

The MAB Programme in Sri Lanka

B. A. ABEYWICKRAMA

Chairman, MAB National Committee

The UNESCO-Biosphere Conference of 1968 highlighted:

- (a) the intimate and inextricable relationships between man and his environment;
- (b) the extremely delicate nature of the equilibrium in eco-systems; and
- (c) the destruction and degradation of environments that have already been caused by the extravagant and unwise use of land and natural resources;

and drew attention to the urgent need for a more rational approach to the use of resources.

As a follow-up program, MAB was officially started in 1971 as an interdisciplinary program of research emphasizing an ecological approach to the study of the relationships between man and his environment. Its main objective was to develop the basis, within the natural and the social sciences, for the conservation and rational use of nature and the resources of the Biosphere. This program now has National Committees in about 100 countries and about 900 Research Projects are in progress in these countries.

In Sri Lanka, the Man and the Biosphere activities are coordinated by the National Science Council and are directed by a National Committee which was appointed by the Ministry of Scientific Affairs with the concurrence of the Ministry of Education. At the outset the Committee noted the very rapid destruction that was going on of the few remaining natural forests in the island and the acute shortage of personnel trained to carry out environmental studies. It was observed that we had only about 20,000 ha of relatively undisturbed forests in the whole country. The committee therefore decided to give high priorities to the establishment and protection of biological reserves and to the education and training of personnel in Environmental Studies.

It was also decided to sponsor field studies in the following areas:

- (a) the ecology of selected natural communities with special attention paid to the role of mycorrhizae in tropical rain forests,

- (b) the impact of man's development activities in a selected area,
- (c) the study of patana grasslands with emphasis on methods of making them more productive, and
- (d) monitoring of pollution from industrial sources.

The actual implementation of the studies were delayed by limitations of personnel and facilities. Activities were initiated in 1975 on a modest scale with a socio-economic survey of a few selected blocks in the Kalawewa area with funds from the National Science Council (N.S.C.) In 1977 activities were expanded with additional funds from the N.S.C. Soon afterwards a very generous grant from the Mahaveli Development Board for equipment enabled us to begin the monitoring of the physical environmental conditions in the Kalawewa area. Two offers of aid for equipment from UNESCO and the IFS were also accepted. We are deeply grateful to all the donor agencies for their assistance.

All the co-ordinators of the MAB projects and the supervisors of the various studies have given their services in a purely honorary capacity. They have worked under very difficult conditions, at times, even without any Research or Technical Assistants.

As we can give the assistants only temporary appointments many of them leave on getting permanent assignments elsewhere. This has delayed work considerably. Still we have made a substantial amount of progress and several studies have been completed and published. This has been possible mainly because of the devoted service of the co-ordinators and their co-workers, and the supporting services provided by the National Science Council. The present Secretary-General, Dr. R. P. Jayawardena, his predecessor, Dr. Neil Jayasuriya, the Deputy Secretary General Mr. Leslie Wijesinghe and the N.S.C. staff have at all times given their fullest co-operation and assistance. The Chairman Mahaveli Development Board, Mr. D. Ladduwahetty, and the General Manager Dr. Walter Abeygunawardena took a personal interest and assisted us in numerous ways in the Kalawewa area studies. I wish to record here our sincere appreciation of, and grateful thanks to all of them and to all participants in the projects for their very valuable contributions to the MAB program in Sri Lanka.

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Miss C. J. Padmaperuma	— Monitoring the Water Quality in the Colombo canal system
Prof. S. Balasubramaniam	— Grassland Eco-systems
Prof. B. A. Abeywickrama Prof. K. D. Arudpragasam Dr. (Mrs.) W. T. T. P. Gunawardena	} — Education & Training in Environmental Studies
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Dr. S. G. Ullangatilleke	— Mahaweli Project — Monitoring of Physical Environment — WATER
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Dr. (Mrs.) K. Abeynayake	— Mahaweli Project — Monitoring of Physical Environment — CLIMATE & HYDROLOGY.
Dr. (Mrs.) C. V. S. Gunatilleke	— Sinharaja Forest Studies
	— Ectotrophic Mycorrhizas in Forest Trees of Sri Lanka.
	— Ecological Investigation of a Montane Forest in Sri Lanka.

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Man and Biosphere Reserves

M. PUSHPARAJAH

The need for an international network of protected representative areas or Biospheres of different ecosystems was recognized by the International Coordinating Council of UNESCO at its first meeting in 1971. Consequent to this decision, arose MAB Project No. 8, titled "The Conservation of natural areas and the genetic material they contain". The protected areas recognized under this MAB Project No. 8 are referred to as Man and Biosphere reserves.

After the second session of the International Coordinating Council of the UNESCO in 1973, a panel on Man and Biosphere Reserves was formed to devise criteria and guidelines for the selection of Man and Biosphere Reserves. The characteristics of the Man and Biosphere Reserves as summarized by the panel are as follows :-

1. Biosphere reserves will be protected areas of land and coastal environments. Together they will constitute a world-wide network linked by international understanding on purposes, standards and exchange of scientific information.
2. The network of Biosphere reserves will include significant examples of biomes throughout the world.
3. Each biosphere reserve will include one or more of the following categories,
 - (a) Representative examples of natural biomes
 - (b) Unique communities on areas with unusual natural features of exceptional interest
 - (c) Examples of harmonious landscapes resulting from traditional patterns of land-use
 - (d) Examples of modified or degraded ecosystem capable of being restored to more natural conditions.
4. Each biosphere reserve should be large enough to be an effective conservation unit, and to accommodate different uses without conflict.
5. Biosphere reserves should provide opportunity for ecological research education and training. They will have particular value as benchmarks or standards for measurement of long-term changes in the biosphere as a whole.

6. A biosphere reserve must have adequate long-term legal protection.
7. In some cases biosphere reserves will coincide with, or incorporate existing or proposed protected areas, such as national parks, sanctuaries or nature reserves.

There are a number of special features which make the Man and Biosphere reserves different to the other international programmes for protecting areas of land for various purposes such as archaeological or historical monuments, or sites of cultural landscapes. The emphasis in selection of some of these features is on representative samples of major ecosystems rather than on those that are exceptional.

- they form an international network in which the international character is ensured by an exchange of information and personnel through MAB Committees and MAB technical notes
- they provide for manipulative research in portions of the reserves
- they combine conservation, research education and training as major objectives
- they play an integrative role with local populations whose social and economic activities comprise a significant management input,
- they focus their efforts on the relationship between man and the biosphere.

The commencement of demarcating of Man and Biosphere reserves in Sri Lanka commenced in 1971 and to-date a total of thirty six Man and Biosphere reserves totalling 316,617 acres have been demarcated to represent the various ecosystems in the country. The areas have been selected from the different climatic zones namely montane, wet, intermediate and dry zones, and represent the different types of climax vegetation such as the tropical wet evergreen forests, dry mixed evergreen forests, patanas and savannah woodlands. The only forest type not covered by the biosphere reserves is Mangroves. The activities performed by the Forest Department in these man and biosphere reserves are purely protection and maintenance of poles that are fixed along the boundaries and the nameboards. It is regretted that no

research activity is performed by the Forest Department staff in any of these Man and Biosphere reserves. The constraints that hinder research studies in these biosphere reserves by the Forest Department are inadequate staff and lack of qualified personnel. Research on endemic tree species and growth rates are being carried out in the Sinharaja reserve by scientists from the University of Sri Lanka, Peradeniya.

The Sinharaja MAB reserves in the wet-zone which is 22,000 acres in extent and the Hurulu-Anaulundawa reserve which is 130,000 acres in extent, in the dry zone, have been granted international MAB standards by the UNESCO. Funds for the maintenance of the Man and Biosphere reserves are met from the National Science Council Grant.

Under the Man and Biosphere Programme, it is proposed to undertake the following activities during the next

year in addition to the present functions performed by the departmental staff, in these reserves.

- (1) opening of permanent growth or incremental plots in every biosphere to obtain quantitative data on growth of the various indigenous species.
- (2) identification and collection of herbarium specimens in the
 - (a) Sinharaja reserve
 - (b) Hurulu-Anaulundawa reserve and
 - (c) Nellikele biosphere reserve
- (3) opening of MAB reserves in the coastal region to cover the Mangrove forest type.



MAB Studies in Sri Lanka

Preparation of Check Lists and Handbooks to the Fauna and Flora

B. A. ABEYWICKRAMA

Sri Lanka, even though it is a relatively small country, has a wide range of environmental conditions and consequently a rich and interesting flora and fauna. At a very early period this attracted many famous foreign scientists. Linnaeus himself worked on a collection of Ceylon plants when he was in Leyden and he published his "Flora Zeylanica" in 1747. Some of his pupils came here and made collections from the island. By 1900 Ceylon, as it was then called, was one of the best botanized tropical islands. Practically all their findings, however, were published in foreign journals and often in continental European languages, and most of them are not readily available to workers in Sri Lanka. This and the inadequacy, and in some instances the total absence, of guides or handbooks to the flora and fauna have been a serious handicap for biological field studies in the island.

The main objective of the present project is to prepare background literature on the local plants and animals. It was started in 1977 and is centred in the Biological Laboratories of the University of Colombo. Under this project, specimens are collected and identified, and all available literature is collected, studied and collated. Using this information Check Lists of species, keys to and descriptions of Genera, and Handbooks for their identification are prepared. The co-ordinators are Professor B. A. Abeywickrama (Flora studies) and Professor K. D. Arudpragasam (Fauna studies) and the principal collaborators are Professor R. N. de Fonseka, Dr. (Mrs) Umarance Coomaraswamy, Dr. (Mrs) Kanti Abeynayake, Dr. S. Kotagama, Dr. (Mrs) Thelma Gunawardena, Mrs. Ranjini Ratnapala, Mrs. P. Arulgnanam, Mr. M. A. B. Jansen, Miss. I. Kotelawala and Mrs. L. K. Senaratna.

Flora studies: A Handbook to the Families of the Monocotyledonous Flowering Plants has been completed and is now in press. One on the Dicotyledonous plants is in preparation. As a revision of Flowering Plants of Sri Lanka is being carried out under another project, studies at generic and specific levels on flowering plants are not being done under this project. As regards flowerless plants preparation of Check Lists of the following have been completed.

Fresh Water algae	160	genera	580	species
Liverworts	69	"	190	"
Mosses	174	"	575	"
Ferns and Fern Allies	93	"	320	"
Fungi parasitic on plants	255	"	750	"
Mushrooms and Toadstools	53	"	380	"
Soil Fungi	63	"	150	"
Fungi associated with insects	62	"	160	"
Macrofungi	106	"	530	"

Several guides and Handbooks to the Genera have also been prepared and the present position regarding publications is as follows :—

1. A checklist of the Liverworts of Sri Lanka.
(B. A. Abeywickrama and M. A. B. Jansen) 1978.
2. A checklist of the Mosses of Sri Lanka
(B. A. Abeywickrama and M. A. B. Jansen) 1978.
3. A checklist of the Pteridophytes of Sri Lanka
(B. A. Abeywickrama) 1978.
4. A Handbook to the Fungi parasitic on plants of Sri Lanka (U. Coomaraswamy) 1979.
5. A Handbook to the Agarics of Sri Lanka
(U. Coomaraswamy) 1979.
6. A Handbook to the Freshwater Algae of Sri Lanka
(Part I) (B. A. Abeywickrama 1980).

In Press :

7. A Handbook to the Soil Fungi of Sri Lanka.
(U. Coomaraswamy and R. N. de Fonseka)
8. The Families of the Flowering Plants of Sri Lanka
Part I — Monocotyledons (B. A. Abeywickrama).

Fauna studies: Checklists of Land Snails, Mosquitoes, Amphibians, Reptiles, Birds and Mammals have been completed. Some of them are in the process of being published. The preparation of the Check List of Butterflies (128 genera with 240 species) and Ants (64 genera with 225 species) is nearing completion. The check list of Reptiles includes 5 families and 8 genera of chelonians, and 5 families and 27 genera of lizards of which 7 genera with 13 species are endemic. In addition there are 21 other endemic species of lizards making up a total of 34 endemic species. 47 genera of snakes have been listed, 4 of them being endemic. The total number of endemic species of snakes is 38. The crocodiles are represented in the island by a single monogeneric family.

The checklist of Land Snails brings together information relating to Sri Lanka on this group for the first time, and includes 23 families, 64 genera and 266 species.

In addition to the checklists, illustrated field keys have been prepared for the amphibians and mammals. Short descriptions of the species have been made using mostly the external features that are easily seen in the field. These would help laymen with little technical knowledge to make quick on the spot identifications.

Ecology of a Montane Forest in Sri Lanka

D. S. A. WIJESUNDARA and C. V. S. GUNATILLEKE

Montane forests, one of the natural vegetation types, which play an important role in water retention and release in the catchment areas of this country are also the home of 413 endemic plant species. These endemics constitute 50% of all the endemics in Sri Lanka.

Despite the importance of montane forests, few ecological studies have been done in them. Most of the work carried out in these areas are related to taxonomic studies. This project was initiated to gather basic ecological information from a natural montane forest in Sri Lanka.

The aims of this project are the following:

- (a) Phytosociological studies of the forest
- (b) Elucidation of causal factors responsible for possible species associations
- (c) Conservation of endemic species

The Hakgala Strict Natural Reserve was selected for this study due to the relatively undisturbed nature of its vegetation, easy access and close proximity to the Botanical Gardens. It has an altitudinal range of 1700m — 2158m, is rather hilly with steep slopes and rocky outcrops. Soils of the area belong to the Red Yellow Podzolic soils with a thick humic A horizon. The mean annual rainfall of the area is 2154mm and its mean temperature is 15.6°C.

Herbarium specimens were collected from plots (each 25m x 25m) demarcated on the North-eastern slope of the forest. The overall height of the vegetation was about 12 — 15m and it was possible to differentiate 3 different strata viz. a canopy layer of 12m and above, sub-canopy layer of 9m — 12m and an understorey of 6m and below. The canopy layer was relatively closed and continuous. Even though little light reached the ground surface of the forest, a dense ground vegetation was present in most plots. A mean density of 3720 individuals per hectare was recorded.

The largest girth size recorded in the area was 270 cm gbh depicted by *Ficus microcarpa*. From the distribution of individuals in different girth size classes 64% of the stems sampled belonged to the 15cm — 29cm girth class; only 1.5% belonged to the 120cm and over girth class. Despite the low density of stems in the highest girth class they represented as many as 16 species. All the individuals over 15cm gbh belonged to 35 families, 62 genera and 90 species including 6 that could not be identified yet. Families with the largest representation of species were found to be Rubiaceae with 15 species, Myrtaceae and Symplocaceae each with 8 species and Lauraceae with 7 species. The distribution of species is highly localized. The minimal area of this forest was concluded as 1 ha.

Dominance: The dominant species and families in different strata of the forest based on density of individuals are given in Table I.

However the dominant species based on height are *Mastixia tetrandra* var. *montana*, *Calophyllum walkeri*, *Syzygium revolutum*, *Celtis cinnamomea* and *Michelia wilagirica*. The population density of the species recorded revealed that each of 7 species are represented by one individual. They are *Kadsura heteroclita*, *Lasianthus varians*, *Micrococa oligandra*, *Photinia notoniana* and 3 unidentified species.

These species may be considered very rare in this forest. It is also interesting that as much as 74% of the species are represented by less than 50 individuals each in the sampled area.

Endemics: Among the 90 species recorded in this study 40% (36 species) are endemic to this country. When individuals are considered it is found that 48% of the individuals enumerated are endemic.

Of the 36 endemic species, 9 may be considered very rare as each of them is only represented by less than 10 individuals in 1.25 ha of the forest sampled. These species are *Lasianthus varians*, *Micrococa oligandra*, *Casearia thwaitesii*, *Eleocarpus glandulifer*, *Hedyotis lessertiana*, *Microtropis wallichiana*, *Pavetta involucrata*, *Sophora zeylanica* and *Urophyllum zeylanicum*.

Epiphytes: Orchidaceae represented by several species of *Cirropetalum*, *Eria bichlor*, *Eria baccata* and *Saccolobium* were very common epiphytes, while others such as *Medinilla fuscoides* and *Peperomia* were also present. *Psilotum* sp., *Lycopodium* spp. and *Vittaria* sp. were some of the epiphytic pteridophytes observed. In addition, a luxuriant growth of epiphytic bryophytes, indicating the high humidity of the forest environment, was quite obvious. Most, if not all, of these bryophytes were epiphytic on the trunks of trees and shrubs, hardly any were present as epiphyllous epiphytes.

Lianas and Creepers: Formed a substantial portion of the forest floor. However, very few lianas or creepers were recorded over 15 cm gbh. *Piper* spp., *Tetrastigma muricatum*, *Toddalia asiatica*, *Zanthoxylum tetraspermum*, *Tyloflora multiflora* and *Morinda umbellata* were among the dominant lianas and creepers in this vegetation.

Among shrubs of the ground layer *Psychotria* spp. and *Lasianthus* spp. predominated in most areas of the forest, but on steep slopes a species of *Indocalamus* replaced them. *Amomum involucratum* and *Rubus* spp. were also present to a lesser extent on these steep areas.

In apparently undisturbed areas of the forest a gregarious cover of *Selaginella* was found.

Other herbs recorded were *Pogostemon heynianus*, *Elatospemon* sp., *Disporum* sp., *Ophiorrhiza* sp., and also orchids like *Phajus wallichii* and *Calanthe veratifolia*.

STRATA OF FOREST	DENSITY DOMINANT SPECIES & THEIR FAMILIES	DENSITY OF INDIVIDUALS IN 1.25 ha	DENSITY DOMINANT FAMILY
Canopy above 12 m height	i. <i>Cinnamomum ovalifolium</i> (Lauraceae)..... ii. <i>Neolitsea fuscata</i> (Lauraceae)..... iii. <i>Michelia nilagirica</i> (Magnoliaceae)..... <i>Syzygium revolutum</i> (Myrtaceae)..... iv. <i>Semecarpus ochracea</i> (Anacardiaceae)..... v. <i>Calophyllum walkeri</i> (Clusiaceae).....	137 132 90 90 70 66	LAURACEAE
Sub - Canopy between 9-12 m height	i. <i>Symplocos Spiceta</i> (Symplocaceae)..... ii. <i>Eugenia mabaeoides</i> (Mynaceae)..... iii. <i>Symplocos i</i> (Symplocaceae)..... iv. <i>Memecylon parvifolium</i> (Melastomaceae)..... v. <i>Actinodaphne sposiosa</i> (Lauraceae).....	207 259 196 191 102	SYMPLOCACEAE
Understorey below 6 m	i. <i>Psychotria bisulcata</i> (Rubiaceae)..... ii. <i>Allophylus varians</i> (Sapindaceae)..... iii. <i>Psychotria gilandulifer</i> (Rubiaceae)..... iv. <i>Saprosnia foetens</i> (Rubiaceae)..... v. <i>Maecia perottetiana</i> (Myrsinaceae).....	437 355 120 103 91	RUBIACEAE

TABLE I - Dominant species and families in different strata of the forest.

Soil Microbiological Studies at Sinharaja Forest

J. MAHESWARAN and I. A. U. N. GUNATILLEKE

Sinharaja is a tropical lowland rain forest located in the South-Western region of Sri Lanka with an extent of 22,000 acres (11,000 ha) which is now a Man and Biosphere reserve.⁵ Leaving out the encroached and selectively logged areas, however, the extent of primary forest remaining may be roughly estimated as 5,000 ha. Its general climate, topography and soils have been described by Merritt and Ranatunga (1959).

Microbes in general and soil microbes in particular, play an important role in maintaining the equilibrium of this luxuriant and complex ecosystem. This study was initiated in January 1979 to compare (a) the total soil microbial activity, (b) nature and quantity of one important group of microbes namely soil fungi, and (c) total and available nutrients, in a primary forest and an adjacent deforested area which at present is a *Dicranopteris* (S-Kekilla) fernland. Preliminary investigations were also made to determine the Nitrogen fixing capacity of some forest components, viz. soil, decomposing litter and a survey of mycorrhizas in seedlings and mature plants of the forest was also conducted.

In our study, forest soils were found to be consistently more acidic (pH 4.5 — 5.4) than fernland soils (pH 5.5 — 5.8) again, in contrast to observations made by Joachim and Kandiah who recorded a pH of 5.3 for both forest and fernland. Soil samples analysed from 100 cm deep pits indicated higher values for organic matter and moisture and lower values for soil temperature and pH in the forest than in the fernland.

Soil Mycoflora

So far 64 different species including 10 Phycomycetes, 6 Ascomycetes, 48 Fungi Imperfecti and 4 Mycelia Sterilia have been identified. The wood rotting Basidiomycetes have not yet been identified. The vertical distribution of fungi shows a gradual decrease from 0-100 cm in forest soils, while in fernland soils a sudden increase at a depth of 50 cm was shown. The qualitative distribution of some microfungi in the forest and fernland soils are found to be different. *Trichoderma harzianum*, *Penicillium simplicissimum* and to a lesser extent *Arthrinium arundinis* predominate in forest soils while *Eupenicillium ehrlichii* was the most dominant in fernland soil and was absent from forest soils. *Monilia sitophila* was also recorded only from the fernland

Seven species each of *Aspergillus* and *Penicillium* have so far been recorded from the forest. These two genera as well as *Trichoderma viride* are well represented in soils of rubber plantations in the Kalutara and Panadura districts. However, the absence of *T. viride* is quite striking. *T. harzianum* though found

to be abundant in forest soils at Sinharaja as well as Kottawa (U. Cumaraswamy, Personal Comm.) were recorded in lower frequency in rubber soils.²

Soil Microbial Activity

The percentage weight loss, a measure of microbial activity, recorded over a period of one year showed a decrease in the following order: *Cullenia* in fernland, *Dicranopteris* in forest and *Dicranopteris* in fernland. In the two experimental plots the rate of weight loss appeared to be positively correlated with the amount of rainfall except in the case of *Dicranopteris* in forest.

The rate of weight loss was slower in the fernland than in all the forest sites suggesting a lower microbial activity in the fernland as compared with the forest.

The preliminary experiments showed that only wood litter from the forest had any detectable activity. Of the 23 species studied, all but one had endotrophic vascular-arbuscular mycorrhizas. Only *Shorea trapezifolia* showed ectotrophic mycorrhizal associations.

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Evaluation and Improvement of Natural Grassland (Patana) in the Hill Country Dry Zone of Sri Lanka for Economic Livestock Production

S. SIVASUBRAMANIAM and R. RATNAKUMAR

(Based on research studies conducted at the MAB Project 3 Research Station — Bandarawela)

The dry patanas or the natural grasslands occurring in the hill country dry zone of Sri Lanka are situated on the Eastern slope of the Central massif and consist of about 67,000 hectares. About 25% or 16,000 hectares of patana are situated on gently sloping areas which is suitable for economic livestock production provided that this grassland is improved to carry additional stock than it is carrying now. Most of the land is found in the Upper Uva basin at an elevation of 800 — 1500 metres.^{2,3}

The temperature is moderate by tropical standards and ranges from 18°C to 25°C with a diurnal variation of 5°C to 10°C. The mean annual rainfall is around 1500 mm of which about 1000 mm is received in the period October to January and the balance 500 mm in April and May.

The dry patana soil was characterised as "Red Yellow podzolic soil"⁴ and described as being deep to very deep, well drained, with a variable A horizon depending on the erosion. The texture is moderately coarse to moderately fine, and the structure weak to moderate crumb. Soil reaction is acidic to strongly acidic with increase in rainfall. Organic matter and nitrogen are low to moderate; Phosphorus, Potassium, Magnesium and Calcium content is low. This shows that the soils are basically suitable for cultivation provided that the low fertility level could be corrected by proper fertilizer treatment and subsequent management.

About 75% to 90% of the plant population consists of grasses, and generally presents the appearance of a close cropped meadow land but composed of tussocky coarse grasses which have, both morphologically and physiologically progressed towards a xeromorphic habit and thus becomes less palatable except for tender shoots.^{2,5}

The principal species of the grass complex are *Themeda tremula*, *Arundinella villosa*, *Eulalia phaeothrix*, *Cymbopogon polyneuros*, *Heteropogon contortus*, *Ischaemum ciliare*. The tall mana grass *Cymbopogon confertiflorus* is dominant at lower elevation and often in association with *Themeda* in ravines and depressions. A small percentage of herbaceous species

such as *Hedyotis* sp. *Elephantopus scaber*, *Desmodium triflorum*, *Pteridium aquilinum* are also observed. Low shrubs like *Knoxia platycarpa*, *Atylosia trinervia* and *Osbeckia octandra* are also common.

At present, the ruminant population in this area depend mainly on the natural grassland, consisting of grasses referred to earlier. The carrying capacity of this native sward was found to be extremely low. In a recent study, it has been observed that without application of any fertilizer the dry matter yield in the first year varied from 1000 — 2000 kg/ha, depending on the frequency of defoliation clipping. However, in the second year there were substantial reduction in the yields and the highest being when the sward was cut more frequently. Although application of nitrogen fertilizer increases the dry matter yield, the response was found to be very low, only about 7 kg of dry matter per kg of nitrogen applied compared to 25 kg of dry matter per kg of nitrogen reported for improved pasture under local conditions. Application of fertilizers to obtain higher dry matter yield from the native grass sward, therefore, could be a wasteful practice.

Based on the above, the carrying capacity of the native grassland would be in the region of one animal for every 3 hectares. But, even at such a low stocking rate there was a general reduction in the yield in the second year reducing the carrying capacity to about 5 hectares per animal.

There is very little scope of improved grassland production and management techniques based on native grasses of the dry patana for economic animal production. Therefore, it is imperative that these poor quality grasses with low rates of productivity be replaced with high yielding improved quality grasses and legumes to make animal production to be an economically viable proposition. However, replacing the native grasses with improved pasture would not be possible unless sufficient organic matter is incorporated into the soil in order to improve both the physical and chemical nature of the eroded infertile soil. Further, procuring sufficient organic manure in the region is not practicable because of high demand of farm yard manure for vegetable cultivation. Therefore, the only alternative would be to produce the organic matter on the

land itself in situ which can be achieved by the cultivation of short duration crops, preferably legumes to improve the fertility status of the land before introducing the desired pasture species.

It has been demonstrated in various parts of the world that the fertility status of soils can be improved by a process of pioneer cropping by growing fertility rebuilding crops, especially legumes.

This phenomenon was tested earlier and it was established that soil fertility rebuilding pioneer cropping phase over a period of one year before establishing improved species resulted in a five fold increase in the dry matter yield of the pasture during the establishment year. However, the question of economic returns from the pioneer crops during the first year was investigated only recently and it was established that growing maize in the Maha season followed by a crop of horse gram in the Yala gives the highest economic returns with the prevailing price structure for these products.

The yields obtained from maize (grain) and horse gram (seed) are 1167 and 1148 kg/hectare respectively. Because of the variable nature of price for these products, changes in the cost of production, and above all the benefit accrued to the pasture established subsequently, it would be difficult to predict the actual cost-benefit ratio of this operation. But, it would be reasonable to assume that the expenses incurred can be recovered without much difficulty. Another combination, but less attractive under prevailing prices, is maize in Maha and Kurakkan in Yala. The grain yield of Kurakkan was estimated to be in the region of 800 kg/hectare.

The *Paspalum dilatatum* (Poir) pasture established after pioneer cropping exceeded the control treatment without pioneer cropping by 100 to 200% depending on the type of pioneer cropping combination during the first year and to 200 to 300% in the second year.

The most interesting observation was that the treatment without pioneer cropping or the control gave the same dry matter yield both in the year of establishment and in the second year. The yield was around 1200 kg/hectare/year which is comparable to the native sward which it has replaced. However, unlike the native sward the digestible organic matter (DOM) is around 55% and was neither affected by different pioneer cropping treatments nor there is any difference observed between the 1st and the 2nd year.

Another desirable feature observed was the number of weeds in the treatment without pioneer cropping, where four or five weedings were required both in the establishment and the second year while the number of weeding required in the pioneer cropping treatments was two and one respectively. This is due to the vigorous growth of the pasture which kept the weeds under control. This is a real advantage and minimises cost of establishment and subsequent management due to infrequent weeding.

Management studies on improved pasture established after one year of pioneer cropping were also

undertaken to evaluate the production potential of one of the popular pasture grass that was identified for dry patana area namely *Paspalum dilatatum* (Poir). This is a pasture grass exhibiting a low and spreading habit, ideal for grazing, forms a dense sward and prevents erosion on steeper slopes and also has a very rapid recovery growth.

The two aspects that were studied are its response to (1) Different nitrogen levels (2) Cutting frequencies. The nitrogen levels were 0,75,150,225,300 kg of nitrogen/ha/year. The cutting frequencies were 30 days and 60 days. The parameters measured were, dry matter and digestible organic matter (DOM) by in vitro techniques.

From this experiment it may be concluded that:

1. There is an increase in both the dry matter and digestible organic matter yield with increase in the level of N and this was most significant when the pasture was cut at 2 months interval.
2. Significantly higher dry matter yield for some nitrogen treatment was observed when cut at two months interval but at lower nitrogen levels because of reduced digestibility, the total digestible organic matter was not significant.

Another experiment was conducted to evaluate the animal production potential of *Paspalum dilatatum* pasture. Two levels of nitrogen at 50 kg/ha and 100 kg/ha was applied in two split doses at the commencement of the experiment and three months later. South Down lambs (7-8 months old) at two stocking intensities of 20 and 12.5 animals per hectare were allowed to graze continuously. The experiment commenced in January and continued for a period of 6 1/2 months. The experiment was discontinued when field grazing was limited due to the onset of the dry season in June/July and animals started losing weight. No supplementary feeding except mineral mixture was provided.

It may be concluded that at 50 kg nitrogen level and at a stocking rate of 20 animals per hectare the daily individual gain is depressed because of insufficient herbage available for grazing. On the other hand individual gains, as expected, reached maximum with high nitrogen level and low stocking rate; and the other two treatment fall within these two values. The ideal nitrogen level and stocking rate out of these combinations depends on the cost of nitrogen fertilizer and price of the finished product.

Summary: The natural grassland or patanas in the Hill country dry zone of Sri Lanka hitherto received very little attention because of its limited potential for

livestock activities. The dry matter production of the native grassland is between 1000—2000 kgs/hectare in the first year and less than 1000 kgs/hectare in the second year under a cutting management without any fertilizers. The response to inorganic nitrogen was only 7 kgs of dry matter per kg of nitrogen applied. The Digestible Organic Matter (DOM) of the chief native grass species was lower than 30%. *Paspalum dilatatum* grass established after pioneer cropping the land for a period of one year produced a 200% increase in dry matter yield in the year of establishment and over 300% in the second year compared to that without pioneer cropping. It has been found that with 200 kg of nitrogen per hectare per year the dry matter yield exceeded 6000 kg and the potential of such a pasture produced a liveweight gain of one kg per hectare per day with growing South Down lambs.

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Water Quality Monitoring in Colombo Canal Systems

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The present sewerage system for Colombo is about 60 years old and consists of two treatment sites (neither of which operates) and eleven pumping stations. The effluent for the Southern area is discharged into the sea at Wellawatte and for the Northern area into the Kelani river. Certain parts of the system are now overloaded and overflows of crude sewage discharged directly into the canal system.

Many of the shanty areas are adjacent to the canals into which are discharged domestic refuse, garbage and domestic waste water. Consequently the canals are used as open sewers and also as sinks for daily toilet facilities.

The canals are also used for the discharge of liquid effluent from a number of large and small scale industries of Colombo area.

A baseline study of the water bodies of Sri Lanka to evaluate their characteristics has never been done and hence the baseline data in respect of the water bodies in Sri Lanka are not available. The 1972 report of the Special Committee on Wellawatte canal pollution Control record 3 day Biochemical Oxygen Demand levels only.

In the circumstances, we undertook a pollution survey of Wellawatte canal, Dehiwela Canal, Kittanpahuwa and Kolonnawa Ela and St. Sebastian Canal.

The Wellawatta Canal is slightly in excess of 1.6 km in length and it has an average width of 0.05 km. The sea outlet is protected with two groynes on either side which prevent the formation of the sand bar for about 8 months of the year. The canal passes through a highly residential area. In certain sections, a large number of shanties have come up along its banks. The shanty dwellers pollute the canal waters with human and domestic waste and garbage. In addition two overflows from Municipal sewers discharge raw sewage above Havelock Road bridge into the canal whenever the sewers in this section remain closed. The Wellawatte Spinning and Weaving Mills discharge untreated effluents and septic tank overflows into the Canal below this bridge.

The Dehiwela canal is 0.4 km long and has an average bed width of about 0.07 km. It does not function at all during normal times because the flow is obstructed by sand bar formation at the mouth of the outlet. During times of heavy rain fall, flood flow causes

the sand bar to open, and the flood waters escape into the sea through this outlet. At other times, canal waters are stagnant and for all purposes it does not behave as a canal. The canal itself functions as a tributary of Wellawatte canal and flows with the drift into the Wellawatte sea outlet. This water way is polluted by shanty dwellers who use it as a garbage dump and as an open sewer.

The San Sebastian canal is about 1.6 km in length, linking Beira Lake and Kelani River. There is evidence of considerable growth of Water Hyacinth and Salvinia. Domestic refuse and domestic waste water pollution from the large shanty town along the banks and industries such as B.C.C., Lever Brothers and Jafferjee Brothers situated along the canals, discharge industrial effluents into the canals. It is in turn further polluted by tributary canals which in turn receive waste water from industries such as Lankem (pesticides) and a number of textile plants. This canal is very important as water has to be taken along it to maintain the Beira Lake.

Monthly samples of water were collected from sampling points in the above canals and tests for 11 WHO recommended basic determinants were done on all the samples.

Temperature
pH
Electrical Conductivity
Dissolved Oxygen (DO)
Total Suspended Solids (TSS)
Nitrate (as N)
Total Phosphate
Faccal Coliform bacteria
Turbidity
Chemical Oxygen Demand (COD)
Biological Oxygen Demand (BOD)

These parameters give a fair estimate of the organic and inorganic load of water in the canals.

The temperatures have almost always been one or two degrees centigrade less than air temperature, except at the Wellawatte Spinning and Weaving Mill's discharging point where the temperature of effluent is relatively higher than the temperature of the canal water. Hence the dissolved oxygen level of effluent is low because of two factors; one, high effluent temperature and the other, high oxygen demand of effluent itself. These are discharged into the canals which are already suffering from dissolved oxygen deficiency.

The pH of most of the samples of the sampling points are in acidic range, except where alkaline effluents are discharged and in the seawater mixing points.

The high electrical conductivity of the water is due to two main reasons; one, due to the sea water entering the canal during high tide and reverse in the direction of flow of water in the canal, the other is due to the discharge of effluents.

The solubilities of oxygen in water in equilibrium with air at 760 mm Hg for the temperatures observed during our study is given in Table I.

Table I. Solubilities of oxygen in water in equilibrium with air

Temperature °C	Mg/l of Oxygen
27	7.97
28	7.84
29	7.70
30	7.57
31	7.45
32	7.33
33	7.21

The more the water body maintains the dissolved O₂ concentration closer to the above dissolved oxygen level at the respective temperature, the more will be its aerobic nature and more will be the chances for self purification. Our study reveals that the dissolved O₂ Levels at all the sampling points during the period of our study are far below the ideal condition. The Indian Standards suggest 40% of the equilibrium concentration at the respective temperatures as the minimum — usually 6.5 mg/l is accepted as a realistic mean level. 75% of our samples are not satisfying the requirement based on the above level, with 15% of the sampling points totally anaerobic. Though the dissolved O₂ level at certain sampling points are increased during rainy days, there are areas where the Oxygen Demand is so high, they show little improvement even when oxygen saturated water is made available. Comparatively, the dissolved oxygen level of Kittanpahuwa and Kolannawa Ela is higher than the other canals.

Total suspended solid levels are very high in Wellawatte, Dehiwela and San Sebastian Canals compared to the levels at Kittanpahuwa and Kolannawa Ela. The levels of Total Suspended Solid increased during rainy months and during cleaning periods in all the canals. Turbidity also shows similar variation.

The Biological Oxygen Demand, Chemical Oxygen Demand ratio of normal effluents is 3 : 4. Our study reveals that it is not so in respect of the canals where the COD values in certain areas are more than the expected values. This may at least be partly due to the organic contents of the industrial effluents and domestic waste. This is manifested in the results for the direct effluent samples from one industry. Table II gives the relevant Indian Standards.

Table II. Relevant Indian Standards.

Purpose	BOD	DO	TSS
(1) Inland Surface waters (fresh water) for bathing, etc.	3	40% or more	
(2) Industrial waste waters discharged into Inland surface water	30		50
(3) Industrial waste waters discharged into Marine Coastal Waters	50		100
(4) Industrial Effluent waters discharged on land for irrigation purposes	250		2100
(5) Industrial waste waters discharged into public (common) sewer	200		500

The limits for industrial waste water discharge into public sewers are exceeded by 63% of our samples and less than 5% of the samples satisfy the condition for discharge into marine coastal waters. 61% of the samples analysed do not satisfy the requirements for discharging on land for irrigation purposes.

Phosphate and nitrate levels are fairly high in these canals. Eutrophication has taken place in a few sampling points.

The following observations could be made based on our studies:—

- (1) These canals have lost their function as canals.
- (2) These are used as a sink to the domestic, municipal and industrial effluents of the area.
- (3) These canals do not meet the requirements of the Indian Standards for waste waters to be discharged into the public sewer.