National Reserve, Peru ....

Group Members: Alistair Pask, Hannes Dempewolf (Edinburgh), Sally Hinds (Edinburgh), Svetka Kuljich Rios, Veronica Galmez Marquez, Christian Rohner Stornaiuolo (all of La Molina University, Lima) ....

Aims: A botanical assessment of the disturbance effects of Ecotourism in an Amazonian tropical forest...

OUTCOME :-

Abstract

This project examined the effect of tourist trampling and tourist trails on the tropical forest surrounding an 'eco-lodge' in the Tambopata National Reserve, S.E. Peru. By using an established lodge as a model, it was found that such ecotourism has definite, notable and long term impacts on both the physical and biological environment along the tourist trails. On the trail itself, soils become compacted with organic layers removed, whilst vegetation is trampled and killed. Experimental trampling suggests that significant damage occurs quickly, after the equivalent of only one season of average use. Further studies demonstrated that highly damaged trails do not recover quickly once abandoned, with notable physical damage remaining after five years of closure.

However, it was found that the increase in ambient light levels along the trails promoted growth of trail side vegetation, particularly those species in the Piperaceae (and perhaps Melastomataceae). This in term promoted animal activity, particularly of butterflies, which appeared to use trails for feeding, access and perhaps mating finding. In addition, it was noted that in an area of relatively low economic activity, this ecotourism does provide jobs and security for local people. A more proactive approach of monitoring and regulation is required to protect the long term survival of the forest, by balancing small scale forest loss and damage with local, sustainable economic growth.

Keywords : Ecotourism, trampling, vegetation, soil, experimental

Introduction

In recent years an alternative form of tourism, 'eco-tourism', has begun to attract the attention of governments, international organisations and academics. This 'eco-tourism' is defined as 'progressive, educational travel which conserves the environment and benefits local communities' (Drumm, 1991) and has been hailed as an alternative to mass tourism with the potential to be an instrument for rural economic development and environmental conservation. However, in every instance, ecotourism requires a two-way link between itself and environmental conservation (Valentine, 1993; Cater, 1994).

Where such a link develops, recent research suggests that ecotourism can both promote and maintain protected areas (Boo, 1990), especially where nature lodge owners have a vested interest in environmental conservation due to their large capital investment (Wesche, 1993). Ecotourism has, however, also come under strong criticism where such tourist traffic in fragile wilderness areas has resulted in the environment becoming more damaged than it has been conserved (Smith, V. 1992; Zurick, 1992). However, as yet, there has been relatively little research into the effects of ecotourism on the natural environment, and thus few suitable management strategies to control and reduce these impacts have been proposed.

Due to the large numbers of tourists visiting the ecolodges located within the Tambopata National Reserve (over 15,000 per year) an assessment of environmental impacts of this ecotourism and the proposal of new and improved methods of trail management system are essential. Indeed, in the area around the chosen study site, only a few years ago certain sections of trails were closed in order for them to recuperate as they became very muddy due to excessive uncontrolled tourist traffic, and in places this has led to significant erosion.

Aims

The overall aim of the project is to contribute to the successful conservation of the biodiversity in the Madre de Dios region of the Peruvian Amazon by providing valuable ecological data on the impact of tourist forest trails on the natural vegetation around the ecolodges. These data will then allow the proposal suitable management techniques to mitigate against these impacts whilst suggesting strategies for the development of sustainable ecotourism in the Tambopata Reserve.

Fieldwork was focused on the area surrounding the 'Explorer's Inn Ecolodge and Research Station' due to the established network of trails over 30km long and long established eco-tourism. Many of these trails are have been used regularly for many years, and there is a realisation that a degree of management is essential to avoid causing them to become excessively muddy or eroded.

Project aims are to examine the effects of forest trails in terms of :

a) Disturbance - A comparative study of the vegetation and site conditions of the undisturbed forest, areas surrounding trails in current use, areas currently closed to allow regeneration, and areas where new trails are being created. Investigation into the vegetation boarding these trails was examined for the existence of an 'edge effect' and the extent to which this penetrates into the forest.

b) Regeneration - A comparison between trails in current usage with those that have been closed and unused for varying periods of time allowed an assessment of the rate at which the vegetation bordering the trails returns to that of the natural forest after disturbance.

c) Management techniques - The data and observations from the fieldwork study used base the proposal of suitable trail management techniques to minimise impact and promote regeneration. The data collected also allows the study whether any changes in the vegetation or plant community is desirable, or indeed reversible. A suitable 'recovery period' before sections of trails are re-opened and management strategies to reduce impacts and promote regeneration will be suggested.

Application of the study

Long term study areas established for the future study of vegetation recovery rates and effectiveness of management techniques, these can be located using a GPS. Trail management techniques and strategies were proposed for the trails at the Explorer's Inn research station, incorporated into the design of the nearby new lodges, such as the Picaflor 'eco-lodge' within the protected area, and offered to the many other established lodges with trails in the area.

Fieldwork methodology
The fieldwork was divided into four distinct phases, each designed to investigate a specific, yet related, aspect of the impact of tourism trails on the forest ecology. The fieldwork period of the expedition took 42 days from Tuesday 06th July until Monday 16th August. In total, therefore, over 240 research days were spent in the forest by the expedition team.

An *initial study* allowed familiarisation with the geography and ecology of the study area. Identification of the key main vegetation types and plant families associated with trail disturbance.

For each aspect of the study, plots within the study area were initially chosen whilst considering factors such as forest type and large scale natural disturbances (such as tree falls). These plots were then marked using biodegradable field marking tape and GPS coordinates taken, ten transects (or so) were then established at regular intervals along the trail within the plot. Quadrats of $0.5m^2$, 0.5m x 1.0m, made from light weight plastic piping were used to make both physical and biological measurements along the transects leading from the trail into the forest. Soil resistance was measured using a handheld 'penetrometer' which allowed rapid multiple readings within each quadrat. The light environment was measured using a handheld digital light meter which provided an instant read out in 'lux'.

Phase.1 - Allowed a preliminary assessment of the impact of the main trail through the forest. Measurements of the trail parameters, both physical and biological, were taken to allow initial comparisons with the trail edge and natural forest (at 10m from the trail centre). In addition, transects into the forest from the trail examined the distribution and abundance of four main families of flowering plants; the Piperaceae, Melastomataceae, Rubiaceae, Cecropiaceae; often associated with disturbance. Repeated light readings along these transects were also taken to allow the examination of changes in the light environment potentially associated with the main trail.

Phase.2 – Using the results, experience and observations gained in phase.1, this phase examined two trails that had been closed for 3 or 5 years respectively in order to investigate forest regeneration after trail disturbance. Transects across the trails allowed the assessment of the forest structure, in terms of vegetation height, density, and type. A paired design was used to allow a comparison between the recovering trails and a control on a nearby part of the main trail (this also eliminated problems caused by the variation in forest type along the main trail).

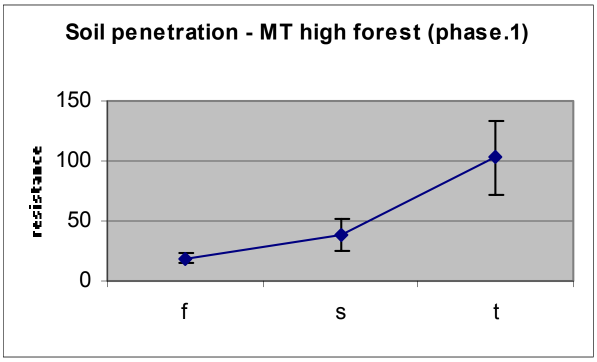
Phase.3 – An experimental trail was cut through the forest and then trampled in a controlled manner by volunteers (permission granted by the Instituto Nacional de Recursos Naturales (INRENA). Data, observations and experience from the initial two phases enabled accurate measurement of the disturbance caused by cutting and trampling. Comprehensive measurements were then taken as the trail was trampled, from 0 to 1500 passes, to allow the assessment of trail damage with usage. This experimental trail was designed and cut by a local man at the request of the project team and was permanently marked to allow re-assessment in future years.

Phase.4 – A rapid examination of the whole trail network (approximately 34 km) collected data on physical and biological trail parameters related to damage by trampling. These data were then be combined with data collected from the trail use logbook and interviews with members of lodge staff and guides, to gain an overview of the current state of the trail network around the Explorer's Inn. The assessment methodology was kept simple and easy to replicate to allow re-assessment in future years, and indeed, in other trail networks in the area.

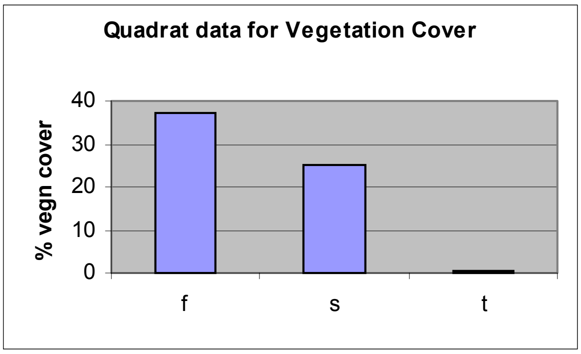
In addition, general observations were noted and many photographs taken during the fieldwork period. Several botanical samples of interest were collected for the herbariums of La Molina University (Lima).

Results and analysis
A large amount of data was collected during the fieldwork period. These data were first sorted and duplicated on paper, and then entered into MS Excel the project laptop computer at the lodge (powered by a heavy duty car battery and power inverter). On returning to Edinburgh the data was further sorted and grouped for comprehensive analysis, and further statistical analysis.

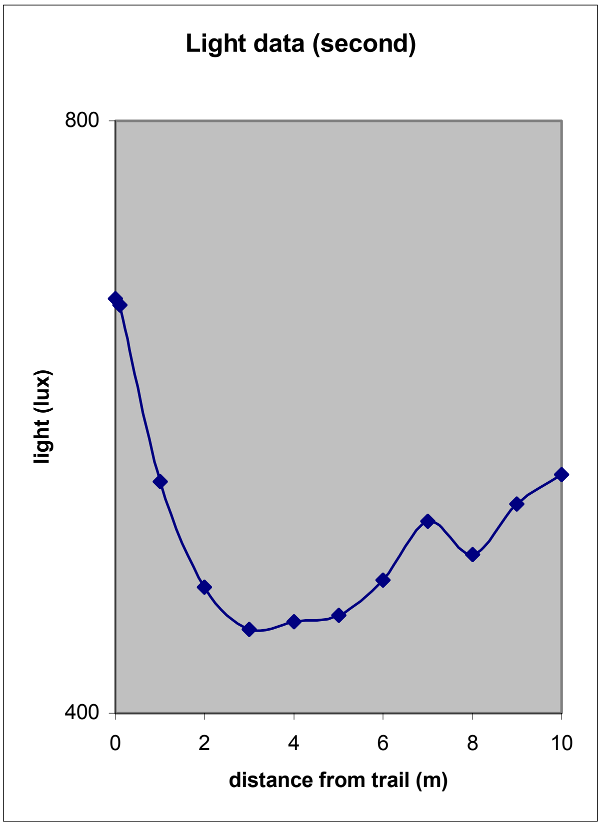
Phase.1
These data indicated a distinct difference between the three identified parts of the trail environment, that of the trail ('t), the trail side ('s'), and the forest ('f') in terms of both physical and biological aspects. Graphs 'a' and 'b' demonstrate aspects of the results which clearly indicate these distinct parts of the trail environment.



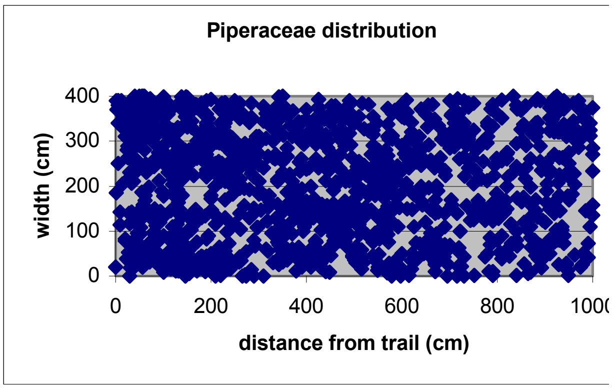
graph 1a – soil penetration readings for phase.1 (plots 1 to 5) with data separated and averaged for the trail, trail side and forest.

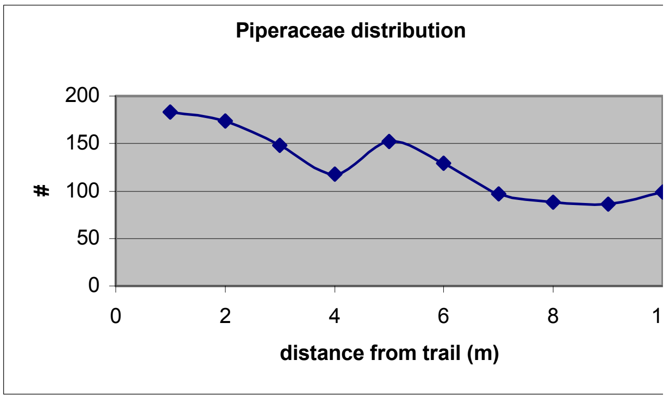


graph 1b – Vegetation cover data for phase.1 (plots 1 to 5). Data expressed as a percentage cover estimated at 1m about the ground level.



Graph 1c – data averaged for multiple light level readings taken from transects in plots 1 to 5, and expressed in terms of distance from the trail (for this graph; 0m is the centre of the trail and 0.1m is the edge).

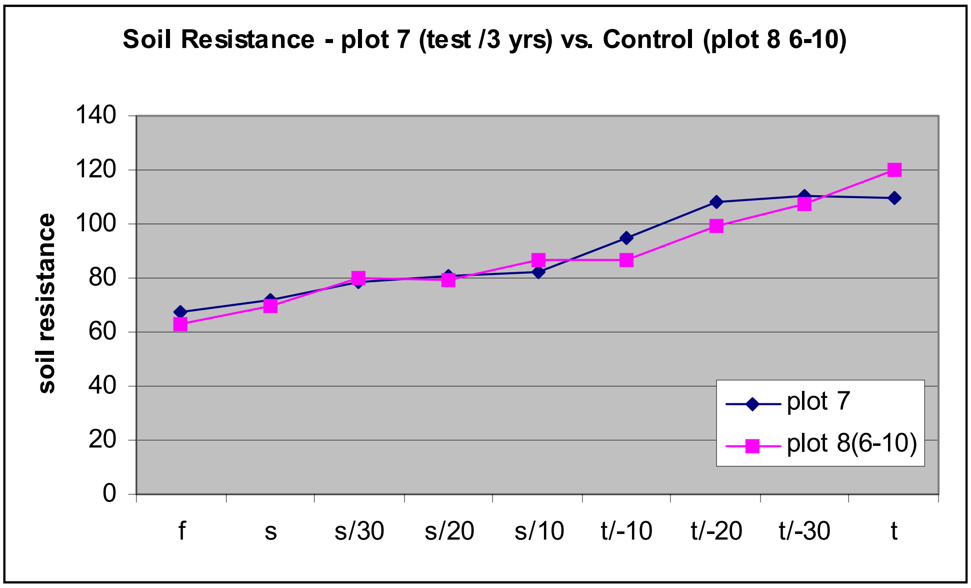




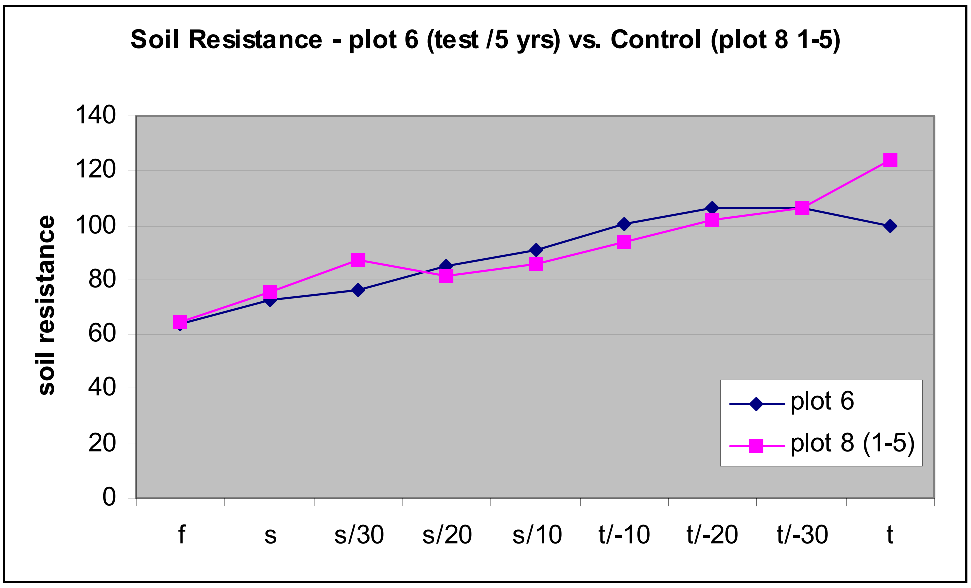
Graphs 1d & 1e – represent some of the data taken on the distribution chosen plant Families in relation to the trail, data has been combined for plots 1-5 of the Piperaceae (1275 individuals). These data can be compared with that of the light data (above), and other sources, in order to look for factors influencing distribution and the extent of, if any, of the 'vegetation edge effect' of the trail.

Phase.2

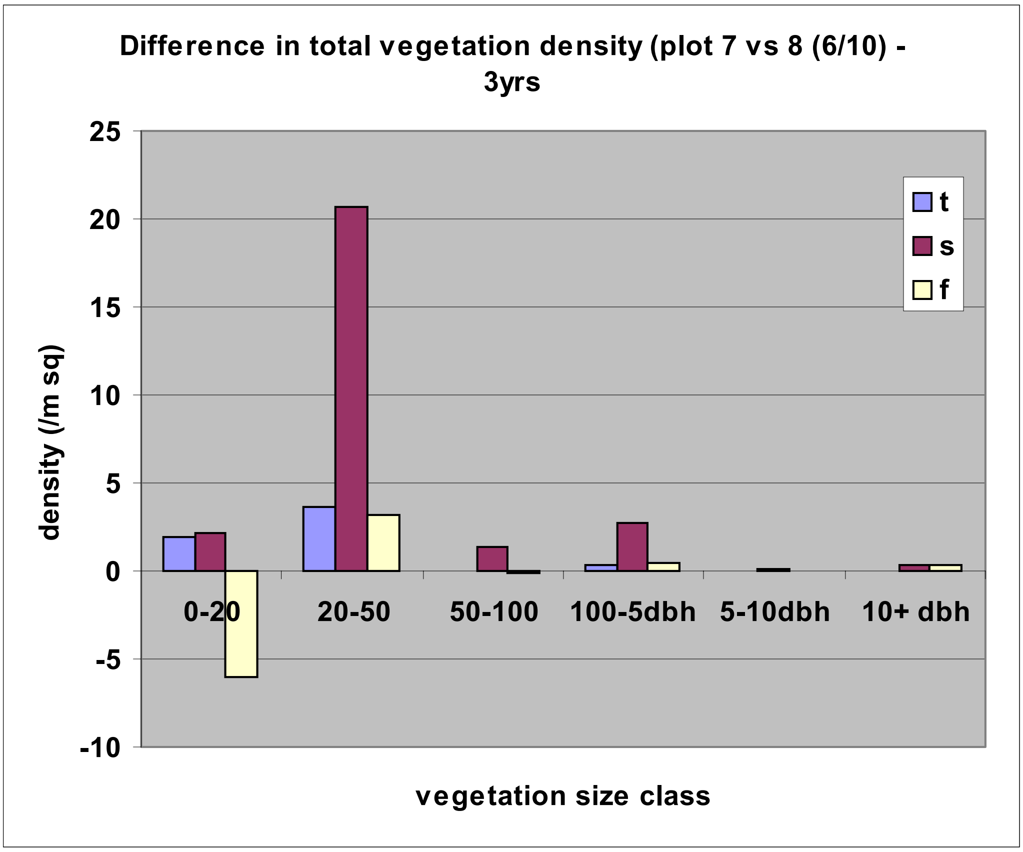
Examined four further plots around the main trail. Plots 6 and 7 had previously been used as a main part of the tourist route but had been closed to tourist traffic for 5 and 3 year respectively. Plot 8 provided a ‘control’ along the current main trail (MT) currently open to tourists, data was taken as close to plots 6 and 7 as possible and so plot 8 has been split into ‘plot 8, transects 1-5’ which is close to plot 6; and plot 8, transects 6-10’ which is close to plot 7. Plot 9 examined the main trail using the same methodology further along in the ‘high forest’ and provides data for comparison with the third phase of the project.



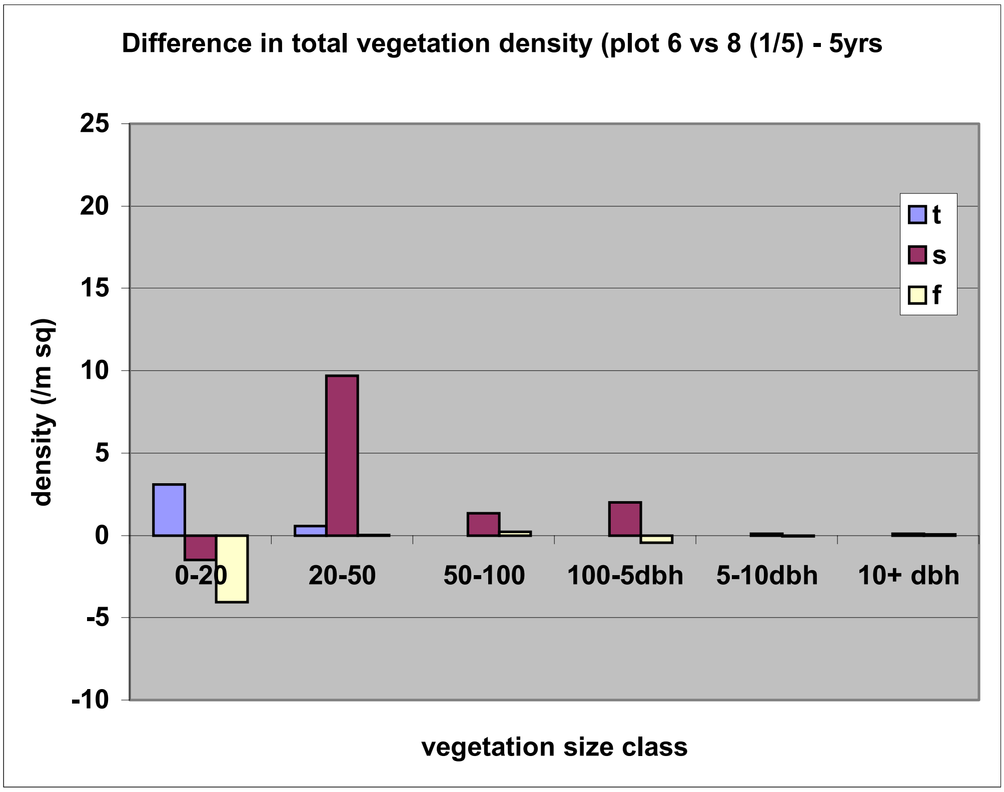
graph 2a – compares the soil penetration resistance using data from transects perpendicular to the direction of the trail, comparing plot 7 (closed for 3 years) with plot 8 t6-10 (currently open to tourists). Positions expressed on the x-axis refer to the position in relation to the trail, such t/-30 being 30cm from the trail edge towards the true trail centre ‘t’, and s/30 being 30cm away from the edge towards the true trail side ‘s’.



graph 2b – compares the soil penetration resistance using data from transects perpendicular to the direction of the trail, comparing plot 6 (closed for 5 years) with plot 8 t1-5 (currently open to tourists). Data is expressed as in graph 2c.



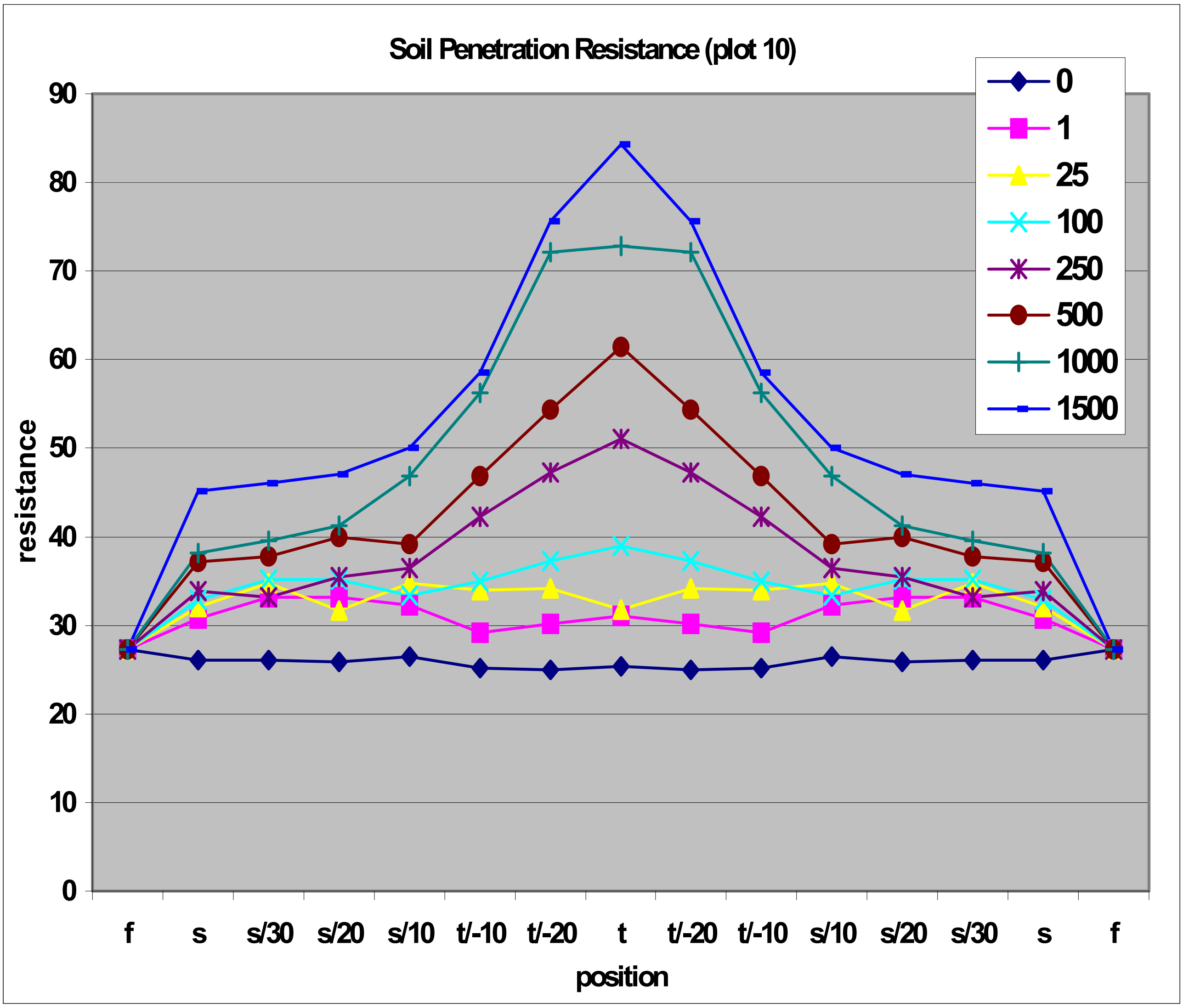
graph 2c - data from quadrats placed along transects perpendicular to the direction of the trail, comparing plot 7 (closed for 3 years) with plot 8 t6-10 (currently open to tourists). Data was collected in categories for height and plant 'type' (dicot., monocot., palm, fern, & grass) but is here expressed as total density.



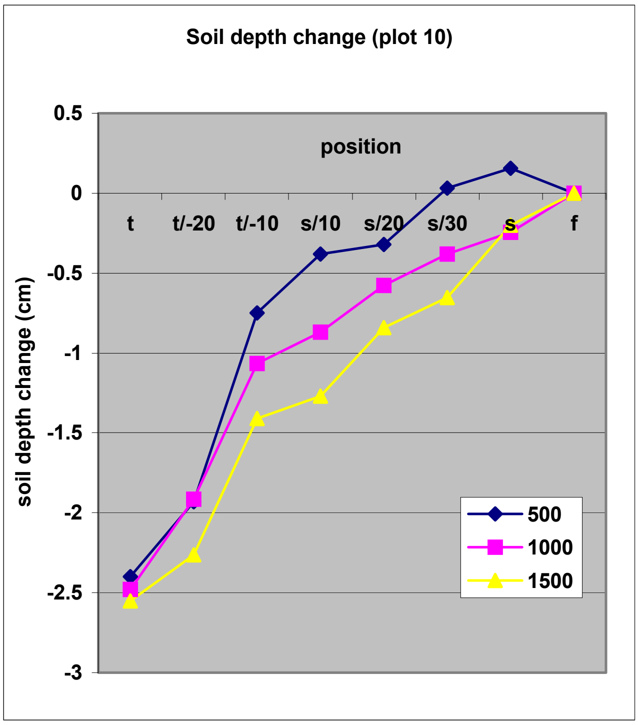
graph 2d – compares vegetation structure across the trail, comparing plot 6 (closed for 5 years) with plot 8 t1-5 (currently open to tourists). Data was collected and expressed as in graph 2c.

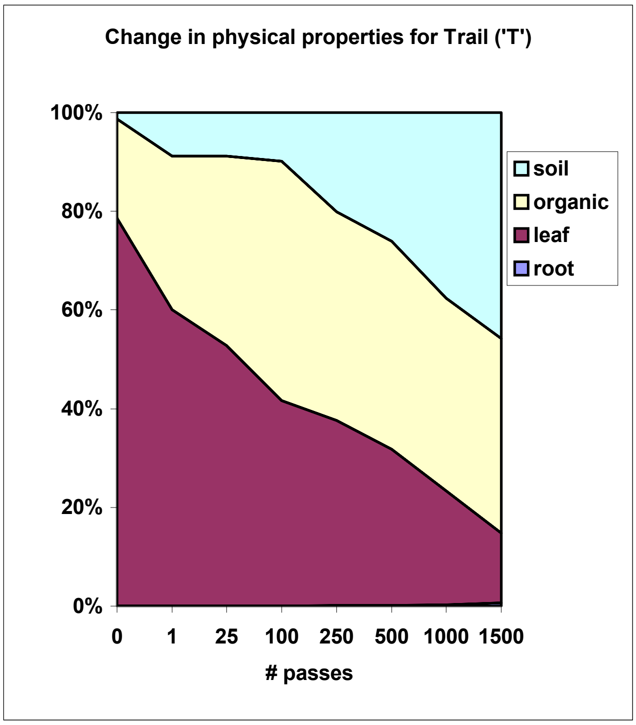
Phase.3
Data was collected from 12 transects established across the new trail (plot 10). Data was collected both before (sometimes expressed as '0') and after (sometimes expressed as '1') the trail was cut, then further data was collected at intervals during the controlled trampling (25, 100, 250, 500, 1000, and 1500 passes). Further data, measurements and observations were recorded which are not expressed here but provide important data to ensure that the comparisons are appropriate (e.g. 'tramplers' body weight, height, foot size).

Physical measurements



graph 3a – soil penetration resistance across the trail with increasing number of passes. Data is calculated as means for 12 quadrats in each position, and these data are expressed in each position across the trail as described in graph 2a.



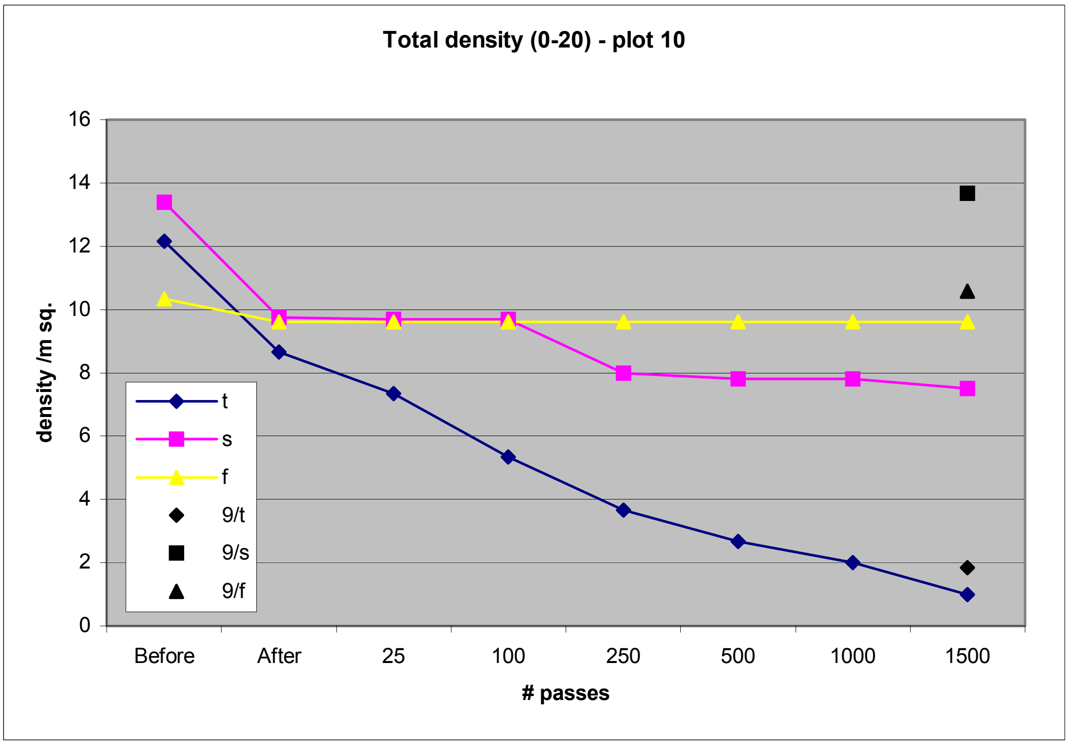


Graph 3b (left) – expresses the change in soil depth as compared with soil level before the experiment (0 passes). Each data point is the average of 12 transects and grouped by 'position'.

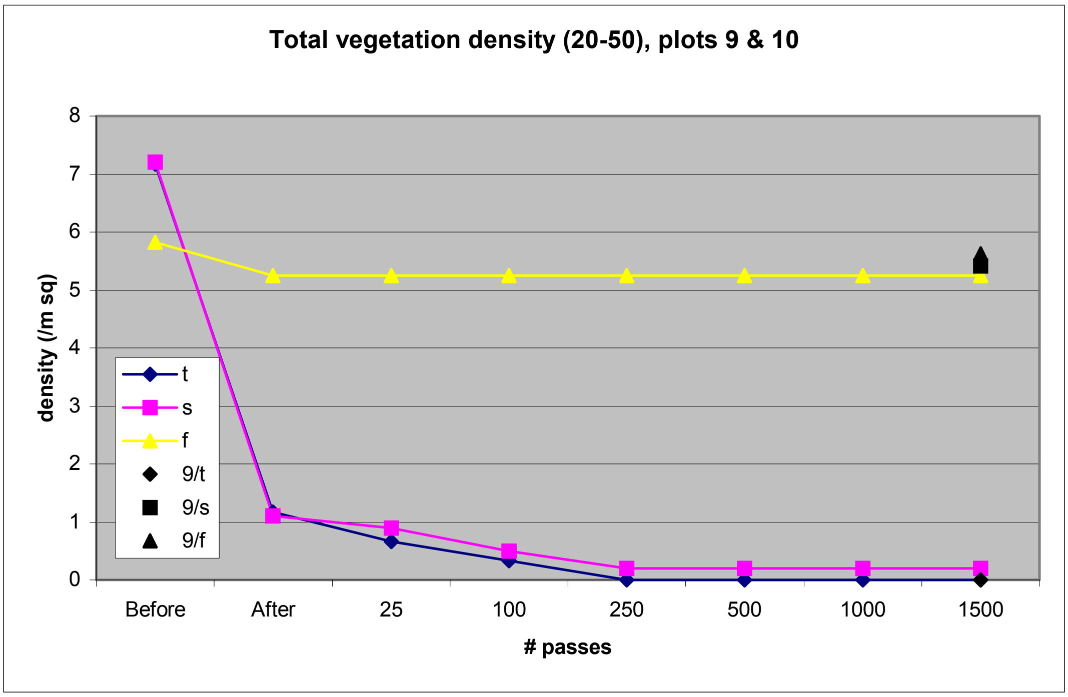
Graph 3c (right) – expresses quadrat data of '% cover' (estimated by eye) through the experiment. Each data point is the average of 12 transects at each '# passes'.

Graph 3d – Expresses data for 'leaf depth' x 'leaf cover' as 'leaf factor' (found to better demonstrate significant differences in the data). Positions are as in previous graphs with S/10 and S/20 combined as S/1&2.

Biological measurements

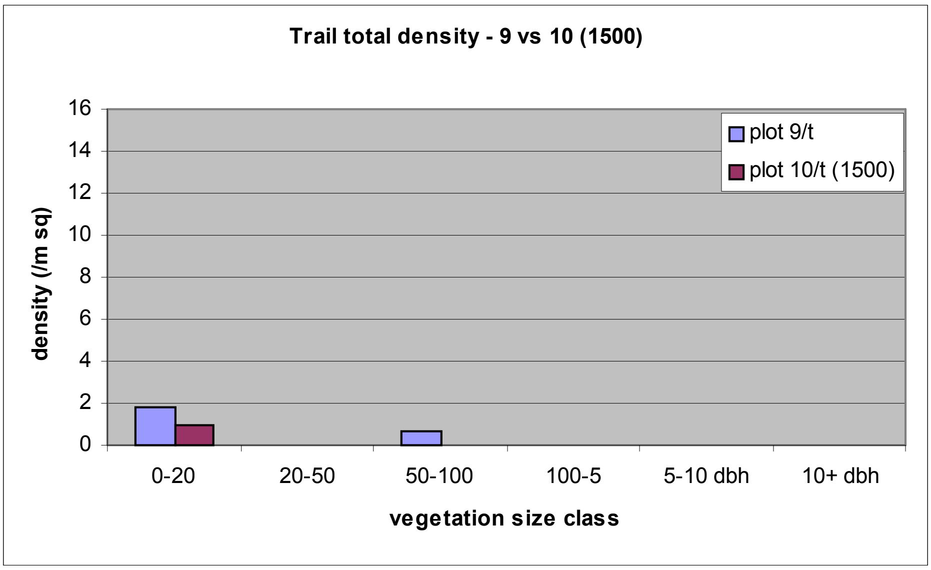


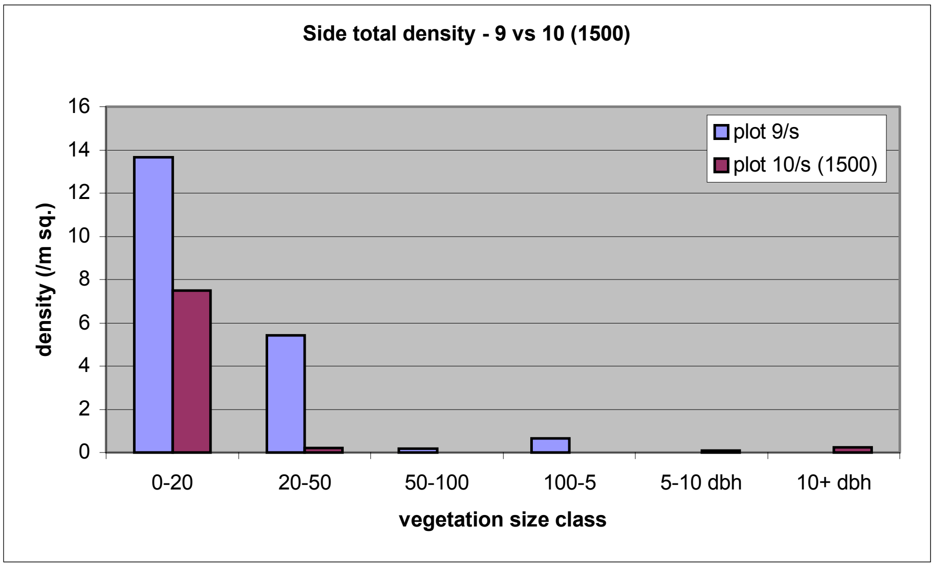
graph 3d – expresses the change (loss) in total vegetation density upto 20cm height through the trampling experiment in the three main positions, 't', 's', and 'f'. Data from plot 9 (main trail, currently open to tourists) is also expressed in comparison to 1500 passes.

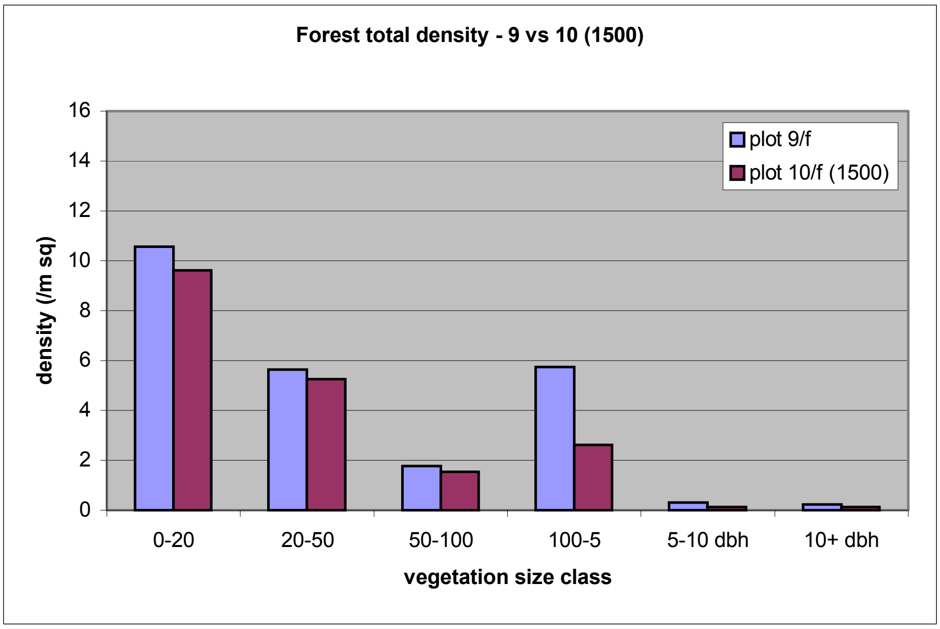


graph 3e – expresses the change (loss) in total vegetation density between 20-50cm height. Data was collected and expressed as in graph 3d.

The following three graphs, 3f, 3g, and 3h respectively, express data for total vegetation density, separated according to height, at the three main positions in relation to the trail; 't', 's' and 'f'. Data for the new trail (plot 10) is compared with that of the nearby existing and open trail (plot 9).

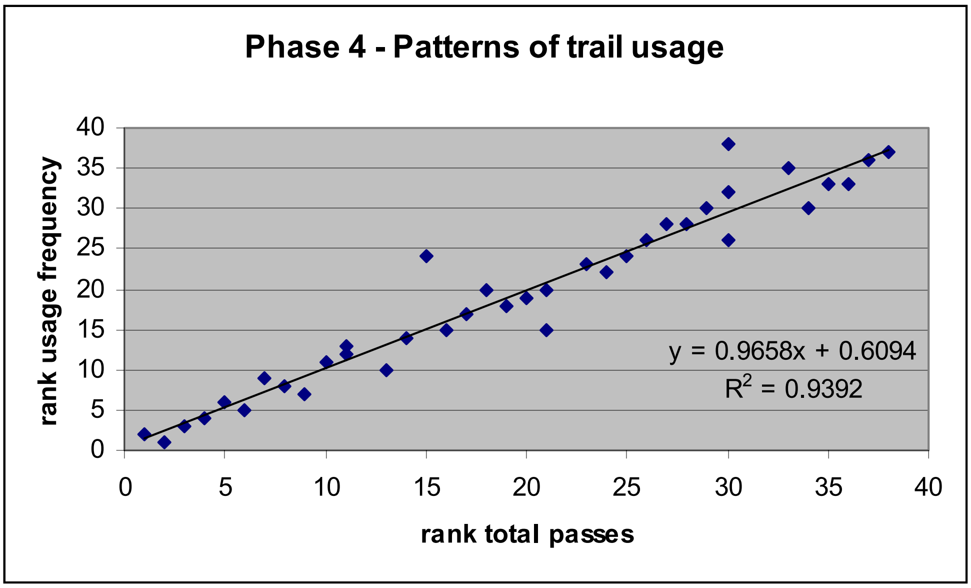






Phase 4.

The data in phase 4 was combined from a number of different sources, the lodge trail log and interviews with lodge staff. Further data for visitor numbers, length of stay and group size is anticipated, and will allow more analysis of these results and those of phases 2 and 3.



Graph 4a – expresses data from the lodge trail log for frequency of use and overall usage of trails.

Graph 4b – expresses data for group size and frequency of use.

Discussion

The results from the four phases have combined to demonstrate the definite effects of the impact of tourist trampling on the forest around the Explorers Inn eco-lodge. The data from phase1 provided quantified evidence of the changes caused by trampling, and the data and understanding gained from this phase provided the basis for the progression of the project into phases 2, 3, and 4. The existence of an 'edge effect' on the vegetation bordering the trail was really only demonstrated in the Piperaceae; with the Rubiaceae, Cecropiaceae (and Melastomatoceae) proving inconclusive; possibly due to a lower sample size.

An examination of the data from phase2 plots 6 and 7, as compared with their controls (plots 8 1-5 and 8 6-10 respectively) has suggested that the changes in soil structure exist for a significant period of time after the trail has been closed. Graphs 2a and 2b demonstrate that the soil penetration resistance of the closed trails remains close to that of the open trail, although the trail centre 't' of plot 6 does appear to be lower than the control (plot 8 1-5) suggesting a slight reduction in soil compaction after five years.

The data for the vegetation structure indicates a rise in the density of vegetation in the 0-50cm height classes along the 'trail side' ('s') vegetation in the years after closure. In particular, ferns and dicotyledonous plants appear to show particularly strong growth as part of the trail recovery, perhaps taking advantage of the increased ambient light levels along the trail. However, the relatively small amount of increase in the density of vegetation above 50cm in height is probably the result of these trails, although closed to tourists, continuing to be used by guides who may infrequently cut recovering vegetation.

The third phase of the project allowed the process of trampling to be investigated in a controlled manner, giving both abundant and accurate data. The physical data suggests that significant change occurs to the soil structure and forest floor relatively quickly. After only 500 passes there was notable increase in trail depth due to both erosion and compaction of the soil, confirmed by increases in soil penetration resistance (and hence reduced water infiltration rates, from observation). At this point, the removal of the surface leaf litter layer shown in graph 3d ('leaf factor'), and exposure of the organic and soil layer beneath (graph 3c) was notable causing possibly long term soil nutrient and structure problems.

The initial cutting of the trail removed a significant amount of the vegetation in the designated 2m wide 'new trail' area. Effectively all plants over 50cm were cut, irrespective of plant 'type'. Of the remaining vegetation, graphs 3c and 3d demonstrate that vegetation within the trail 't' area is trampled and killed quickly, and by 1500 passes (approximately only one or two years of average MT tourist use) was at a density equivalent to that of plot 9 on the open tourist Main Trail. However, a comparison of vegetation densities between plot 9 and plot 10 indicate that there is a significant growth of trail side vegetation after the initial establishment and trampling of the trail (seen in graphs 3c, 3d and 3g).

An overall current state of the impact and damage of the trail system gained in phase 4, when combined with the data from phase 1, 2 and 3, indicates that those trails receiving regular, heavy use from large groups of tourists could be classified as significant, long term damaged trails' whereas those trails which receive only periodic light use by small groups (such as individual bird spotters) would in contrast be likely to recover quickly and be difficult to distinguish after only a few months of disuse. It is expected that the next part of the data analysis will examine the number of trails in each damage category and hence extrapolate this data to define the overall extent and longevity of the impact to the forest around the Explorers Inn (and perhaps to other lodges in the area).

This project has provided a large amount of valuable ecological data on the relatively new, and as yet relatively unstudied, phenomenon of 'eco-tourism'. The Tambopata National Reserve is experiencing large and steadily increasing numbers of tourists, which are acting as an 'uncontrolled force' on the plants and animals inhabiting this fragile ecosystem. As demonstrated in the project results, definite physical and biological effects are being seen in the forest surrounding these eco-lodges, such that justifies both further research and increasing control measures.

In terms of management strategies, the rapid and relatively permanent nature of the damage done by trampling suggested that trails, once established, should be kept open and maintained in preference to the cutting of new trails. Although this would entail an increase in labour costs, such as clearing occasional fallen trees, it would reduce the overall impact to the forest and maintain a higher quality 'resource' for ecotourism purposes. Additional maintenance to accommodate the changes in the trail during the wet season, such as localised drainage and construction of walkways, would reduce the 'spreading effect' of the trail as tourists avoid walking through deep mud or water.

It is hoped that further statistical testing of these data will reinforce the conclusions made in the discussion above, and an additional production of an 'overall environmental impact statement' from the data in phase 4, sufficient to justify publication.

Acknowledgements

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Dr. Oliver Phillips	School of Geography, University of Leeds
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Derek Scott	University of Edinburgh
Peter Wilkie	Tropical Botany dept., Royal Botanic Gardens Edinburgh
Nigel Winser	Deputy Director, RGS

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