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Some Problems of Climate—Vegetation Correlations with Special Reference to Ceylon

by

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IT is no exaggeration to say that climatic classifications grew out of a desire to make sense of the vegetation pattern of the earth. Investigators like Alexander von Humboldt described the structure and composition of the plant communities they found and tried to trace their distribution. Similarly, later in the 19th century, Russian soil scientists outlined the distribution of soil types. It was to be expected however that these workers should speculate on the reasons for the distributions they discovered and, since climate had such an obvious general influence, should begin a search for significant isotherms and isohyets. In doing this they sought to explain the limits of vegetation and soil types in simple climatic terms. This led to oversimplification and ultimately to the exercise of making the climatic region fit the vegetation.

It is the aim of this paper to show with special reference to Ceylon the obvious pitfalls and the inaccurate results obtained by those who try to fit vegetation with climatic boundaries in the manner of fitting vegetation into a procrustean climatic bed. Vegetation and soils are concrete elements of the landscape; climate by definition has only statistical reality. When mapping soils or vegetation, though faced with many practical and theoretical problems, one is nevertheless dealing with existing features. When the distribution of these has been assessed one can look around for those factors that have been responsible for it. Climate is one of these factors—*but only one.*

Though the factors of mean annual precipitation and temperature can be said to influence the broad distribution of vegetation types, considerations of these factors alone is quite inadequate to explain the response of plants to the climate. The salient features of the distribution of rainfall in Ceylon is that the S.W. quadrant of the island does not experience a marked dry season while the rest of the island has one, of between a month and five months in duration. Another significant contrast is the decrease of temperature with altitude, so that the hill country has a lower temperature than the surrounding plains; the area above 5,000 feet experiencing temperatures akin to those of temperate latitudes, though the diurnal and seasonal regimes are, of course, very different. At these elevations it is not uncommon to experience frosts during the early hours of the morning in January and February.

When the distribution of these two aspects of climate are compared with that of the natural vegetation zones, there is no doubt there exists a broad correlation. But the limitations of such a broad correlation are apparent

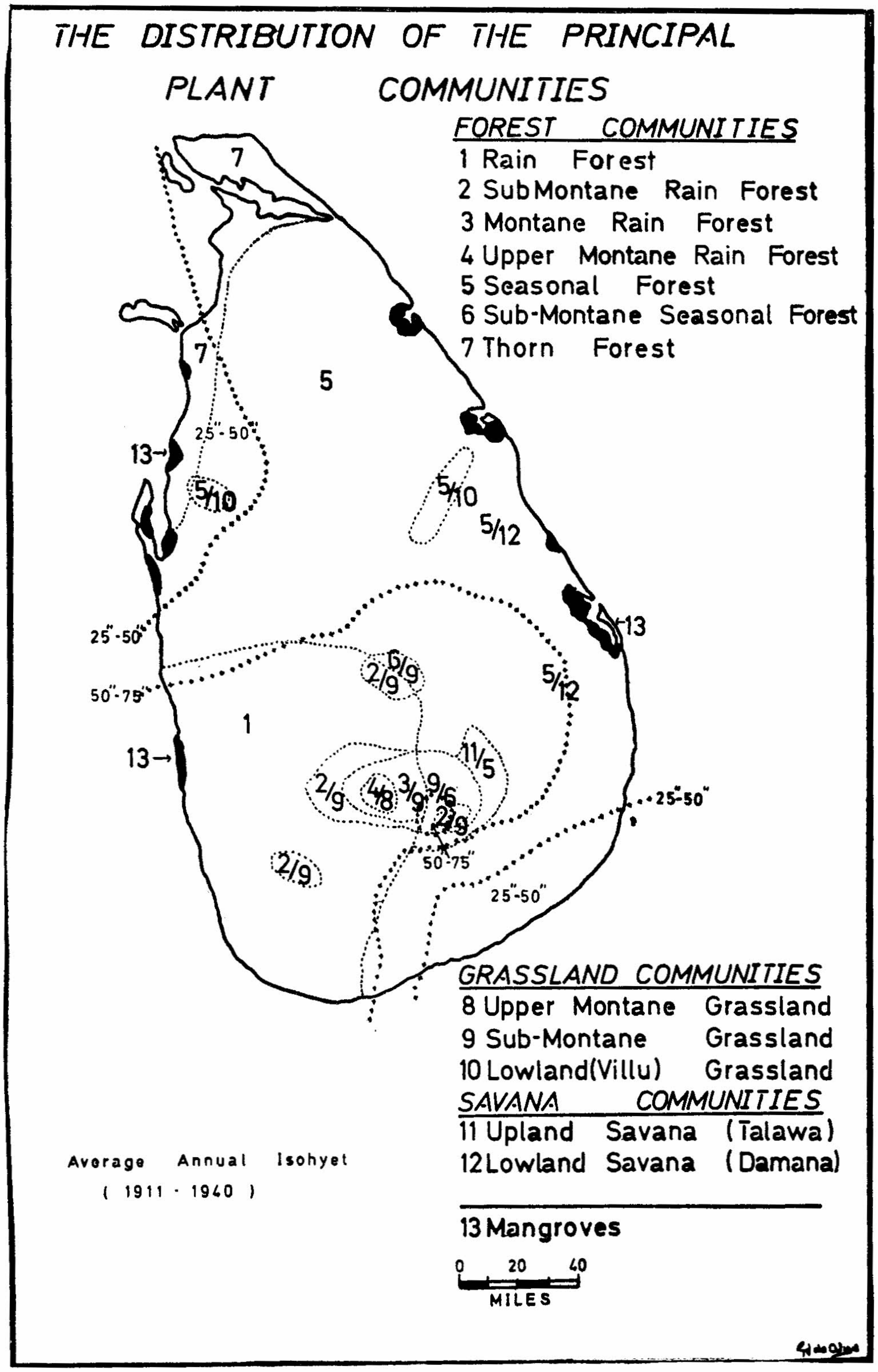
THE DISTRIBUTION OF THE PRINCIPAL PLANT COMMUNITIES
FOREST COMMUNITIES
1 Rain Forest
2 SubMontane Rain Forest
3 Montane Rain Forest
4 Upper Montane Rain Forest
5 Seasonal Forest
6 Sub-Montane Seasonal Forest
7 Thorn Forest
GRASSLAND COMMUNITIES
8 Upper Montane Grassland
9 Sub-Montane Grassland
10 Lowland(Villu) Grassland
SAVANA COMMUNITIES
11 Upland Savana (Talawa)
12 Lowland Savana (Damana)
13 Mangroves
Average Annual Isohyet
(1911 - 1940)
0 20 40
MILES
25"-50"
50"-75"

Fig. 1.

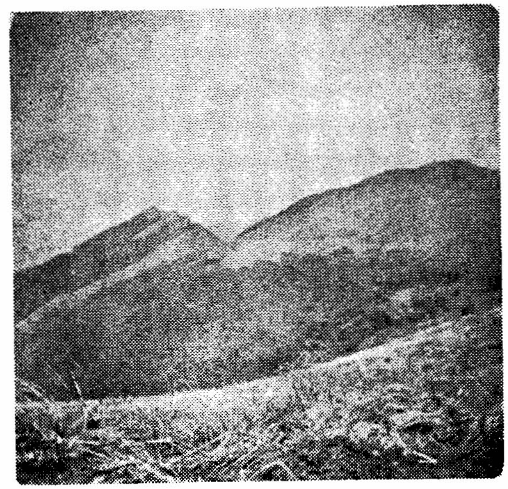

Fig. 1.

Sub Montane Forest & Sub Montane Grassland at Hantana in "*Wet Zone*".

Fig. 2.

Fig. 2.

Cymbopogon Confertiflorus dominated Sub Montane Grassland ('*Dry Patana*') Community.

Fig. 3.

Fig. 3.

Sub Montane Grassland on recently cleared land at HINDAGALA.

when attempts are made to discern critical values of rainfall and temperature which correspond with the boundaries of the actual vegetation communities. This is equally true when even more refined climatic criteria as those propounded by Koppen (1931),[1] Swain (1938),[2] and Thornthwaite (1931[3] and 1948)[4] are used. Holmes (1956)[5] and Koelmeyer (1958)[6] attempted to define the boundaries of the major vegetation types in terms of such climatic criteria but both found numerous anomalies particularly when they sought to correlate the finer divisions of climatic type with the occurrence of distinct plant communities. Further, they found that each method of climatic classification produced a boundary in a different position from that of a particular plant community with which they sought to correlate the climatic type.

The earliest attempt in Ceylon to demarcate areas of effective rainfall where, in particular months or seasons, the amount of rain water available in the soil is sufficient in quantity to maintain a plant above wilting point, was by Cooray (1948).[7] He worked on monthly averages of rainfall and assumed a mean monthly wind velocity of five miles per hour for all stations in all months of the year. Such an assumption regarding wind speed is clearly unrealistic in view of the obvious variations between localities as well as at different times of the year. For example, the S.W. Monsoon wind sweeps over the North Central Plains as the *Yalsulang*, and the East Coast as the *Kachchan* and over the Eastern Highlands from May to August in violent gusts. Farmer (1956)[8] adopted a similar scheme to that of Cooray when assessing the reliability of effective rainfall at different stations in order to calculate the approximate percentage of years in which effective rainfall may be expected. One striking advance in the work of both Cooray and Farmer, however, was that they demonstrated that a region demarcated as arid on the basis of the amount of annual rainfall, i.e., having less than 50 inches per annum, need not necessarily be so in terms of effective rainfall.

This is illustrated by the natural vegetation of the Mannar and Hambantota areas. Mannar receiving an average annual rainfall of 37.96 inches and Hambantota 40.8 inches. But Hambantota appears to receive effective rainfall in an exceptionally large number of years having an average of 123 rainy

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1. Koppen, W., *Grundriss der Klimakunder*, 2nd ed. 1931.
2. Swain, H., Climatic Index, E.H.P. Forestry Commission, N.S.W. Australia, 1938.
3. Thornthwaite, C. W., Climates of North America. *Geog.Rev.* Vol. XXI, 1931.
4. Thornthwaite, C. W., An approach to a Rational Classification of Climate *Geog. Rev.* Vol. XXXVIII, No. 1, 1948, pp. 55-94.
5. Holmes, C. H., The Broad Pattern of Climate and Vegetational Distribution in Ceylon in Study of Tropical Vegetation, *Proceedings of the Kandy Conference*, UNESCO, 1956, pp. 99-114.
6. Koelmeyer, K. O., Climatic Classifications and the Distribution of Vegetation in Ceylon, *Ceylon Forester*. Vol. 13, 1958, pp. 265-88.
7. Cooray, P. G., Effective Rainfall and Moisture Zones of Ceylon. *Bulletin of the Ceylon Geog. Society*. Vol. 3, 1948, pp. 39-42.
8. Farmer, B. H., Rainfall and water supply in the Dry Zone of Ceylon, in *Geographical Essays on British Tropical Lands*, ed. R. W. Steel and C. A. Fisher, 1956.

days per annum during the period 1911-1940, as compared with 76 for Mannar. The mean annual temperature for Mannar is 82 degrees F, with a mean yearly diurnal range of 9.2 degrees F; while the corresponding figures for Hambantota are 80.7 degrees F and 11.2 degrees F, respectively. These differences in the climatic conditions coupled with the differences in the soils in the two areas, which among other factors create differences in the amount of available soil water, are reflected in the plant communities found in the two areas. Hambantota with a longer period of effective rainfall (Cooray 1948)[9], has a more mesophytic type of vegetation having a 'Dry Evergreen Forest' (Koelmeyer 1958,[10] Farmer 1956[11] and Abeygunawardena 1948-1949),[12] while Mannar has a plant community having many xeromorphic features described as 'Tropical Thorn Forest', (Koelmeyer 1958, Eriyagama 1961);[13] and where there are patches of virtual desert with practically no vegetation (Wayland 1915).[14] Even the 1948 Thornthwaite classification failed to provide clues to these differences (Koelmeyer 1958). Climates on this classification showed Jaffna as having a moist sub-humid climate with a large summer water deficiency, and megathermal equable temperatures; while both Mannar and Hambantota was shown as having a semi-arid climate with no water surplus and megathermal equable temperatures. Yet the natural vegetation of Mannar and Jaffna are similar (Koelmeyer 1958), while that of Mannar and Hambantota are different. These different examples substanciate the point that it is dangerous to delimit climatic zones on the basis of limited data, intending them to coincide with natural vegetation zones but without giving much thought to a whole range of ecological considerations.

With these points in mind it is not inappropriate to attempt an appraisal of the extent to which purely climatic factors influence vegetation and the extent to which geographers can conceive of vegetation regions and climatic regions which are, in a sense, coterminous. De Philippis (1951)[15] showed that correspondence between boundaries of plant communities and a few isoclimatic lines does not automatically constitute a conclusive proof of causal connection; climatic factors always operate collectively. Thornthwaite and Hare (1955)[16] showed that the climate of a locality, considered statistically, is often simply regarded as average weather, this is essentially a meteorologists view. But climate, considered in the light of the physical processes, is

9. Cooray, P. G., *Op.cit.*, 7.
10. Koelmeyer, K. O., *Op.cit*, 6.
11. Farmer, B. H., *Op.cit*, 8.
12. Abeygunawardena, T. D. H., A regional survey of the Hambantota district, *Bulletin of the Ceylon Geog. Soc.*, Vol. 3, 1948-49, pp. 89-102.
13. Eriyagama, G. J., The Semi-Arid vegetation in the Mannar region. *Ceylon Forester*. Vol. 5, 1961, pp. 66-81.
14. Wayland, E. J., Notes concerning the occurrence of small desert tracts in N.W. Ceylon, *Spolia Zeylanica*, Vol. 3, 1915, pp. 166-74.
15. De Philippis, A., Forest Ecology and Phytoclimatology. *Unasylva*, Vol. 5, 1951, pp. 10-15.
16. Thornthwaite, C. W. and Hare, F. Kenneth, Climatic classifications in Forestry. *Unasylva*. Vol. 9, 1955, pp. 51-59.

better thought of as the complex interaction of the vegetation and atmosphere just above the earth's surface. This appraisal is particularly apposite with regard to the exchange of energy and momentum between the surface and the atmosphere. A soundly based classification to be of real value in the study of vegetation, must seek its parameters in those complex exchanges and not in the raw segregated observational data of the meteorologist. Hence, to obtain the moisture content from climatic data, requires a knowledge not only of evapo-transpiration and the amount and intensity of the precipitation, but also the amount of run-off and infiltration, the soil type and its structure.

Koelmeyer (1958)[17] worked out the potential evapo-transpiration and related data, according to the 1948 Thornthwaite classification for 16 stations in Ceylon. He based his calculations on soil temperatures obtained during the course of a year from January 1953-January 1954 on a 'non lateritic reddish brown loam' at Anuradhapura. The potential evaporation values when compared with evaporation data from the Meteorological Department for 5 stations, namely; Colombo, Anuradhapura, Kande-Ella and Ridiyagama showed that the theoretical values were less than the recorded evaporation. The ratio varied from 80-86%, except at Colombo where it was 96%. Since potential evapo-transpiration is closely related to temperature, the altitudinal variation in temperature is paralled by a corresponding variation in evapo-transpiration. Koelmeyer's figures indicate that in the wet-zone low country at Galle it is 65.7 inches and that in the arid-zone low country at Mannar it is 70.5 inches. The lowering of the water need with elevation is illustrated by the mean potential evaporation figures.

Badulla (2,225')	41.4 inches
Diyatalawa (4,093')	32.5 inches
Talawakele (4,500')	30.4 inches
Hakgala (5,580')	25.7 inches
Nuwara Eliya (6,178')	24.3 inches

These figures give some indication of soil moisture regimes which are more useful than any map of climatic regions yet constructed. But differences from the evaporation rate from a free water surface, and from soil, under the same atmospheric conditions are quite different; as Thornthwaite (1954)[18] has pointed out, a full understanding of the climate, vegetation and soil complex can only be achieved by what he termed the 'Topographical Approach' based on local climate, variation of slope, soil characteristics and the albedo of the vegetation cover. It involves detailed study of certain aspects of the land and recognition of the qualities of the vegetation that determine the evapo-transpiration and the soil moisture. This approach is in essence an effort to bring

17. Koelmeyer, K. O., *Op.cit.*, p. 6.
18. Thornthwaite, C. W., Topoclimatology, pp. 227-232 in *Proceedings of the Toronto Meteorological Conference*, London, 1953.

climatology down to earth. On the one hand are the climatic influences of energy and momentum exchanges and on the other the biological and edaphic controls of relief, slope, soil texture and the composition of the vegetation. Eyre (1963)[19] has shown that though climate has a basic control of vegetation yet the nature of the soil and the soil parent material is as important as the climatic factor. He has cited several examples of different plant communities growing under the same climatic conditions in verification of this point. As measurement of evapo-transpiration and soil moisture has yet to be perfected, and methods of estimation, where no measurement has been made, are fraught with hazard, would it not be better when attempting to delimit areas of contrasted physical environment to study what actually exist? Tangible features such as vegetation communities, as Eyre (1964)[20] suggests, might well be a more satisfactory starting point for environmental analysis than rather illusive concepts such as climatic means. The contribution of climate and other features to the present total environment can probably be considered more realistically when the more concrete realities have been assessed. It may well be, then, that the distribution of plant communities may lead to a much more realistic assessment of innate environmental contrasts, though the hand of Man may well have blurred the picture. Wherever human occupance may have played some part in determining the vegetation type it is even more desirable to study the distribution of the plant community carefully and objectively.

With the above remarks on climate-vegetation correlations in general it is now proposed to discuss a specific problem from Ceylon, the Sub-Montane *Dry Patana* Grassland vegetation, and to show in the light of the writer's study of this problem (Perera 1967),[21] that this type of grassland community is not confined to a particular climatic region nor is it a result of 'unique climatic conditions' as propounded by de Rosayro (1945-46).[22]

Two areas having the same plant community but in two different climates were selected. Welimada is in the 'dry zone' of the hill country while Hindagala is in the 'wet zone'. The Welimada site was in an area which is, in a sense common land, although actually in the ownership of the state. At Hindagala it was different, nearly all land is privately owned as the site investigated. The owner said that he had cleared the land which until then was covered with a miscellaneous array of fruit trees, medicinal plants and timber trees. Both

19. Eyre, S. R., *Vegetation and Soils—A world picture.* Arnold, London, 1963.
20. Eyre, S. R., Determinism and the Ecological Approach to Geography, *Geography,* Vol. XLIX, 1964, pp. 369-376.
21. Perera, N. P., An Evaluation of the Human Impact on the Nature and Distribution of Wild Plant Communities in the Ceylon Highlands. Ph.D. thesis, University of Leeds, 1967.
22. de Rosayro, R. A., The Montane Grasslands of Ceylon, *Tropical Agriculturist.* Vol. 101 and 102, 1945-46.

sites were analysed by the quadrat sampling method using the Broun-Blanquet's system of rating. Attention was mainly concentrated on the identification and the spacing of the individual species within the community.

Analysis of the Sub-Montane Grassland (*Dry Patana*)
study sites at Welimada and Hindagala

Welimada Site—(Eastern part of Highlands—'Dry Zone'), near 4th mile post Welimada-Boralanda road. Approx: height 3,600 feet, slope 1 : 20

	2′	4′	6′	8′	10′
2′	A2	A3 B1 E1	A1 H1	A4	A1
4′	A1 B1	A1 F1	A2	A3	A4
6′	A5	A1 G1	A2 B3 E3	A1	A1 D1 H2
8′	A1 C1	A1 H1	A4	A5	A2 F1
10′	A3 B1 E1	A4	A2 G1	A1 D1	A3

Hindagala Site (Western part of Highlands—'Wet Zone'), near 6th mile post Peradeniya-Galaha road. Approx: height 1,800 feet, slope 1 : 20

	2′	4′	6′	8′	10′
2′	A3 L1	A2	A4	A2	A4
4′	A3	A1 D1	A1 G1	A2 L2	F1 J1
6′	A1 I1	A2 F1	A3	A3	A1 K1
8′	A2 L1	A4	A1 D2	A3	A2
10′	A3	A4	A3	A1 F1	A2 G1

	Systematic Name	*Family*	*Welimada* No. of Plants	*Welimada* Percentage	*Hindagala* No. of Plants	*Hindagala* Percentage
A.	Cymbopogon confertiflorus	Gramineae	58	72.5	57	81.4
B.	Arundinella laxiflora (Raddi)	,,	6	7.5	—	
C.	Careya arborea	Myrtaceae	1		—	
D.	Leucas zeylanica Br	Labiatae	2		3	
E.	Pteridium aquilinun	Dennstaedtiaceae	5		—	
F.	Viscosa auriculata L	Compositae	2		3	
G.	Lantana aculeata	Verbenaceae	2		2	
H.	Pinpinella heyeana L	Umbelliferae	4		—	
I.	Mussaenda frondosa L	Rubiaceae	—		1	
J.	Mikania scandens Will d	Compositae	—		1	
K.	Alstonia scholaris Br	Apocynaceae	—		1	
L.	Gleichenia linearis Sm	Gleicheniaceae	—		2	
		Total	80		70	

On both sites the *Cymbopogon confertiflorus* is dominant and almost completely obscures the other herbaceous species when viewed from a distance. But scattered around both sites, solitary tall bushes and shrubs break the monotony of the grassland. The *Cymbopogon confertiflorus* though dominant on both sites, presented a different appearance at the two sites. At Welimada it presented a cut lawn or turf-like appearance while at Hindagala the bushes were well developed, carrying a large number of fresh green leaves, and the community as a whole exhibited the appearance of a cultivated field of Guniea grass—*Panicum maxium*. This difference may be due to the fact that the Welimada site was examined in late August—at the height of the dry season, while there had been rain at Hindagala without a prolonged dry spell.

At Hindagala the only grass present was *Cymbopogon confertiflorus*, while at Welimada there was also *Arundinella laxiflora*. It was observed that *Lantana aculeata* (*Verbenaceae*), though not fully grown to form its typical large straggling bush, was growing on an old termite nest on the site at Welimada. At Hindagala, *Lantana* was more luxuriant and the blooms were of different hue. Of the species that are able to grow up to tree size, the one plant enumerated at Welimada was *Careya arborea* (*Barringtoniaceae*) and at Hindagala, *Alstonia scholaris* (*Apocynaceae*). Both plants were low growing however, and exhibited signs of frequent coppicing. This is especially true of the *Alstonia*, the top of its trunk being of much greater circumference than the base of individual branches. The *Careya* was about five feet in height while *Alstonia* was about eight feet and a spread of three feet. Both plants cast a considerable amount of shade and the effect of this is seen in the composition of the vegetation on the two feet square plots in which they were growing. On each of these sites the only other species within the squares were solitary plants of *Cymbopogon confertiflorus* and, at the Hindagala site, even this did not exhibit the fresh green colour of most of the other individual plants of the same species.

Two plants not enumerated at Welimada but present at Hindagala were *Mussaenda frondosa* (*Rubiaceae*) and the twiner *Mikania scandens* (*Compositae*). *Mussaenda frondosa* is a scrambling shrub which is very conspicious because of its large leaf like enlarged calyx lobes and brillant though not large flowers. It occupies a considerable amount of space and casts a greater amount of shade than any other plant on the site. *Mikania scandens* is a creeper that spreads very rapidly and envelops all the vegetation around it. This is aptly illustrated by the Sinhala word for it *Lōkapālu*—which literally means 'world destructor'. On this site it had spread about ten feet in all directions but a major portion of it was outside the quadrat under study.

Of the ferns, *Pteridium aquilinum* was found at Welimada and *Gleichenia linearis* at Hindagala. Both these plants spread by rapidly growing rhyzomes and runners and so are able to spread very quickly over considerable areas. The above study indicates that irrespective of climate a similar plant community exists in two contrasted areas of climate. The average annual rainfall for Welimada (1907-56) is 57.42 inches getting less than 2.4 inches per month during February, June and July. During this same period Peradeniya Gardens (the one nearest to Hindagala) received an average rainfall of 90.32 inches having only February as the month receiving less than 2.4 inches.

Different views have been expressed as to the origin of these grasslands. On the one hand are those who think that this type of grassland arose by the destruction of the original forest vegetation by fire and is maintained by fire: (Broun 1891,[23] Pearson,[24] Champion 1936,[25] Holmes 1951)[26] though they differ on the type of forest. On the other hand de Rosayro (1945-46,[27] 1961)[28] was of opinion that this type of vegetation is "a natural grassland climax that rose from a hydrosere condition, localised by peculiar topographical features, geological origin and the prevailing unique climatic conditions". Hindagala and Welimada are in an area having a similar lithology (Cooray 1964).[29] In both areas this type of grass community is found on similar slopes of the hills and ridges while the valleys are either cultivated or forested. It has been shown by many workers in the Tropics that except under specific edaphic conditions no natural grasslands exists in humid tropical regions. (Beard 1946,[30] Bartlett 1956,[31] Sauer 1958,[32] van Steenis 1961)[33]. But if these grasslands are protected from fire as in the establishment of *eucalyptus* plantations (Holmes 1957)[34] or by planting wind breaks (Wijesinghe 1962)[35] the necessary micro-climatic and soil conditions are induced which enables the colonising of these areas by native tree species. Ovington (1965)[36] has shown that soil changes rarely lead to a static condition, and since woodland organisms

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24. Pearson, H. W., The Botany of the Ceylon Patanas. *Jl. of the Linean Society*, vol. 34, pp. 300-325 and Vol. 35, 1903 pp. 430-463.
25. Champion, H. G., A Preliminary survey of the forest types of India and Ceylon. *Indian Forest Records.* Vol. I, 1936, pp. 1-286.
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27. de Rosayro, R. A., *Op.cit.*, p. 22.
28. de Rosayro, R. A., Nature and Origin of Secondary Vegetational communities in Ceylon. *Cey. For.* Vol. 5, 1961, pp. 23-49.
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31. Bartlett, H. H., Fire, Primitive agriculture and grazing in the Tropics. *In Man's Role in Changing the Face of the Earth*, 1956, pp. 692-720.
32. Sauer, C. O., Man in the Ecology of Tropical America, in *Proc. 9th Pacific Science Congress*, Vol. 20, 1958, pp. 104-110.
33. Van Steenis, C. G. G. J., Axiomas and Criteria for Vegetatiology, *Tropical Ecology*, Vol. 2, 1961, pp. 72-6.
34. Holmes, C. H., Natural regeneration of wet and dry evergreen forests of Ceylon, *Cey. For.* Vol. 13, 1957, pp. 111-127.
35. Wijesinghe, L. A. C., Some aspects of land use in the dry montane grasslands. *Cey. For.* Vol. 5, 1962, pp. 128-138.
36. Ovington J. D., *Woodlands*, English Universities Press, London, 1965.

influence soil development in various ways, the soil changes differently according to the nature of the woodland community. When stocks of trees of different species are planted side by side on the same soil type, the soils of adjacent plots change in many ways, often differing in the nature of their organic content, aeration, water content and nutrient status. While in old natural forests, which have attained an equilibrium with the environment, the biomass remains constant from year to year, in a young, actively growing woodland, organic matter accumulates rapidly. Further the build up of organic matter in woodland ecosystems is most obvious when treeless areas are invaded or planted with trees. From this it is possible that given the protection of the forest with its attendant effects on the micro-climate and nutrients accumulating in the soil, the Sub-Montane grasslands, (*Dry-Patanas*) will be colonised by native tree species.

van Steenis (1961)[37] showed that grasslands closely akin to these in Indonesia, revert to forest under protection. Such a colonisation would lead through a succession ultimately to a forest cummunity, similar to a climax forest that still exists, e.g., on the slopes of Namunukula and Udawattakele reserve. Such forest communities in this area though by no means undisturbed by the long history of settlement in this area, from pre-historic times (Noone 1940,[38] Deraniyagala 1958)[39] and permanent settlement on a large scale from the 15th century (Nicholas 1958),[40] still provides a clue to the nature of the forest climax that existed in these areas now occupied by Sub-Montane Grasslands. This process of forest clearence was greatly accelerated during early 'British Times' (1832-1850) with the coming of plantation agriculture, coupled with the increasing pressure of population and the balance of the man-land ratio being upset.

Sauer (1947),[41] Aubert De La Rue (1958),[42] Sears (1956),[43] van Steenis (1961)[44] and Brookfield (1966)[45] have shown that with the aid of fire, primitive man could destroy vegetation to an unbelievable extent. This is particularly so in areas which have a marked dry season as the Uva Basin with its original Sub-Montane Seasonal Forest, the largest area of Sub-Montane

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37. Van Steenis, C. G. G. J., (1961), *Op.cit.*, p. 33.
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Grassland today. Moormann and Panabokke (1961)[46] described the soils in the Uva Sub-Montane Grasslands as red yellow podzolic soils. These are developed by the weathering of the country rock which is the Highland Series of Pre-Cambrian age. (Cooray 1964).[47] In many cases the A horizon is greatly eroded so that very little of it remains. Where it is found it varies from 0-12 inches and consists of a dark brown clay loam, fairly compact with inclusions of quartz gravel. The B horizon which is often about 9-10 inches thick, contains quartz fragments of ½-¼ inches diameter with large iron stone concretions. The C horizon which is often about 10-18 inches is composed of decomposing parent rock which breaks up into pure quartz and sand with some clay inclusions. That much of the original A horizon has been eroded is an observed fact. What remains on the surface are the B and lower horizons. The micro-climate has changed with the erosion of the soil so that forest species cannot recolonize. This is the case in the abandoned tea and coffee plantations in nearly every part of the Highlands—from the very wet areas like Watawala and Ginigathena receiving over 200 inches of rain per year as is indeed in the Uva Sub-Montane Grasslands.

Hence the Sub-Montane Grassland community is a secondary vegetation resulting from the destruction of the climax forest (Sub-Montane Rain Forest or Sub-Montane Seasonal Rain Forest). This grassland is maintained by fire, though the fundamental reason why spontaneous re-invasion of the native forest trees does not occur is that the soil has become too shallow since the original forest clearence, to be able to support seedlings and saplings even during short periods of drought.

The above analysis of the ecology of the Sub-Montane grassland community has shown that this vegetation develops in response to many different stimuli among which cultural and edaphic conditions are possibly more important than climate. The response of vegetation to climate is both direct and indirect—direct through the role of the factors of temperature, radiation, moisture and wind play in the growth of vegetation; and indirect through the influence that these climatic factors have on soil conditions, disease organisms, competing plant associations and cultural practices. In addition the reciprocal influence of vegetation on the micro-climate of a particular area and on the factors of the micro-environment creates another level of influence that must be considered in evaluating the factors that contribute to the distribution of vegetation.

In Ceylon it is only the areas of Tropical Rain Forest and its altitudinal variations which generally fit into the climate-vegetation relationship; in the other types of natural vegetation like the different types of montane grassland, Savana (both lowland & upland), and Thorn forest the role of climate becomes of less import.

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46. Moorman and Panabokke, C. R., The Soils of Ceylon, *Tropical Agriculturist* Vol. 157, 1961.
47. Cooray, P. G. (1964) *Op.cit.*, p. 29.