CHAPTER 6

VEGETATION CONDITION IN RECREATIONAL FOREST

Result

Attempts to determinate vegetation wear in forest recreational areas are based on a combination of sampling estimate of vegetation cover presence and transects investigations to determine the extent of change in the plant community. In this respect, parameters such as numbers of plants, species, occurrences, frequencies and variations are adopted for use to monitor vegetation changes relative to the differences in recreational intensities (control, lightly, medium and heavily used).

Ground Cover

Ground cover for the experimental plots each measuring 100 cm x 100 cm in the undisturbed forest, range from 47.2%-78.2% with mean ground cover of 64.54%. For the lightly, medium and heavily used sites, the ground cover range from 26.4%-32.8%, 16.4%-22.0% and 0.00% with mean ground cover of 29.27%, 19.66% and 0.00% respectively (Table 20). Figure 19 represents the graphic presentation of ground cover mean and the range of their standard errors, for the different categories of recreational use. The results are in support that ground cover is reduced progressively from a mean of 64.54% in control site (undisturbed forest) to 29.27% for lightly used site, 19.66% for medium used site, and finally to 0.00% for the heavily used site.

Table 20. Mean and Standard Error of Ground Cover at 4 Sites, Sg. Tua FRA

Zonal Variation +	Vegetation (%)					Organic Matter (%)					Bare Ground (%)				
	Sample ++			Mean	Std Error	Sample ++			Mean	Std Error	Sample ++			Mean	Std Error
	1	2	3			1	2	3			1	2	3		
I	32.8	28.6	26.4	29.27	± 1.88	35.4	52.8	66.8	51.67	± 9.08	31.8	18.6	6.8	19.66	± 7.22
II	16.4	20.6	22.0	19.66	± 1.68	36.4	26.6	38.6	33.86	± 3.69	47.2	52.8	39.4	46.48	± 3.89
III	0.0	0.0	0.0	0.0	± 0.0	55.4	67.0	32.8	51.73	± 10.04	44.6	33.0	67.2	48.27	± 1.00
IV	68.2	47.2	78.2	64.54	± 9.13	25.0	42.4	14.6	27.33	± 8.11	6.8	10.4	7.2	8.13	± 1.14

\+ I, II, III, IV representing lightly, medium, heavily recreational used and control sites respectively.

++ Each sample is a mean percentage of cover of 20 sub-plots.

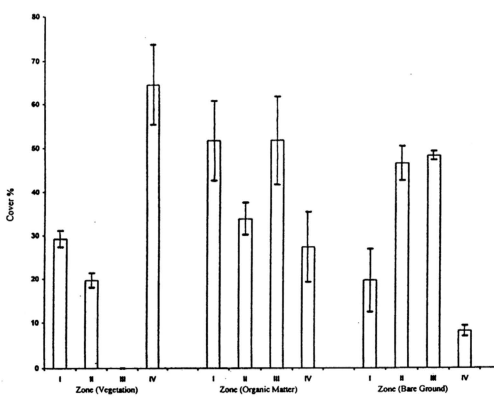

Figure 19. Vegetation, Organic Matter and Bare Ground at 4 Sites, Sg, Tua FRA

+I, II, III, IV representing lightly, medium, heavily recreational used and control sites respectively

However, the decline in mean ground cover between control and lightly used recreational site is 54.65%, while 32.87% cover reduction is registered between lightly and medium used recreational site. Although a 100% reduction in ground cover is recorded between medium and heavily used recreational site, but the decline in mean ground cover is only 12.48% of total vegetation cover. Therefore in terms of ranking of mean ground cover loss, most occur between control and lightly used sites; where 54.65% of cover loss is recorded. This is followed by the decline between lightly and medium used sites, where 32.87% loss is registered and finally, between medium and heavily used sites where the loss of ground cover is 12.48%. The above results are in support that changes in ground cover are most affected when the area is first opened for forest recreation rather than one arising directly from increased recreational use. Thereafter, the ground cover will continue to decline with increasing recreational use though less in severity, until the recreational impact exceeds the ability of the vegetation to sustain itself or its carrying capacity. This will eventually result in bare ground condition, as experienced with the heavily used site in the study area.

Although decline in ground cover increases with increased recreational use, but the decline is not one of linearity. Results from the study also support that ground cover loss is most severe between the undisturbed and lightly used sites (54.65%) rather than between lightly and medium used (32.87%) or between medium and heavily use sites (12.48%), as one would have expected with increased recreational use. This implies that the ground cover after its initial reaction to forest recreation, can readapt itself to further recreational use. As a result, the severity of decline in ground cover is reduced from 54.65% to 32.87%, and finally to 12.48%, with respect to increasing recreational use, until recreational impact exceeds the ground cover carrying capacity and its ensuing

bare ground condition. The results are in support of the observation that given time, vegetation can recover itself as indicated by the milder decline in ground cover loss with respect to increased recreational use. However, continued recreational use result in bare ground since it has already exceeded its carrying capacity.

Though differences in ground cover of the experimental plots, within each zonal variation (lightly, medium, heavily used and control sites) are recorded, but their differences are not pronounced as illustrated by the range of their means and standard errors (Figure 19). This is because each of the experimental plots within the used sites consists of 25 sub-plots of 20 cm x 20 cm dimension and are replicated thrice for each categories of recreational use (undisturbed, lightly, medium and heavily used). As such, small differences in vegetation cover within the experimental plots do occur, as a result of their positions along the vegetation gradient which inevitably contributes to ground cover variations.

The absence of vegetation cover in the heavily used experimental plots, is a result of significant recreational impact, which few plants can tolerate. This condition is generally accompanied by increased soil compaction, significant reduction of litter accretion due to the absence of ground vegetation, as well as enhanced surface run-off of whatever available humus and litter. Continual utilisation of such sites are unexpected, since bare ground is aesthetically less appealing to the users than one having vegetation cover. Nevertheless, continuous heavy demand on these sites in Sg. Tua FRA can be explained by its proximity to water sources, while not allowing sufficient time for the vegetation to recover. Another reason for the bare ground is its strategic location whereby users have to trespass onto such sites on their way to and

from the central service area. The impact on the vegetation cover is therefore affected by such constant foot traffic.

Since surface soil cover is a combination of vegetation, organic matter and bare ground, and increase in any of the components will result in a similar decrease in the other components. Results of mean ground cover observation of experimental plots in Sg. Tua FRA support that organic matter as represented by dry leaves and twigs and bare ground at the different recreational use sites are inversely proportional to vegetation cover. As such, an increase of any one or two of the components will result in a decrease in the other components. Table 20 and Figure 19 attest to this observation.

In the absence of vegetation cover at the heavily used site, mean ground coverage of organic matter and bare ground are 51.73% and 48.27% respectively. The other extreme, is at the undisturbed (control) site where the mean vegetation cover, organic matter and bare ground are 64.54%, 27.33% and 8.13% respectively. In general, as the vegetation cover decline, the organic matter and bare ground increase proportionately. Considering that the amount of bare ground will increase with increased soil compaction, a lack of vegetation cover is indicative of use which inevitably cause ecological changes, which in turn affect the species present, as well as the regeneration of the over-storey species.

Species Association

Three transects, each with a dimension of 100 cm x 50 m are established for each recreational site (control, lightly, medium and heavily used) and within each

transect are placed 100 cm x 100 cm quadrats at regular intervals. These quadrats are in position to span the whole vegetation gradient associated with each level of recreational use. All plant species are sampled using a point quadrat comprising of five (5) pointed needles held 20 cm apart on a wooden frame. All vegetation are sampled at 25 cm intervals along the 50 m transect line, which gives 200 sampling points per study site. All plants hitting the five needle tips are scored and the position of each point as it relates to the four recreational use, are recorded. Values are then averaged for each category of the recreational use (control, lightly, medium and heavily used) and appear as Table 21.

Of the plants appearing in the point quadrat survey, only one species (sp) (*Buchloe dactyloides*) in control site, 4 species (*B. dactyloides*, *Ruellia. repens*, *Bauhinia* sp, and *Dendrocalamus* sp) in lightly used site, 2 sp (*B. dactyloides* and *R. repens*) in medium used site and 10 sp (*B. dactyloides*, *Scleria purpurascens*, *R. repens*, *Bauhinia* species, *Agelaea macrophylla, Zingiber* species and 5 woody sp) in heavily used site, comprise more than 5% of the total cover. This tends to suggest that certain species are apparently favoured by that part of the ecological gradient associated with different intensity of forest recreation. Table 21 summarises the data collected from the mean point quadrats from each zone.

In general, three types of vegetation responses can be determined from the study. Some understorey species such as, *Elephantopus mollis*, *Mikania cordata*, *Aystasia* sp, disappear upon forest recreation (decreasers), while others include *R. repens*, *Sc. purpurascens*, *Pueraria / Centrosema* which tend to thrive under low

Table 21: Mean Number of Point Quadrat in Each Zone Occupied by Each Species

	Species++	Zone+			
		I	II	III	IV
A	Grasses				
	Buchloe dactyloides	24	15	1	71
B	Creepers/Climbers				
	Agelaea macrophylla	-	-	1	-
	Bauhinia sp	2	-	1	-
	Mikania cordata	-	1	-	1
	Mimosa pudica	-	-	-	1
	Pueraria/Centrosema	1	-	-	-
C	Herbs				
	Elephantopus mollis	-	-	-	1
	Ruellia repens	5	8	1	3
	Scleria purpurascens	1	1	-	-
	Zingiber sp	-	-	1	-
D	Low Shrub/Ferns				
	Aytasia sp	-	-	-	2
	Dicranopteris sp	1	-	1	-
E	Woodys/Trees				
	Herschelia scyphus	1	-	-	-
	Pterygota horsfieldii	-	-	-	1
	Vernonia arborea	1	-	-	-
	Eugenia sp	1	-	1	-
	Shorea leprosula	-	-	-	1
	Shorea parvifolia	-	-	1	-
	Sterculia sp	-	-	1	-
	Anthocephalus cadamba	1	-	-	-
	Cinnamomum iners	1	-	-	-
	Dendrocalamus sp	2	-	-	-
	Artocarpus sp	-	-	1	-
	Pandanus klossii	1	-	-	-
No of plant		42	25	10	81
No of sp		13	4	10	8
Bare ground		158	275	200	119
No of points		200	200	200	200

+ I, II, III, IV representing Lightly, Medium, Heavily and Control sites respectively

++ Species number rounded up to whole unit

recreational intensity and disappear upon further forest recreation (increasers/decreasers), and those apparently favoured by forest recreation (increasers) which include woodys, such as, *Eugenia* sp, *Shorea parvifolia*, *Sterculia* sp.

However, on further analysis the plant distribution can be described as follows. where species distribution for each used category is examined, control (Zone IV) has only 8 species, lightly used (Zone I) 13 species, medium used (Zone II) 4 species while the heavily used (Zone IV) sites having 10 species. This indicates greater species aggregation in the heavily and lightly used sites than control and medium used sites. Although 2 species (*B. dactyloides* and *R. repens*) are common for all of the recreational categories, only *B. dactyloides* experience much reduction in frequency with increased recreational use. This support that *B. dactyloides* is directly sensitive to increasing habitat wear. Similarly, many of the other characteristic plants of the forest floor (control) such as, *E. mollis, Mim. pudica*, *M. cordata,* and *Asystasia* sp tend to disappear when the area is opened up for recreation. Basically, creepers/climbers (*Mim. pudica*, *M. cordata*), herbs (*E. mollis, Sc. purpurascens*), and low shrubs (*Asytasia* sp) are the predominant ground cover species of the undisturbed forest floor. Perhaps because of their broad leafed and succulent nature, these species fail to tolerate minimal recreational use. As a result, they soon disappear upon further forest recreation.

R. repens exhibits an unexpected distribution. It increases in frequency when the area is opened for forest recreation under lightly and medium recreational use, but decreases in frequency upon heavy habitat wear. In this respect, this species can thrive under some amount of use, but unsuitable in areas subjected to heavy habitat wear (Zone IV). This behaviour matches those exhibited by *Sc. purpurascens* and *Pueraria /*

Centrosema sp. These species being herbs and creepers/climbers are light demanders and proliferated in response to changes in the environment, in the form of increased light emission onto the forest floor when the area is first opened for forest recreation. Thereafter, because of their succulent and broad-leaved nature, these species decline rapidly upon further habitat wear until they disappear altogether upon further recreational use (medium used). In this respect, forest recreation imposes a number of conditions on the environment including changes in soil compaction and mechanical damage to the vegetation thereby resulting in their decline. However, no common species shows increased frequency directly to increased recreation used, while absence of recreational used as in the undisturbed forest site, results in succession development with litter accumulation, increased competition for light and the alteration of micro-climate.

Perhaps, because of their tough woody exterior, tree seedlings of *Eugenia* sp, *Shorea leprosula*, *Shorea parvifolia*, *Sterculia* sp, and *Artocarpus* sp prevail in the heavily used sites. They manage to maintain themselves remarkably well despite the high demand being placed on such sites. It is likely that the woody plants may have established themselves here, as a result of seeds dispersed from mother trees located in the adjacent hill slopes. The heavily used sites are not only more exposed, but also nearer to water sources making such places more conducive in the establishment of forest tree species in view of the lack of competition from existing ground cover vegetation. Another example in this group is the *Zingiber* sp. Its presence in heavily used sites is made possible because of its rhizomatic ability to withstand soil compaction stemming from constant habitat wear associated with heavily used sites. The creepers/climbers in the form of *Ag. macrophylla* and probably *Bauhinia* sp are said

to be well suited to heavy used sites. This suggests that the extreme habitat wear and the development of rank vegetation in the undisturbed (control) areas are the main factors influencing the composition of vegetation at Sg. Tua FRA.

In terms of plant occurrences, plant numbers tend to fall from undisturbed (control) sites (81 plants), to lightly (42 plants), medium (25 plants) and the heavily (9 plants) used sites, although *R. repens* appears more frequent in the intermediate areas (lightly and medium used areas). In general, there is a tendency for fewer plant numbers to occur in heavily used recreational site than medium, lightly used and control sites.

With respect to vegetation form, herbs with broad, succulent leaf blades such as, *E. mollis*, *R. repens*, *Sc. purpurascens*, which are common in the control (Zone IV) and lightly used sites (Zone I), are replaced by plants having longer and narrow leaf blades such as, *Ag. macrophylla* and woody plants of *Shorea*, *Eugenia*, *Artocarpus*, *Sterculia* species in well worn sites; medium (Zone II) and the heavily (Zone III) used sites. In addition, some of the vegetation also undergoes physical modifications resulting from different levels recreational use. Good examples of morphological changes can be found, especially in grasses and herbs of *B. dactyloides* and *Sc. purpurascens* respectively.

B. dactyloides are common occurrences both in the control and lightly used sites, as they appear as succulent, broad-leafed grasses, whereas increased recreation use has the effect of suppressing this vegetation formation. The blades of *B. dactyloides* leaves have not only become narrower in appearance, but also that the number of leaves has been reduced drastically. The plants now possess more prostrate culms instead of

leaves, as well as the increased presence of leave sheath offering leave protection from mechanical damage stemming from increased recreational used.

Similarly, herbs such as *Sc. purpurascens* has taken the appearance of isolated tussocks linked by extended prostrate culms with increasing recreational used, as opposed to being a well distributed ground cover species in the control sites. Although there is the absence of recreation in the control sites, the plant interaction is not static, but one of successional dynamics whereby plants within the community continue to compete with one another.

Transect Survey

Of the three transects established for each of the recreational used categories, only one from each category is chosen, where relatively large areas of 'similar' vegetation occurred and the assumption is made that the area was originally homogeneous.

Results of transect surveys, each of width 100 cm and extending 5 m from the experimental plot, support the existence of a vegetation gradient from the undisturbed conditions at the forest margin to bare ground at the experimental plot centre for the heavily used site. Table 22 shows the species occurrences at point quadrat along transect. Plant distribution along the transects from plot centre, as well as their cumulative numbers appear as Table 23, while Figure 20 and Figure 21 represent their graphical presentations respectively. Similar occurrence of vegetation gradient is also observed in the medium recreational used site. In the undisturbed (control) site, the

Table 22. Number of Point Quadrat in Each Zone Along Transect and Distance From Centre of Experiment Site

Dist. from study site (m)	Recreational Used (No. of Plants)			
	+Zone I	Zone II	Zone III	Zone IV
0.0 – 0.5	5	1	0	9
0.5 – 1.0	4	1	0	10
1.0 – 1.5	5	2	1	8
1.5 – 2.0	5	2	1	8
2.0 – 2.5	4	2	2	9
2.5 – 3.0	5	3	1	9
3.0 – 3.5	4	2	1	7
3.5 – 4.0	3	4	2	7
4.0 – 4.5	3	4	1	7
4.5 – 5.0	4	4	1	7
No. of Plants	42	25	10	81

+ I, II, III, IV representing Lightly, Medium, Heavily and Control sites respectively

Table 23. Cumulative Number of Point Quadrat to Each Zone Along Transect and Distance From Centre of Experimental Site

Dist from study site (m)	Recreational Used (No. of Plants)			
	+Zone I	Zone II	Zone III	Zone IV
0.0 – 0.5	5	1	0	9
0.5 – 1.0	9	2	0	19
1.0 – 1.5	14	4	1	27
1.5 – 2.0	19	6	2	35
2.0 – 2.5	23	8	4	44
2.5 – 3.0	28	11	5	53
3.0 – 3.5	32	13	6	60
3.5 – 4.0	35	17	8	67
4.0 – 4.5	38	21	9	74
4.5 – 5.0	42	25	10	81
No. of Plants	42	25	10	81

+I, II, III, IV representing Lightly, Medium, Heavily and Control sites respectively

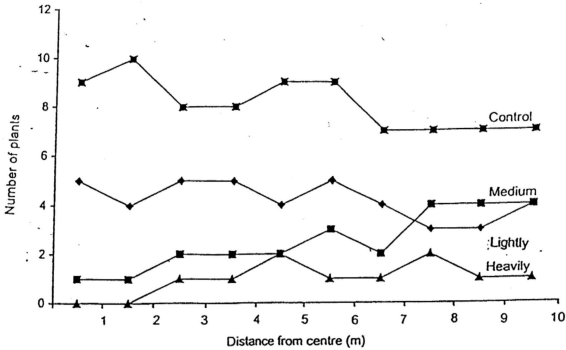

Figure 20. Mean Number of Point Quadrat With Distance From Plot Centre

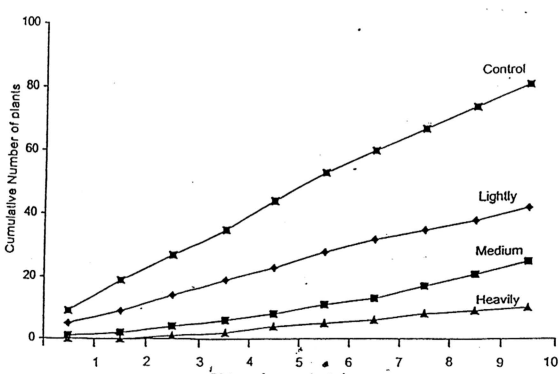

Figure 21. Mean Cumulative Number of Point Quadrat With Distance From Plot Centre

vegetation gradient is one of ecological continum; members of plant community evenly distributed, continuous competition for light, alterations to the micro-climate, and continuous natural successional dynamics. Vegetation gradient for the lightly recreational used site mirrors that of the undisturbed site, but with plant population much reduced. This indicates that lightly recreational used though causing reduction in plant numbers, does not affect the vegetation homogenuity.

Table 22 and Figure 20 represent plant distribution with distance from experimental plot centre. For the undisturbed (control) and the lightly recreational used site, the results indicate even distribution of plants irrespective of distance from the plot centre. The mean number of plants for the lightly used site mirrors that of the undisturbed site, but lower in magnitude. They are also ranged bound between 7-10 and 3-5 plants for each sampling point along the transect respectively. This supports that the plant occurrence are fairly homogeneous for both these sites. However, under medium and heavily recreational used, the number of plants increases with distance away from the plot centre. This can be explained that at plot centre, the plants mortality are much higher as they are subjected to constant habitat wear and related mechanical damage arising from being trodden by forest recreationists. However, at distance 4-5 m away from the experimental plot centre towards the forest margin, where they are less exposed to recreational wear, the number of plants improved in response to lower recreational impact towards the forest edges. The number of plants are range bound between 0-2 and 1-4 for the heavily and medium recreational used respectively.

Table 23 and Figure 21 show the mean cumulative number of plants with distance from experimental plot centre. A progressive increase in the cumulative

number of plants with distance from plot centre is experienced for all categories of recreational use. Guided by the gradient of the graphs in Figure 21, the increase in the cumulative number of plants is most pronounced at the undisturbed site and followed by the lightly, medium and heavily used sites. In the undisturbed conditions, the cumulative number of plants increases evenly with distance from the plot centre, while the same is said for the lightly recreational used site except that the quantum is much less, due to habitat wear. However, in medium and heavily recreational used sites though the number of plants increase with distance from the plot centre to the forest margin, but the increase as supported by their gradients are marginal, especially at distance up to 4 m from their plot centres. Thereafter, their gradients improved, especially with the medium recreational used reflecting the proliferation of plants away from the site of direct recreational use. Figure 21 reflects this observation.. Generally, the number of plants tends to increase at forest margin and lowest at point centre where habitat wear is the greatest.

Principal Components Analysis (PCA)

PCA is performed on the mean vegetation data of four transects representing the four zones of recreational use namely, Zone I, II, III and IV representing lightly, medium, heavily used and control respectively (Table 21). The stand is first ordinated to examine the degree of vegetation homogeneity of site and their relationship with the degree of recreational use.

As such, the principal axes obtained, are correlated with data for the vegetation and recreational use and the results are given in Figure 22.

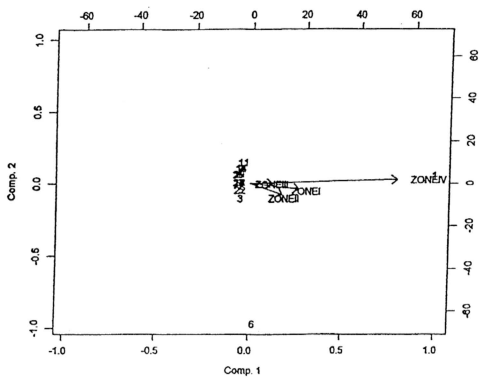

Figure 22. PCA Results on Four Transects in Sg. Tua FRA

The results show the concentration of plant species at the centroid of the PCA plot, with only one species that of *B. dactyloides* predominating in all of the four zones. One can always identify a gradient from the centroid due right towards the second axis for Zone IV, while near due right for Zone I, II and III. In other words, there appears to be an underlying gradient in which the population of *B. dactyloides* increases. For the other species, as shown by the clustering at the centroid, their distribution along gradient appear to be weak.

Sg. Tua recreation area, located along the busy Gombak-Ulu Yam trunk road, has a long history of unrestricted public access for recreation prior to the area being designated as forest recreation area by the Selangor State Forestry Department in 1992. Forest recreation is a multi-factorial effect. Since the status of the plant community prior to public use is not known, it seems reasonable to assume that the plant community is in equilibrium with the environment and that differences in vegetation characteristics directly or indirectly be attributed to habitat wear due to forest recreation. Such approach of establishing relationship between detailed measurements of recreational use and observed effects on vegetation response is adopted for this study. As a consequence, this study has taken the form of transect surveys across tracks or paths which demonstrate the existence of an ecotone gradient with a sharp gradient of wear from the centre to the forest margin, and in combination with individual experimental plots related to direct recreational impact. Such investigation on vegetation response to recreational impact is not new and have been studied by LaPage (1967), Burden and Randerson (1972) and Dale and Weaver (1974).

Plant response data from Sg. Tua FRA support the conclusion drawn. The vulnerability of vegetation to recreational use is a function of a complex chain of factors. Four such factors have been identified as causes for vegetation vulnerability. Firstly, plant species undergo morphological changes resulting from increased recreational use. Secondly, habitat wear which selects against species less resistant to mechanical damage and causes the formation of increasing "opened" habitats due to their mortality, thereby allowing the more tolerant species to proliferate. The latter

species are generally more amenable to habitat wear. Thirdly, thickening of herbage under light habitat wear, which increases competition by developing increasingly "closed" habitats due to domination by the more resistant species. Fourthly, plant successional dynamics and species involvement.

Under intense recreational use as seen in the study on forest recreation in Sg. Tua FRA, some of the vegetation undergoes morphological modifications to adapt itself to changes in the environment. Graminoids such as *B. dactyloides* have not only manage to reduce the number of leaves as well as their sizes, but also see the development of leaf sheaths which offer additional protection to leaves against mechanical damage in the medium and heavily increased recreational used sites. However with *Sc. purpurascens,* in the medium used site, plant has taken the appearance of isolated tussocks connected by increasing prostrate culm formations, as opposed to evenly distributed flattened herbage with leafy area much exposed under the undisturbed and lightly used sites. Chappell et al (1971) have reported similar observations of morphological changes such as, flatten stems, leaves in folded buds in response to increasing recreational impact in a study of recreational use of chalky grassland near Winchester, Hampshire County, England. Likewise, Liddle and Greig-Smith (1975) in their study of sand dune ecosystem in Aberffrew, Wales have reported that plants under increased recreational use have undergone several physical modifications such as, narrower leaves and higher cellulosic deposition (woody). With longer and narrower leaves, the surface area is much reduced, thus less exposed to mechanical damage, while cellulosic deposition function as good absorbency to counter stem damage arising from increased recreational use. Similarly, McEwen and Tocher (1976) have alluded on the physical changes on the resistant species when subjected to recreational use. They have

deliberated on the usefulness of ranking plants based on 'recreational hardiness' to rehabilitate badly damaged recreational used sites. Ripley (1962) has also made an early effort to do this. In general, characteristic broad-leafed, succulent plants suffered most, whereas those species having narrower-leaf, reduced leaf size and development of leaf sheath survived, as a result of morphological adaptations to the recreational use.

With respect to the proliferation of resistant species in areas of increased recreational use, the results from the study in Sg. Tua FRA are in support of this observation. Lightly used sites show an increase in species numbers, though having less number of plants than the undisturbed (control) sites. Grasses (*B. dactyloides*), herbs (*R. repens, Sc. purpurascens),* creepers/climbers (*Puereria/Centrosema*), ferns (*Dicranopteris* sp) and pioneer woody species (*A. cadamba, V. arborea, Eugenia* sp) readily respond to light and site disturbances when the area is first opened for recreational use. As a result, they proliferated in the lightly used site. This increase in species numbers is at the expense of the characteristic plants of the forest floor such as the broad-leafed, succulent ground cover species, such as *B. dactyloides,* creepers/climbers as *Mim. pudica, M. cordata,* herbs as *R. repens, E. mollis* and low shrub as *Asytasia* sp.. These plants are generally broad-leafed and succulent and are intolerant to recreational use. They tend to disappear upon forest recreation. Dale and Weaver (1974) concurred with this observation and have reported not only on the disappearance of many of the forest floor herbage, but also the increase in woody plants in the heavily used site. Similar observations of such nature have also been reported by Ripley (1962), Wagar (1969), LaPage (1967), Chappell et al. (1971) and Liddle and Greig-Smith (1975). Nevertheless, on further recreational use both number of plants and species decline, eventually giving way to bare ground interceded with woody species

towards the forest margin. When this occurs, recreational use has exceeded the vegetation ability to sustain themselves or its carrying capacity leading to the breakdown of the plant community. in face of mounting recreational use. Chappell et al. (1971) recognised the presence of a vegetation threshold beyond which factors damaging to grass will reduce and modify the plant community and strongly urged that recreational wear should not exceed this critical stage. In general, habitat wear favours those resistant species which are more amenable while allowing them to proliferate until habitat wear exceeds its threshold value, when it causes drastic and permanent modifications to the plant community, as indicated at the heavily recreational used site.

Lightly recreational used is generally associated with minor site disturbance caused by trampling. The intolerant, broad-leafed and succulent ground cover species which blanket the undisturbed site, give way to the more resistant species. As with the Sg. Tua FRA, additional light emission onto the forest floor stimulate the growth of numerous herbs (*Sc. purpurascens)*, creepers/climbers (*Bauhinia* sp, *Pueraria/Centrosema*), ferns (*Dicranopteris* sp), and woodys (*H. scyphus, P. horsfieldii, V. arborea, Eugenia* sp. *An. cadamba, C. iners*). In the undisturbed condition, these species normally lie dormant and are suppressed by the intolerant, broad-leafed and succulent species comprising mainly of *B. dactyloides, E. mollis, Mim. pudica, M. cordata* and *Asystasia* sp. During light recreational use, the habitat undergoes changes; the ground conditions disturbed, soil more compacted, soil capillary affected. The ensuing results are the increase in mortality of the less tolerant ground cover species, and the increase in light emission onto the forest floor. The more resistant species lying dormant, now readily responded and they proliferate. Similarly, Burden and Randerson (1972) in their study have alluded that in response the more resistant species are

amenable to habitat wear, their herbage proliferate and the ensuing "closed" habitat is the result of domination by the more resistant species.

The intolerant species have now given way to the more tolerant and hardy species. Nevertheless, minor site disturbance as caused by light recreational use has resulted in an increase in species diversity, but a decrease in plant numbers, as compared to the undisturbed site (control). In tandem is the loss of the less tolerant, broad-leafed and succulent species which have blanketed the site prior to its opening for forest recreation. This observation is in consonance to the study by Liddle and Greig-Smith (1975). They have elucidated that trampling affects vegetation composition. Although vegetation species show reduction in biomass and species numbers in most well worn out areas, but diversity was not always affected. McEwen and Tocher (1976) have reported that during the initial stage of use, broad-leafed herbaceous species and tree seedlings have little or no resistance to trampling and are quickly eliminated. Development of resistant species in lightly recreational used sites has been reported by LaPage (1967) and Chapppell et al. (1971). They have reported that open woodlands or meadows show a much greater resistance to moderate trampling, while Burden and Randerson (1972) have alluded that recreational use causes the development of resistant characteristics on the residual vegetation. These include narrow-leafed and clonal grasses that are not so easily crushed by recreational use. Most of these resistant species are sun-loving and cannot invade shady sites (Liddle, 1975).

Towards the forest margin, especially with the heavily used site, the plants which managed to survive are mainly woody plants strengthened by deposition of lignin and celluloic materials. These include *S. parvifolia, A. cadamba, Eugenia* sp,

Artocarpus sp, *Sterculia* sp. With the exception of *S .parvifolia,* the others are pioneer species and are commonly found in disturbed habitats in Peninsular Malaysia. These pioneer species are generally well adapted to thrive under poor forest conditions; soil with little humus, compacted soil and soil having lower moisture capacity. The ensuing plant community will be one dominated by the more resistant species

However, not all the changes induced by recreational use are bad. Thus, understorey plants at the heavily used sites receive more precipitation, since they are more exposed to light and less root competition than do plants in the forest understorey (unused or control sites). Lightly used may occasionally benefit the biological interest and may result in the growth of more resistant species which are tolerant to higher levels of use than the original vegetation. In general, species diversity improve under light recreational use, though less in plant number. Thus by changing the amount of wear, the type of vegetation produced can be manipulated for conservation purposes to create aesthetically pleasing communities and diversify the vegetation in an otherwise undisturbed habitat.

The effects of recreational use also cause changes to the plant community sucessional dynamics. The study of forest recreation in Sg. Tua FRA witnessed changes in vegetation according to the intensity of recreational use (lightly, medium, heavily used and control). In areas where forest recreation are undertaken, recreational use affect vegetation through three principal modes; trampling, mutilation and mortality.

The reaction of vegetation to recreational use depends on species present. On the lightly recreational used site, natural selection favours species diversity and

development of trampling resistant characteristics in the vegetation. Species proliferation following lightly recreational used in the Sg. Tua FRA, bears testimony to this observation. Similarly, development of trampling resistant characteristics such as, smaller leaves, lesser number of leaves, development of leaf sheath, culm formation instead of succulent and prostrating stems and finally tussocks appearance instead of spreading appearance. All these are part of the plant community successional dynamics relative to the lightly recreational used site.

In the medium and the heavily recreational used sites, plant succession is related to the physical demand being placed on such sites. If the recreational demand exceeds its threshold value, the plant community will break down and result in bare ground. Succession dynamics of the vegetation has no doubt been broken down.

Whereas in the undisturbed condition (control), natural succession is one of ecological continuum; plant continuously compete with one another for light and growing space, growth, seedlings recruitment and natural mortality. The process of natural succession is not static, but one of continuous change. Despite the different intensity of recreational use, natural succession is constantly evolving with respect to the changing environment. There is no doubt that the different recreational intensity have placed additional pressure on the forest recreational areas, but because of the ability of the forest to sustain itself is part of the natural plant community successional dynamics.