CHAPTER 4

METHODS AND MATERIALS

Methodology Used

A spatial-substitution framework approach was adopted for studying recreational use and its effects on forested areas in Peninsular Malaysia. This consisted of observing a situation within FRAs, which has been subjected to recreational use, at a certain time period. In this approach, "after-the–fact" analysis was applied, since recreation in forested areas in the peninsula was undertaken long before the area was designated as FRAs by the FDPM. As such, it will be impossible to reconstruct the environment minus the effects of recreation and therefore the area is assumed to be homogenous prior to introduction of recreational used and there has not been an overall change in the environment since the area was made available to visitors. As such, the differences in impacted sites and adjacent areas were solely attributed to the effects of recreational uses. These differences, as determined by the intensity of recreational use and its effects were measured, using established environmental indicators of soil, vegetation and water quality. This study was undertaken during the first half of 1996.

Study Site

The field research began early in January, 1996. An initial step was networking of information among the ninety-nine (99) FRAs in the peninsula, encompassing over 9.796 ha. The networking consisted of developing a common data set among the FRAs, from the Forestry Department Peninsular Malaysia's (FDPM) Reserve Records, office files, published materials (for internal and external circulations) and pamphlets.

Common attributes among the FRAs in Peninsular Malaysia include being water-based, located within the Lowland *Dipterocarp* Forest, serviced by both public and private transportation systems, nearness to population centres and centres having a good mix of rural and urban population. These attributes were in important ways, form the basis for selecting the "representative" or "average" FRA in Peninsular Malaysia.

Sungei (Sg.) Tua FRA in the state of Selangor, was selected as the study site based on its representativeness of the spectrum of attributes of FRAs as listed above, and managed by the Selangor State Forestry Department (SSFD). Representation was further achieved by selecting the attributes, each of which is typical of the five most prevalent attributes found among the FRAs of Peninsular Malaysia.

Hulu Gombak Forest Reserve (FR) encompassing 10,269 hectares is located north-east of the nation's capital, Kuala Lumpur. It astrides the Kuala Lumpur-Selayang-Ulu Yam trunk road at the 23-28 kilometre (km). The area is readily reached by both private and public transportation systems.

Topographically Hulu Gombak FR is fairly steep with fragile soils of granitic and quartzic origins. These medium fertile and fragile soils support a fairly large number of species of differing densities. On the basis of structure, physiognomy and altitude, the forest at Hulu Gombak, can be divided into two formation types; the Lowland *Dipterocarp* Forest (altitude between 0-300 metres) and the Hill *Dipterocarp* Forest (300-750 m) (Symington, 1943; Wyatt-Smith, 1966). Structurally, the Lowland *Dipterocarp* Forest at the valley bottom and lower slopes, have a characteristic three layered canopy 25-30 metre high, often little ground cover except fallen leaves, mega- and mesophyllous leaves, numbers of woody climbers, some epiphytes and large buttresses. At the higher elevations, the Hill *Dipterocarp* Forest formation dominates. This forest is similar in structure, but possesses less distinct canopy layering as only the emergent crowns and the lower shrub layers are common. There is more ground cover, less buttressing, fewer lianas and poor development of epiphytes.

Common forest species may includes distinct ecological association; the pure stands of Seraya *(Shorea curtissi)* in the upper hills and along the ridges, together with Meranti bukit (*S. platyclados*), Meranti kepong (*S. ovalis*), Nyatoh taban merah (*Palaquium gutta*) and Merbau (*Intsia palembanica*). Towards the lower slopes and valley bottom, the species increases to include Medang (*Cinnamomum iners*), Rezak (*Vatica ordorata*), Meranti tembaga (*S. leprosula*) and Meranti sarang punai (*S. parvifolia).*

Hulu Gombak FR managed for sustainable development by the Selangor State Forestry Department (SSFD), was selectively logged between the 1960s and 1970s and these logged areas were rehabilitated with indigenous species by mid-1970s (Figure 4).

However, at lower altitude and along former logging roads Bertam (*Eugeissonia tristis*) together with bamboo (Genus *Dendrocalamus*) shrubs and Resam *(Dicranopteris linearis*) proliferate.

Compartments 8 (326 ha) and 15 (244 ha) of Hulu Gombak FR, comprise the Sg. Tua FRA, as well as its hinterland (Figure 5). The Sg. Tua FRA in Compartments 8 and 15, encompasses an area of about 32 ha. The FRA in Compartment 8 extends as a

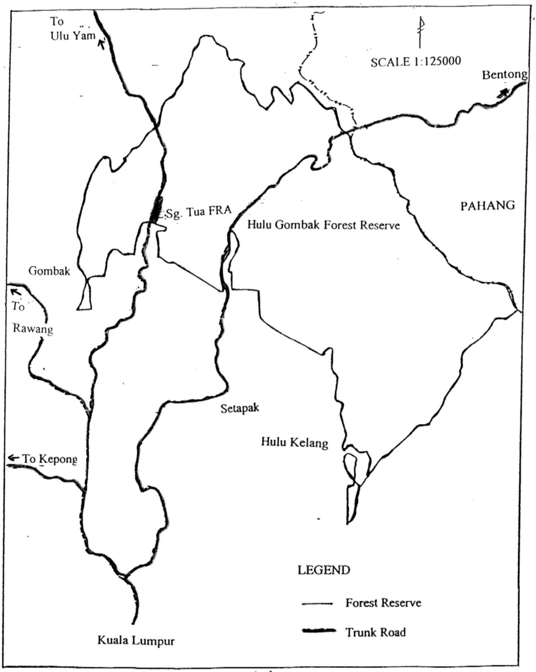

Figure 4. Hulu Gombak Forest Reserve and Sg. Tua Forest Recreational Area

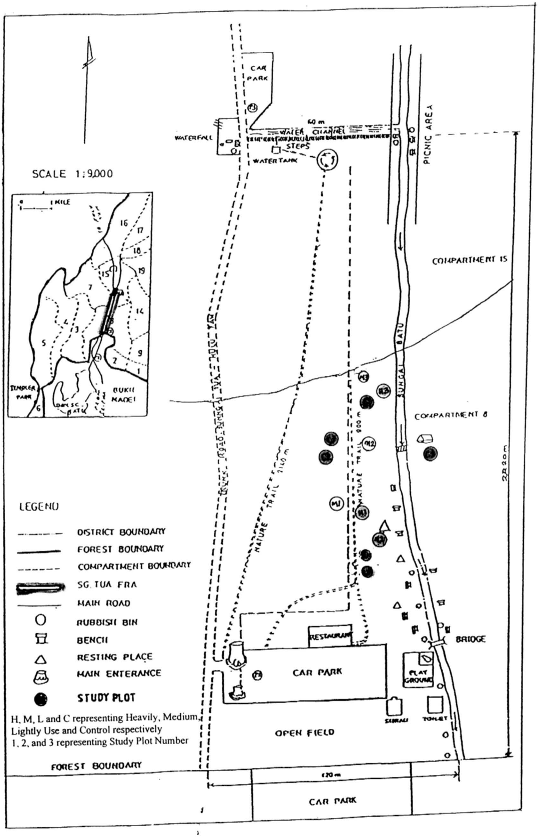

Figure 5. Sg. Tua FRA

narrow strip along Sungei (Sg.) Batu, with numerous bathing pools, both man-made and natural. The area along Sg. Batu is relatively flat, undulating and having a more gentle relief than those of the hinterland, which are generally much steeper. Complementing this, are a number of picnic facilities, bird watching hides, nature trails and recently an information centre have been established by the SSFD. It is in this area, also that it receives most visitors, while major recreational activities include picnicking, swimming, nature walks and camping.

Part of the Sg. Tua FRA also extends into Compartment 15 of Hulu Gombak FR. At the northern end of the Sg. Tua FRA, the land is much steeper and in some parts, rising of some 180 metres over a horizontal distance of 1,200 metres, which culminates in a three stage waterfall. Here, the assent rate can be, as much as 100 per cent and combine with the presence of fragile soil, make this area erosion proned, especially during the monsoonal periods between March to May and from September to October.

The Selangor Tengah District Forestry Office at Cheras, is responsible for the management of both Hulu Gombak FR and Sg. Tua FRA. The Sg. Tua FRA provides a significant part of the spectrum of recreational opportunities for residents of Kuala Lumpur and Selayang.

Study Approach

Having identified the spatial-substitution framework associated with forest recreational use and its effects, the next step was to identify the studies to be undertaken, to meet the requirements of this forest recreational framework. The studies undertaken include:-

1. Recreational Use Categorisation

2. Measurable Components Study of soil, vegetation and water quality, and.

3. Analytical Method Study.

Each of the above study presented, include a description of the study objectives, materials used and procedures applied.

Recreational Use Categorisation

Objective

The objective in classifying recreational use category was to identify "zones" of similar characters and "visibly" self-contained areas on the basis of site occupancy, as heavily, medium and lightly used, as well as the undisturbed (control) condition.

Material Used

The materials used in this study include both natural and man-made facilities that were available within the FRA. These include waterfalls, nature trails, bird watching hides, wooden shelters, benches, picnic sites and camping sites that were not only frequented by visitors, but also were subjected to varying degrees of recreational use. Sample counts on the basis of site occupancy were undertaken in these areas, to identify "zones" of similar characters and visibly "self-contained areas".

Procedure Applied

Numerous field investigations were undertaken between June and October

1996 in Sg. Tua FRA to identify by their locations, those sites that were subjected to varying degrees of recreational use and its effects. Throughout June to October, 1996, sample counts of site occupancy on the first and third week of the month, were undertaken on designated areas where visitors frequented, as well as those sites experiencing environmental degradation.

Each of the designated areas were visited four times between 1000 hours (hrs), 1200-1400 hrs, 1400-1600 hrs and 1600-1800 hrs and a recording of the site occupancy were undertaken, in terms of number of people at designated sites. Two hours intervals and beginning at 1000 hrs were used, since inventory of visitors to this FRA indicated that visitors usually arrived around 1000 hrs and they stayed for well over two hours. This procedure was cost effective and yielding adequate amount of data. Details of visitors' count were listed in Appendix 1.

On the basis of the sample count on designated used sites, "zones" of similar characters and visibly "self contained areas" were identified and areas within FRA were classified, as heavily, medium and lightly used, as well as control. These use categories form the baseline data to test the approaches, as contained in the methodology used.

Measurable Component Study

Although the measurable components of soil, vegetation and water quality were common for both spatial-substitution framework studies, but applications of these indicators differ with respect to assessing the impacted sites at certain time.

In this study, the indicators of soil, vegetation and water quality were used to assess impacted sites, resulting from recreational use. Although each of the three indicators was assessed separately, they were examined in a sequence that allowed for comparison within and between them on a cross-sectional approach on sites identified as heavily, medium, lightly used and undisturbed (control) condition.

Changes in soil compaction were related to bulk density, soil moisture content, total and air-filled pore space, while changes in the vegetation were related to quantitative differences in floristic composition and ecological co-relations. Water quality changes were related in terms of its physical and chemical properties.

The study began by assessing the following indicators of:-

1. Soil
2. Vegetation, and
3. Water quality.

Soil Study

A combination of field and laboratory methods were adopted in this study to investigate the differences in soil strength, as it relates to varying degrees of recreational use, as well as varying soil depth, through changes in soil compaction, soil moisture content and soil porosity.

Field testing of changing soil strength in terms of bulk density and soil moisture content against varying degrees of recreation use were compared by using pocket-sized penetrometer and soil moisture meter respectively. In addition, Gravimetric Method or Soil Coring Method of determining soil compaction was also investigated. This study involved a combination of field and laboratory conditions, to determine compaction in terms of soil bulk density, relative amounts of soil moisture content, total and air-filled pore space. Combining these studies would determine the amount of variations in the edaphic environment, in relation to the intensity of recreational use and varying soil depth. As such, the studies undertaken were as follows:-

1. Penetrometer Study.
2. Soil Moisture Content Study, and
3. Gravimetric Method Study.

Penetrometer Study

Objective

To investigate the relationship between varying recreational use and soil compaction.

Material Used

Soil compaction was measured by a penetrometer. This instrument measured the force of penetration of a metal point into the soil and computed, as a function of depth. A small spring, hand held operated Eijkelkamp penetrometer (Model 06.03) was used in this study.

This instrument incorporated a piston which rested against a loading spring and housing within a measuring scale, was calibrated in kilogrammes per centimetre square (kg/cm^2) from 0-4.5 kg/cm^2. Along this scale was attached an indicator sleeve, which automatically held the compaction reading, after the piston was released.

Procedure Applied

The hand held Eijkelkamp penetrometer (Model 06.03), was already calibrated by the manufacturer and rechecked, prior to being used in the field. The instrument worked by pushing the piston into the soil, until the grove tip of the piston was flushed with the soil surface. The penetrometer was then withdrawn from the soil and compaction was read-off, from the measuring scale.

The penetrometer was used to measure soil compaction to soil depth of 5, 10, 15 and 20 cm at sites, which were identified as heavily, medium, lightly used and the undisturbed (control) condition.

At the heavily used site, a soil pit measuring 40 x 40 x 40 cm was dug. The penetrometer was then driven at right angle into one of the four faces at soil depth at 5 cm and the penetration resistance measurement read-off, from the measuring scale. The process was repeated at the same soil depth (5 cm) for the other two faces of the soil pit. The mean of the three measurements would represent soil compaction resulting from the penetration resistance at soil depth of 5 cm, for the heavily used category. The process was repeated for soil depth of 10, 15 and 20 cm for the heavily used category as well as in the other two sites representing the heavily use category.

For the medium, lightly used and control categories, the whole process was repeated and mean soil compaction at the various soil depths determined. After which the soil pits were refilled with the extracted soil and ground compacted back to its previous status. Comparisons were then made between soil compaction at the different sites.

Soil Moisture Content Study

Objective

To investigate the relationship between soil moisture content and varying degrees of recreational use.

Material Used

An Aquaterre Soil Moisture Meter (Model 200) was employed to determine soil moisture content at soil depth of 10, 15 and 20 cm that resulted from compaction.

This instrument comprises of a probe, which housed the soil moisture sensor. The sensor was powered by a 9 volt battery and connected to the soil moisture meter, at the other end of the probe.

Procedure Applied

In operation, soil moisture is constantly being absorbed or released from the sensor. As the soil dries out, the sensor moisture is reduced and the electrical resistance between the electrodes (located within the probe) increased. This resistance is then recorded by the Aquaterre Soil Meter (Model 200).

This instrument was calibrated by dipping the probe into a bucket of water and the "Test" button was activated. While pushing down the "Test" button, the "Set" knob was turned until the meter read 100 (ie. 100 % moisture content) and the instrument was now calibrated.

In operation, the instrument was pushed into the heavily used soil category to a depth of 10 cm and the "Test" button was pushed and the reading indicated the soil moisture level for that used category, at 10 cm depth. The process was repeated at the same spot for soil moisture contents reading at depth of 15 and 20 cm. Three other soil moisture readings at soil depth of 10, 15 and 20 cm for the heavily used category were recorded. These readings were then averaged out, as the soil moisture content for the heavily used category. The process was repeated for soil depth of 10,15 and 20 cm for the other used categories of medium, lightly used and control, as well as its replicates. Comparison was then made between the soil moisture contents at the different sites.

Gravimetric Method Study

Objective

To find the extent of the differences in soil porosity in terms of bulk density, pores containing relative amounts of solids, air and water under varying degrees of recreational use.

Material Used

Gravimetric Method undertaken in this study involved a combination of field and laboratory activities. Field activities involved the collection of soil samples at depth of 5, 10, 15 and 20 cm for each of the categories of heavily, medium, lightly used and control, using the Eijkelamp stainless steel rings, hammer head with guiding cylinder (Model 07.53.5A), while laboratory activities involved the determination of soil bulk density, soil moisture content, total and air-filled pore space. Instrumentation used included electric oven and weighing scale for drying and weighing the soil samples respectively.

Procedure Applied

The Eijkelamp stainless steel rings having a diameter of 53 mm and depth of 68 mm was clamped to the hammering head by a retaining ring. The guiding cylinder was to ensure that the sample was taken in a true straight line. The soil sampling ring was hammered into the ground to a depth of 5 cm by the use of the pressure absorption hammer.

Next, the soil sample was extracted from the ground by withdrawing the hammer head and the soil from the open end of the ring was trimmed off using a small framed saw. The stainless steel ring was capped to ensure no moisture escaped from the sample and details of the place, time and date of the sample were recorded, prior to transporting the sample to the laboratory for analysis. The process was repeated for soil depth of 10, 15 and 20 cm, for the heavily used site, as well as for the medium, lightly used categories, as well as control. Since the process was destructive, soil pits representing each category of recreational use, as well as its replicates were dug.

In the laboratory, using a method by Anderson and Ingram (1993), the core samples at soil depth of 5, 10, 15 and 20 cm in each sampling site were analysed to obtain the respective soil compaction, as indicated by bulk density, soil moisture content, total and air-filled pore space.

Vegetation Study

Objective

To study vegetation differences in terms of changes in vegetation cover to varying degree of recreational use.

To investigate the effects of changes in vegetation cover, as it relates to changes in vegetation species.

Material Used

A square wooden frame measuring 100 x 100 cm (Figure 6) was used to record the presence or absence of vegetation cover, was employed in the first part of this study. The plot frame was further divided into 25 sub-plots of 20 x 20 cm dimension with wire, which were used to locate and support 0.2 cm thick plastic grid (Figure 7). The plot frame was adjusted, suoh that the wires supporting the plastic grid were above the vegetation, during vegetation cover and bare ground area readings.

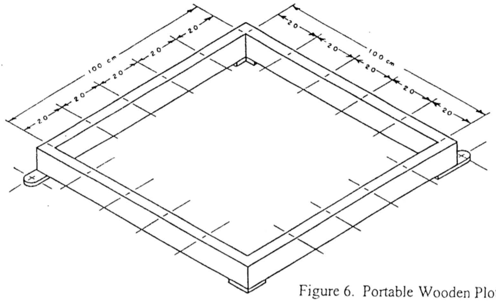

Figure 6. Portable Wooden Plot Frame

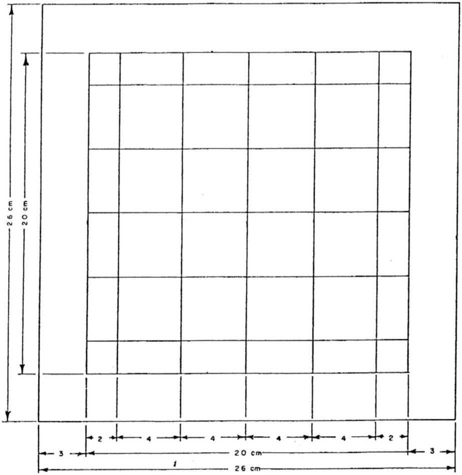

Figure 7. Clear Plastic Grid

The projecting steel lugs on the frame were used to locate steel marker pins, which were left projecting about a 1.5 cm above the ground. The ends of the pins were printed to facilitate finding them during the study period. In addition, dimensional sketches were taken during the initial plot layout, so as to facilitate locating the pins, in case they were accidentally removed by visitors during the study period.

The second part of this study undertook to detect vegetation species changes relative to recreational intensities. This method employed a five-pointed needles held at 20 cm apart, on a wooden frame, for sampling vegetation at 25 cm intervals, along a 50 metre line bisecting the plot center and spanning the whole gradient of recreational impacts (used).

Procedure Applied

The square plot design of 20 x 20 cm for recording vegetation data, was placed centrally in each of the impacted zone (heavily, medium, lightly used and control), with plot centres being referenced to permanent landmarks or places where visitors frequented; picnic spots, wooden shelters, benches and fire places. Sample plots located in similar use impact zones and control, were replicated three times, for a total of twelve sample plots. Vegetation data were then collected from each sample plot. Observations were made by vertically sighting through the 25 inter sections of the line on the plastic grid. The grid was scanned for vegetation cover, organic matter and bare ground.

The observations were supplemented by photo-file techniques, which was merely a photo recording, using a Minolta 35 mm, single lens reflex (SLA) camera of vegetation changes that was taken from permanent plots. This technique was extremely valuable in cases of confirming changes in percent of ground cover.

Supplementary (co-variance) information of the effects of vegetation species response to recreational impact was obtained by a systematic sampling of each of the used category and its replicates, by recording the number of hits the five pointed needles, as sampling was carried out at 25 cm interval, along a 50 metre line bisecting the sample plot. All plants hitting the needle tips were scored. The position of each point in relation to study site was also described.

Water Quality Study

Water quality of FRAs in Peninsular Malaysia in terms of temperature, pH, electrical conductance, dissolved oxygen and turbidity was adopted for this study. Physical (water temperature and turbidity) and chemical (pH, electrical conductance and dissolved oxygen) properties of water were measured by both *in-situ* and *ex-situ* processes (Table 5). In this study water properties parameters, as represented by water temperature, pH, electrical conductance and dissolved oxygen were determined by the use of the ICM Aqua Check Water Analyser (Model 5110), while turbidity by the HACH turbidimeter (Model 2100P). *In-situ* measurements comprising of water temperature, pH, electrical conductance and dissolved oxygen study, while *ex-situ* measurement the water turbidity study.

In-situ Measurement

Objective

To ascertain the existing water quality, as represented by water temperature, pH, electrical conductance and dissolved oxygen of FRA.

To determine the impact of recreational use on water quality, as represented by the above parameters, as well as to establish quantitative relationships between them.

Table 5. Water Quality Parameters in FRA

Measurements	Water Property		Parameter
	Physical	Chemical	
In–situ	X		Water temperature
		X	Dissolved oxygen, pH, electrical conductance
Ex-situ	X		Turbidity

Material Used

Physical and chemical properties of water in FRA, as represented by water temperature, pH, electrical conductance and dissolved oxygen were measured by the ICM Aqua Check Water Analyser (Model 5110). This instrument simultaneously measured the above parameters within a single large compact probe, housing four different probes, without the need of drawing water samples. The electrical sensors within the compact probe are connected by a cable to the portable meter, which consecutively displayed the four readings.

Procedure Applied

Prior to using this instrument, each of the probe was calibrated against a range of values, as recommended by the manufacturer. For pH, the pH sensor was calibrated at three points; one acid point (pH 4), one basic point (pH 10) and neutral (pH 7). For dissolved oxygen, the buffer solution of sodium sulphite, which is zero oxygen buffer was used for calibration. For electrical conductance, the conductivity standards used were 73.9 microsiemen per centimetre (μS / cm), 718 μS / cm, 6.7 millisiemen (mS) / cm and 58.8 (mS) / cm. For water temperature, the sensor need not be calibrated, since the manufacturer's calibration would meet its temperature specificity.

Having calibrated the instrument, the next step was to measure these *in-situ* parameters by dipping the probe mid-stream at 0.5 metre deep below the water surface, one metre upstream/downstream of discharge points (ie. heavily, medium and lightly used categories and control, as well as its replicates) with date, time and name of sampling points recorded. As the river is fast flowing and of medium width, sample points one metre upstream and downstream from discharged point was sufficient to ensure a thorough mix of the "effluent" with the river water, and differences between the two readings would determine the measurement associated with that site.

All of the above readings were recorded on field sheets and the whole process was repeated with the other used categories, as well as with its replicates.

Ex-situ Measurement

Objective

To ascertain water quality in FRA, as represented by its turbidity.

To determine the impact of recreational use on water turbidity, as well as to determine the relationship between the two.

Material Used

In this study, water turbidity in FRA was measured by the use of the portable HACH turbidimeter (Model 2100P), which operates on the nephelometric principle of turbidity measurement. As such, a value of zero represents distilled water, whereas value of several hundreds represent water with large amounts of suspended solids.

Procedure Applied

The instrument operates by scattering light onto the water sample, where a 90 degree (°) and a transmitted light detectors, measure the amount of light transmitted through the water sample. The microprocessor within the instrument then calculates the ratio of the signals from the 90 ° and the transmitted light detectors and transmitted the turbidity value of the water on to the LCD screen in Nephelometric Turbidity Units

(NTU).

The instrument was calibrated against formazin standard of 20, 100 and 800 NTU prior to be used in the field. This instrument powered by four AA batteries, measured turbidity from 0.01 to 1000 NTU.

Water samples collected by the grab method at the same locations, as the pH water samples. This consist of collecting a water sample through random scooping of water sample in mid-stream, 0.5 metres below the water surface and at one metre upstream/downstream from the discharged points.

As the river is fast flowing and of reasonable width, collection of water sample one metre upstream and downstream of discharged points is sufficient to ensure a thorough mix of the "effluent" with the water, and differences between the two measurements would determine the turbidity associated with that site.

The sample cell (glass vial of 15 mls) was then filled with the water sample and capped. Next, the instrument was placed in the Hach turbidimeter and measurement recorded. The process was repeated three more times and then averaged out to determine the turbidity for that category of use, as well as those of its replicates. This process was repeated for the other categories of recreational use.

Analytical Method

The following were the analytical methods, as applied throughout this part of the thesis. These include:-

1 Analysis of Variance (ANOVA) Test

2. Multiple Component Test (MCT)

3. Multivariate Analysis of Variance (MANOVA) Test

4. Principal Components Analysis (PCA)

Analysis of Variance Test

The analysis of variance comparison of means (ANOVA) procedure was used to test whether there were significant differences between the measurable components of soil and water quality and the recreational used categories of heavily, medium, lightly and control. The calculations involved in ANOVA were automatically computed by statistical S-Plus 2000 MathSoft Inc., software package.

The F-statistics calculated were then translated into a probability using the critical values of the F-distribution. If the probability (ρ) was less than the desired confidence level of 0.05 for a 95% level of confidence, then the significance between the recreational used categories of heavily, medium, lightly used and control were rejected. Conversely, when the (ρ) level exceeded 0.05, then there were significant differences between the recreational used categories, on the basis of the measurable components.

As such, during the data computing process, the replicates of the used categories were grouped and averaged out for that category, and then tested against each other for significance at the 95% confidence level, using the parameters as testable factors for the measurable components of soil and water quality.

Multiple Component Test (MCT)

MCT is a test of homogeneity of the mean of the parameters of compaction for the range of soil depth against each level of recreational use. It proved instructive to relate these measurable components to levels of recreational use and then by calculating their significance (F-values) to exclude from this, certain environment effects.

This technique being a modification of the multivariate analysis is called a "stepwise regression". This technique involved the testing of one of the parameters at any one time, against another from the measurable components from the list of parameters measured in the study. The purpose of this technique was to include all parameters that were significantly related to the measurable components and to eliminate those that were not.

Significance were tested at probability (ρ) levels of $\rho=0.05$ representing a 95% level of confidence.

The MCT at the various confidence levels was performed with the aid of computer. The S-Plus 2000 Software Package (Data Analysis Products Division MathSoft, Inc.1999) gives the F-values for each pair of the parameters tested.

Multivariate Analysis of Variance Test

MANOVA Test was used to demonstrate the overall significance of all the measurements for soil compaction; bulk density, soil moisture content, total and air-filled pore space at $p=0.05$ representing 95% level of confidence. The test is for confirming the measure of significance which was determined by the univariate analyses, as represented by the ANOVA Test and MCT between the treatments of different levels of recreational use and soil depth against the various response in soil compaction, such as bulk density, soil moisture content, total and air-filled pore space.

Principal Components Analysis

PCA provides a method of examining patterns of vegetation variations or groupings of vegetation from the project site. PCA in this study was not only used in describing site characteristics of relevance to the vegetation community structure, but also was used to describe the preferred environment of those species present. As such, the PCA produced axes summarising the vegetation data and relating them to the various zones of recreational use.

This analysis used the S-Plus 2000 MathSoft Inc., statistical package running on personal computer.