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VEGETATION MAPPING AND ANALYSIS OF ARALAM WILDLIFE SANCTUARY USING REMOTE SENSING TECHNIQUES

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ABSTRACT

Vegetation of Aralam Wildlife Sanctuary was mapped using remote sensing techniques. Maps were prepared in 1:25,000 scale using Black and White aerial photographs and in 1:50.000 scale using IRS 1B Geocoded satellite imagery. Digital image processing of the area was done using IRS 1B LISS-I data. A set of supplementary maps viz. physical, digital, drainage, slope maps were also prepared. Vegetation analysis of the area like density, relative density, abundance, percentage frequency, relative frequency, basal area, relative basal area, importance value index, species distribution, maturity index, continuum index, diversity index and concentration of dominace were also done and structural data supplemented. Dominant species of Westcoast semi-evergreen forest of this sanctuary are *Mesua nagassarium Myristica malabarica* and *Mangifera indica* while that of Southern secondary moist mixed deciduous forest are *Bombax malabarica, Tetramelus nudiflora* and *Xylia xylocarpa*. Of the total area of 55 Sq Km. evergreen 39 percent. semi-evergreen 47 percent, moist deciduous 2 percent and other minor types 11 percent.

Key words: Vegetation mapping. Phytosociology. Remote'sensing, Photointerpretation, Aralarm Wildlife Sanctuary.

INTRODUCTION

India has about 15 percent of the worlds population and 2 percentage of the forest area of the world. The importance of scientific management of forest was realised as early as in the year 1965 when the Forest Act was passed. As per the State of Forest Report 1993. the total area under forest is 6.40.107 sq km which is 19.47 percentage of the total geographical area (FSI. 1993). The proper management of this vast. area and monitoring the condition of forest would require reliable information about them. Management of forest resources in the country is carried out through working plans which are prepared at 10-15 years interval. At present the information needed for working plans is conveniently obtained through ground-based surveys which are beset with inherent limitations. Further. the conventional ground survey is time consuming and strenous.

The inventory and monitoring of forest resources over extensive areas has become increasingly important in recent years. Timely and accurate forest inventory information is essential for the formulation of regional and national resources management plans, as well as providing the basis for addressing current issue of international concerns such as deforestation and loss of biodiversity.

Remote sensing in combination with ground based studies has proved to be an effective technique to study and monitor changes in natural resources. Remotely sensed information may be gathered from airborne platforms such as airplanes or space bound platforms such as satellites. A picture taken from air or space contains information of a large area than a picture taken from the ground.

Recent statistical data shows that in developing countries the total forest cover is hardly 2200 m ha with 1350 m ha of closed and 850 m ha of open type providing less than 1.35 ha per capita countries (Rao. 1990). In India. National Forest policy (1952) recommemted one-third of the geographical area to be reserved for forest cover, However, the recent survey reports of Forest Survey of India, Dehradun (FSI. 1991 show an estimated forest cover of 19.47 percent only.

The impact of population growth has a direct effect on forest ecosystem which is passing through a critical phase of ecological stress. Therefore. conservation and judicious management of actual flora and fauna through

ecologically viable conservation strategies are essential for sustainable management of National Parks and Wild Life Sanctuaries.

In India. at present there is a considerable regression to the forest areas. Much of the Wildlife once widely distributed are now seen in certain pockets. Hence. 'in situ' conservation of wildlife is necessary. In order to conserve the natural flora and fauna it is suggested that a minimum 5 percent of the geographical area should be conserved as Wildlife Sanctuaries and National Parks. In Kerala. there are at present 12 Wildlife Sanctuaries and 2 National Parks encompassing an area of about 5.78 percent of the geographic area of the State. The information on the spatial distribution of different cover classes and the pattern of their change is a pre-requisite for planning. utilisation and management of Wildlife Sanctuaries and National Parks.

The structural status of the permanent vegetation such as quantitative aspects and floristic composition ofvegetation types are the major lacuna for the better and effective management of sanctuary.

To meet such an inevitable need for vegetation maps for better management, the present study has been undertaken and vegetation mapping, a vegetation analysis of Aralam Wildlife Sanctuary was done using remote sensing techniques.

STUDY AREA

LOCATION

The Aralam Wildlife Sanctuary covers an area of 55 sq km and has a rich diversity of flora and fauna. The sanctuary is located in the south-eastern side of the Kannur Revenue District of Kerala and lies in Aralam and Kottiyoor villages. Tellichery is the nearest rail head, which is about 70 km from the Sanctuary. The wide network of roads in this area connects it with Tellichery. Kannur, Wayanad and Veerajpetta. The area lies between 11°50 to 11°52' N Lat. and 75°49 to.75°57' E Long. Biogeographically, Aralam Wildlife Sanctuary is located in the Western Ghats. However, this sanctuary is not included in the Nilgiri Biosphere Reserve though it has all the characteristic important endemic to the Western Ghats.

BOUNDARY DESCRIPTION

The notification declaring the formulation of the Aralam Wildlife Sanctuary was issued on 15th October, 1984. The Sanctuary was formulated by carving out areas from the Odanthode Malavaram of Tellichery Special Division which was an ernstwhile private forest (through the Kerala Private Forest Vesting and Assignment Act. 1971) and from Kottiyoor Reserve Forest of the Wayanad Forest Division. However, before the enactment of the Act of 1971. a sizeable area (3060 Ha.) of these forests was cleared for the purpose of setting up of a Central State Farm at Aralam. The vested forest portion of the sanctuary is about 3500 Ha. and the remaining portion is part of Kottiyoor Reserved Forest.

The boundaries of the Sanctuary are:

North - Karnataka state boundary covering the area of Odanthode Malavaram. and therefrom the Kottiyoor Reservad Forest upto Chavachithode of Coorg District, Kottiyoor Reserved Forest and Wayanad District.

East - Wayanad district boundary upto the part where Chavachithode begins.

South - Chavachimala covering north-western portion of Kottiyoor Reserved Forest where Chavachithode joins at Cheennkannipuzha and then through the southern boundary of Odanthodemala and Aralam I and III Ranges upto Valayanchal where it's trenches meet the eastern boundary of Central State Farm is the western boundary of Aralam I and III Ranges.

West - Eastern boundary of Central State Farm, Aralam and western boundary of Adakkathode beat of Manathana section.

The sancutary supports two distinct forest types *viz.* West coast tropical evergreen forest and west coat semi-evergreen forest. Evergreen forests are self supporting and stable with diverse flora and fauna. About 490 Ha. of teak, eucalyptus and cahew plantations are also found in the sanctuary.

GEOMORPHOLOGY

Geologicaly the area can be grouped into two main rock types:

i. Laterites - Laterite is a ferrugenous, reddish, soft rock with irregular galleries fill with yellow clay which hardens are on exposure to atmospheric agencies. Laterite formation is attributed to monsoon conditions repeated through ages. Decomposition of gneiss and partial rearrangement by mechanical action of water give rise to lateritic rocks.

ii. Crystalline rocks - The mountains of the Western ghats are composed of sncient crystalline and metamorphic rocks of Archaean age, mainly quatzose gneiss. The principal rock types are granites and their gneissic variations. The genissic rocks are biotite gneiss, their chief constitients being quartz, Felspar, biotite and garnet. The main feature og gneiss in Western ghats is the tendency to weather or decompose. generally into white, yellow or red flespathic clayey rocks, which in many places and often very extensively became lateritic. The soil types met within the sanctuary are mainly of laterite soils, red soils and forest and hill soils variety. Laterite and red soils are met within the lower reaches where the soil depth is fairly good. As the elevation increases the soil changes to forest and hill type. Also. at the lower reaches the soil contains appreciable amounts of gravel which is an indication of good internal drainage. The accumulation of humus in the top soil gives it a dark reddish brown to dark brown colour which changes to red in the sub-soil. The surface soil has granular structure which favours good root development. The soil is predominantly calcareous in character and acidic in reaction.

CLIMATE

Temperature - The temperature at the foothills varies from 11ºC to 40ºC. As the altitude increases, the variation is comparatively minimal which is between 8ºC and 25ºC.The hottest months are April and May. December to January are relatively cool.

Humidity - At the foothills the humidity varies from 60 to 100%.

Rainfall The Sanctuary is fed by both south-west and north-east monsoons. The greater part of the rainfall is during'the south-west monsoon which is normally during June to august. The north-east monsoon is intermittent.

METHODOLOGY

VEGETATION MAPPING

Data used

In the present study , the following data products are used.

(a) Aerial photographs (1:15,000 scale). procured from NRSA

The black and white aerial photographs are used for the preparation of vegetation map with the following specification.

Scale	: 1: 15,000
Camera	: RMK 15/23
Focal length	: 15.3 cm
Date of photograph	: Jan.1986.
Format size	: 23 X 23 cm
Nature of the print	: Glossy and single weight
Overlap : Forward	: 60 -80 %
: Lateral	: 10 - 40 %
Direction of flight	: South to North
Film	: Kodak XX Aerographic
Filter	: D 124455

(b) Satellite data products , procured from NRSA data centre

i. IRS -1B LISS 2 B Geocoded 2 FCC having Scale 1:50.000 Geocoded. dated Feb 1993 was also used for the preparation of vegetation map.

ii. Computer compatable tape (CCT)

(c) Ancillary data

Survey of India Topographic Map 49 M/ 13 of 1:50,000 scale.

AERIAL PHOTOINTERPRETATION

Recognition of objects on aerial photographs was done with the help of photo-interpretation key (based on photo-elements like tone, shape and size, shadow. texture. pattern and location and association (Tomar. 1968, 1969 and 1976) (Table 1).

Table 1. Image interpretation key for land cover type mapping using 1:15.000 scale B &W aerial photographs

No.	Landcover	Tone	Texture
1.	Evergreen	Dark Grey	Coarse
2.	Semi-evergreen	Medium to light black	Coarse
3.	Moist-deciduous	Greyish	Medium
4.	Grass	White	Smooth
5.	Crub	Dull white	Smooth
6.	Teak plantation	Light grey	Medium
7.	Agriculture land	Medium grey	Coarse
8.	Rock	Light grey/White	Smooth/Coarse

VISUAL INTERPRETATION OF SATELLITE IMAGERY

Tone, colour. texture and site/location etc. are used as parameters in visual interpretation. Based on the photoelements described above an interpretation key was prepared using on photostratification scheme(Roy et al..1991). The methodology used was the monoscopic visual interpretation of the satellite imageries for identification of different categories of forests using standard visual interpretation techniques based on photoelements. in addition the local knowledge about the terrain has contributed considerably in interpretation.Other auxillary data like topographical maps, forest maps and other available details are collected and made use of for identification and mapping of land cover classes.

FIELD CHECKING

The units delineated on the aerial photographs and satellite imageries were compared with ground details at random to verify the correctness of interpretation and to check the doubtful areas.

FAIR MAP PREPARATION AND PRINTING

Fair mapping is done on transparent film. The aerial photo/satellite imagery interpreted details were transferred on the base maps. The transparent fair maps were used for making photocopies or prints.

AREA ESTIMATION

The area estimation of different land cover classes was carried out using Planix-5000 digital planimeter (Table 2).

Table 2. Area estimates (Area in Km2) of different Land cover types as obtained through 1:15.000 B & W Aerial Photographs

Vegetation types	Density	Total
Evergreen		21.523
Semi-evergreen (SE)		25.968
SE1 (1.25% density)	11.076	
SE2 (26-50% density)	1.357	
SE3 (>50%hdensity)	13.535	
Moist-deciduous (MD)		1.111
MD1 (1-25% density)	0.097	
MD2 (26-50%hdensity)	0.967	
MD3 (> 50% density)	0.047	
Grass		0.049
Scrub		0.237
Scrub Dense		0.046
Scrub Open		0.191
Plantation Teak		5.408
Agriculture land		0.105
Rock/shadow		0.895
Total		54.720

PREPARATION OF DRAINAGE MAP

A drainage map was prepared using 1: 15,000 B & W aerial photographs and Survey of India Topograhic sheets.Al1 the major and minor rivers were marked from photographs.

DIGITAL IMAGE PROCESSING

The digital analysis was carried out on VAX 11/780 computer with pericolor image processing system at Regional Remote Sensing Service Centre (RRSSC).Bangalore using VIPs-32 software. IRS Liss 1 data acquired on 26 January, 1994 was used for digital analysis. A subscene of 512 x 512 pixels was selected for analysis. The data in the form of CCT was procured from NRSA, Hyderbad after preprocessing supervised classification system using maximum likelyhood algorythum was used.

PHYTOSOCIOLOGY

With a view to study the phytosociology vegetation in Eravikulam National Park, a thorough reconnaisance survey was carried out initially to assess the overall florestic and structural characterastic of the permanent vegetation so as to design the sampling procedure and intensity.

Sampling

Based on strata identified on aerial photographs. stratified random sampling was carried out in the area to study the vegetation types, their composition and structural e1ement.A sampling strategy was adopted in order to cover the entire vegetation . The whole area was divided into 7 localities.

Census quadrat method

Ten quadrats of 10 m x10 m were laid down in each locality. Maximum care was taken to lay quadrats in different forest types in each locality. Ten randomly selected quadrats of size 10m x10 m in each locality were established to characterise the floristic composition and structure of vegetation. thus covering a sampling area of 1000 sq.m in each locality and 7000 sq.m of total sampling in the study area.

Primary analysis

From quadrat studies the data on density (D), percentage frequency (%F). abundance (AB). basal area (BA), relative basal area (RBA). relative frequency (RF), relative density (RD). and important value index (IVI) etc. were calculated as per the following formula (Phillips. 1959). Mueller-Dombois and Ellenberg (1974).

$$\text{Density (D)} = \frac{\text{Total No. of individuals}}{\text{Total No. of quadrats studied}}$$

$$\text{Abundancee (AB)} = \frac{\text{Total No. of individuals}}{\text{No. of quadrats of occurrance}}$$

$$\text{Frequency (F)} = \frac{\text{No. of quadrats of occurrance}}{\text{Total No. of quadrats studied}}$$

$$\text{Relativee densityy (RD)} = \frac{\text{No. of individuals of species}}{\text{No. of individuals of all species}} \times 100$$

$$\text{Relativee frequencyy (RF)} = \frac{\text{No. of occurrance of the species}}{\text{No. of occurrance of all species}} \times 100$$

$$\text{Relativee basall area (RBA)} = \frac{\text{Basal area of the species}}{\text{Total basal area of all species}} \times 100$$

important value index (IVI) Relative density +
Relative frequency +
Relative basal area

The mean density, mean abundance, mean frequency, mean important value index of different species and the percentage IVI value of each species with respect to the total IVI value of the locality as a whole are calculated seperately for each locality to establish the stand relationships.

SECONDARY ANALYSIS

Distribution

The abundance/frequency value of each locality was calculated for gathering information regarding distribution of species.

Maturity index

The maturity index (MI)is calculated[Pichi- Sermolli, 1948) to assess the status of the community in relation to successional stages. The maturity index is calculated by the formula:

$$\text{Maturity Index} = \frac{\text{Total frequency percentage of a locality}}{\text{Total No. of species present}}$$

Diversity index

General Species diversity is calculated using the concept of informa-tiontheory of Shannon Weinner which modified by Margalf (1968). The formula is

$$\text{The Diversity Index } H = -E\frac{n1}{N} \log \frac{(n1)}{N}$$

Where $n1$ = No.of individuals of a species
N Total No. of individuals of all species

RESULTS

VEGETATION MAPPING

Two different kinds of vegetation maps were prepared as follows.

Medium Scale Map

A map prepared from IRS 1B Geocoded FCC of Februvary. 1993 (Fig. 1) in 1:50,000 scale is compatible with Survey of India toposheets. Stratification of cover classes was done in three canopy density levels. *viz.* morethan 50%. between 26-50% and lessthan 26 percent.

Large Scale Map

A map is prepared from 1: 15,000 B&W aerial photographs of March 1990 in 1:25.000 scale (Fig.2). A total of about eight land cover classes (Table 1) were identified in the map prepared from B & W aerial photographs. Among the natural forests three density classes were identified for ever-green/semievergreens and moist-deciduous forests. In addition, two scrub classes (open and dense), grass cover, reed area, etc. were also identifiable (Table 2).

Area under different landcover

The study covers a total area of about 54.72 km^2. As per the area statistics generated from photointerpreted maps, evergreen forests occupies 21.52 km^2, semievergreen forests occupies an area of 25.97km^2 and moist deciduous forest occupies an area of 1.11 km^2. The estimated area of other minor cover types 6.12 km^2 are tabulated in Table 2.

Drainage map

A detailed drainage map in 1:50,000 scale was prepared. All the perennial and non-perennial rivers were marked. Perennial streams like thodu. lyankunthodu. Narikadavuthodu. Chavachithodu. etc drain in to the Chikannipuzha (Fig.3).

Contour map

Based on Survey of India toposheets a contour map of the area was prepared (Fig. 4).

DIGITAL IMAGE PROCESSING

A hard copy output of digital analysis showing eight land cover classes of Aralam and its environs was obtained [Plate 1). The major landcover classes were evergreens. semievergreens, grassland. scrubland, and agriculture. The accuracy of the classification was worked out using confusion matrices.

PHYTOSOCIOLOGY

The study area has two natural forest types out of the four major types described by Champion and Seth (1968)for Kerala region. They are the West Coast Semievergreen forests and the South Indian Moist deciduous forests.

SOUTH INDIAN MOIST DECIDUOUS FOREST

VEGETATION ANALYSIS

Percentage frequency

The percentage frequency of moist deciduous forests was calculated(Appendix 3).*Bombax, Grewia Macaranga. schleichera Siziphus* and *Terminalia* are the major genera having high frequency in distribution.

Density

The species density and relative density values were also worked out (Appendix 4). *Bombax. Mallotus. Mesua. Myristica* and *Xylia* are the common species with high mean density in the area.

Abundance

Four species had a mean abundance value above one. The abundance values of species in each locality were calculated (Appendix 5). *Bombax. Calophyllum, Mallotus. Vateria* and *Xylia* are the most abundant group in the area.

Importance value index

The Importance Value Index of species were worked out to get the overall status of the species with respect to growth parameters. The species with maximum mean Importance Value Index (IVI) are *Bombax arundinaceae* (56.29). *Tetramelus nudiflora* (40.53) are *Xylia xylocarpa* (31.07). A total of about 9 species have IVI value of more than 10 (Appendix 2).

Distribution pattern

Distribution of species is one of the important aspect of ecological studies which has attracted attention of a number of ecologists (Cole. 1949, Frackler and Brischle. 1944:.Witford. 1948; Ashby. 1948). Witford (1948) suggested the abundance/frequency ratio as a measure of contagiousness. As a general rule the high frequency and low abundance indicates regular distribution where as the converse indicates contagious distribution, The distribution scale states regular, 0.025 to 0.05 is random and 0.05 is contagious distribution. Mean distribution pattern studied shows all species are either contiguous or random in distribution. Regular distribution of species are absent.

SEMI-EVERGREEN FORESTS

Data on primary analysis of semi-evergreen forests are given in appendix 1.

VEGETATION ANALYSIS

Percentage frequency

The percentage frequency for each locality was worked out separately and the data are given in appendix 1. *Mesua nagassarium Baccuria courtallensis. Hydnocarpus pentandra* and *Ziziphus glabrata* are the dominant species in this type.

Density

The mean density studies indicated that very few species are having density value above one indicating the scattered nature of vegetation.

Abundance

Out of 21 species. about four species had a mean abundance value of two and above two.. and are *Calophyllum amophyllus, Myristica attenuata, Myristica malabaricum* and *Mesua nagassariurn*

Basal area

The mean basal area studies indicated that species having the maximum mean basal area was *Mangifera indica* followed by Lagerstroemia lanceolata, Chukrasia tabularis and Holygarna bedomei (Appendix 1).

Importance value index

The species with maximum mean importance value indices were *Mesua nagasarium* (32.44). *Myristica malabarica* (36.61) and *Mangifera indica* (22.62) A total of 14 species had an IVI value above 10 (Appendix 1).

Distribution pattern

Mean distribution studies indicated that all species are either contiguous or random in distribution.

POOLED DATA

The data of moist deciduous forest and semi-evergreen forest were pooled to get an overall idea of the sanctuary with respect to its percentage frequency (Appendix 3), density (Appendix 4). abundance (Appendix 5). basal area (Appendix 6) and Importance Value Index (Appendix 7) of tree species.

REFERENCES

Ashby. E. 1948. Statistical ecology 2: Areassessment. *Bot. Rev*., 14: 222-224.

Cole, L.M.C. 1949. The measurement of interspecific associations. *Ecology,* 30: 411-424.

Champion. H.G. and S.K. Seth 1968. A Revised Survey of the Forests Types of India. Manager of Publications. New Delhi. 404p.

Curtis, J.T. and R.P. Mclntosh 1950. The interrelations of certain analytic anbd synthetic phytosociological characters. *Ecology,* 32: 434-455.

Fracker, S.B. and H.A. Brischle. 1944 Measuring the local distribution of *Ribes. Ecology.* 25: 283-303.

Gleason. H.A.. 1920. Some application of quadrat methods. Bull *Torry Bot. Club*.. 53: 7-26.

Gleason. H.A., 1926. The individualistic concept of the plant association. Bull. *Torry Bot.* Club.. 53: 7-26.

Gleason. H.A.. 1939. The individualisitc concept of plant assoclation. *Am Midland Naturalist*. 21: 92-100.

Jaccard, P. 1912. The disbibution of the flora of the Alpine zone. *NewPhytol*.. 11: 37-50.

Margalef. R. 1958. Information theory in Ecology. Yearbook of the society for general systems research, 3: 36-71

Mueller-Dombois. D. and H. Ellenberg. 1974. Aims and Methods of plant Ecology. John Wiley and Sons, New York.

Phillips, E.A. 1959. Methods of vegetation study. Henry Holt & Co.. Inc. New York.

Pichi-Sermolli. R. 1948. An index for establlshing the degree of maturity in plant communities. *J. Ecol.* 36:85-90.

Roy, P. S.: K.K. Das: K.S.M. Naidu 1991. Forest cover and landuse mapping in Karbi Anglong and North Cachar Hills districts of Assam using Landsat MSS Data *J. Indian Society of Rem Sen*.. 1912): 113-123.

Sorenson. T.. 1948. A method of establishing group of equal amplitude in plant sociology based on similarity of the species, Content. Det. Kong Danske Vidensk. Selsk. *Biol. Skr*. (Copenhaugen),5(4): 1-34.

Tomar. M.S.. 1968. Manual of Photo-interpretation in Tropical Forests (South zone, Kerala &Madras). UNSF/GOI/FAO Project/ IND / 100/4. Preinvestment Survey of Forest Resources.

Tomar, M.S. 1969. Identificatian of land use and forest cover types on aerial photographs. *Ind. For.*. 93(2): 85-89.

Tomar. M.S. 1976. Use of aerial photographs in working plans. *Ind. For.*, 102(2): 98-108.

Whitford, P.B. 1948. Distribution ofwoodland plants in relation to succession and clonal growth. *Ecology.* 30 199-208.

Appendix1

WEST COAST SEMI EVERGREEN FOREST

SL. No.	SPECIES	D	AB	PF	BA	RD	RF	RBA	IVI	ABF
1	*Hydnocarpus pentandra*	0.30	1.50	20.00	1052.1	6.52	6.45	2.53	15.50	0.07
2	*Vateria indica*	0.10	1.00	10.00	2165.9	2.17	3.23	5.21	10.61	0.10
3	*Holigarna beddomei*	0.10	1.00	10.00	4972.2	2.17	3.23	11.96	17.36	0.10
4	*Adina cordifolia*	0.10	1.00	10.00	795.54	2.17	3.23	1.91	7.31	0.10
5	*Buchanania axillaris*	0.10	1.00	10.00	877.09	2.17	3.23	2.11	7.51	0.10
6	*Polyalthia longifolia*	0.10	1.00	10.00	71.60	2.17	3.23	0.17	5.57	0.10
7	*Hopea parviflora*	0.10	1.00	10.00	3182.2	2.17	3.23	7.65	13.05	0.10
8	*Mangifera indica*	0.10	1.00	10.00	7159.9	2.17	3.23	17.22	22.62	0.10
9	*Myristica attenuata*	0.20	2.00	10.00	315.75	4.35	3.23	0.76	8.34	0.20
10	*Mesua nagasarium*	0.80	2.00	40.00	893.87	17.39	12.90	2.15	32.44	0.05
11	*Myristica malabarica*	0.80	2.00	40.00	548.05	17.39	12.90	1.32	31.61	0.05
12	*Schlechiera poovam*	0.10	1.00	10.00	1449.9	2.17	3.23	3.49	8.89	0.10
13	*Cinnamomum verum*	0.10	1.00	10.00	1145.6	2.17	3.23	2.75	8.15	0.10
14	*Calophyllum inophyllum*	0.30	3.00	10.00	673.35	6.52	3.23	1.62	11.37	0.30
15	*Baccuria courtallensis*	0.30	1.50	20.00	81.46	6.52	6.45	0.20	13.17	0.07
16	*Dillenia pentagyana*	0.10	1.00	10.00	1145.6	2.17	3.23	2.75	8.15	0.10
17	*Xylia xylocarpa*	0.30	1.50	20.00	1015.8	6.52	6.45	2.44	15.41	0.07
18	*Lagerstroemia lanceolota*	0.10	1.00	10.00	4972.2	2.17	3.23	11.96	17.36	0.10
19	*Ziziphus glabrata*	0.30	1.50	20.00	910.82	6.52	6.45	2.19	15.16	0.07
20	*Chukrasia tabularis*	0.10	1.00	10.00	4972.2	2.17	3.23	11.96	17.36	0.10
21	*Artocarpus hirsutus*	0.10	1.00	10.00	3182.2	2.17	3.23	7.65	13.05	0.10

MATURITY INDEX 14.76

CONTINUUM INDEX = 1487.81

DIVERSITY INDEX = 2,7170

CONCENTRATION OF DOMINANCE = 0.09

Appendix 2

SOUTHERN SECONDARY MOIST MIXED DECIDUOUS FOREST

SL. No.	SPECIES	D	AB	PF	BA	RD	RF	RBA	IVI	ABF
1	*Alstonia scholaris*	0.10	1.00	10.00	644.39	1.25	3.23	2.38	6.86	0.10
2	*Mallotus phillipensis*	1.10	3.67	30.00	81.46	13.75	9.68	0.30	23.73	0.12
3	*Actinodaphene indica*	0.10	1.00	10.00	574.78	1.25	3.23	2.13	6.61	0.10
4	*Bombax malabarica*	3.70	12.33	30.00	97.45	46.25	9.68	0.36	56.29	0.41
5	*Xylia xylocarpa*	0.90	1.80	50.00	997.93	11.25	16.13	3.69	31.07	0.04
6	*Haldinia cordifolia*	0.40	1.33	30.00	423.95	5.00	9.68	1.57	16.25	0.04
7	*Olea dioica*	0.10	1.00	10.00	286.40	1.25	3.23	1.06	5.54	0.10
8	*Grewia tilliifolia*	0.10	1.00	10.00	1243.0	1.25	3.23	4.60	9.08	0.10
9	*Terminalia bellarica*	0.20	1.00	20.00	3182.2	2.50	6.45	11.77	20.72	0.05
10	*Atalantia rotundifolia*	0.10	1.00	10.00	71.60	1.25	3.23	0.26	4.74	0.10
11	*Streospernum tetragonum*	0.10	1.00	10.00	3677.4	1.25	3.23	13.60	18.08	0.10
12	*Schleichera oleosa*	0.40	1.33	30.00	1766.2	5.00	9.68	6.53	21.21	0.04
13	*Lagerstroemia reginae*	0.10	1.00	10.00	1790.0	1.25	3.23	6.62	11.10	0.10
14	*Artocarpus hirsutus*	0.10	1.00	10.00	795.54	1.25	3.23	2.94	7.42	0.10
15	*Tetralmelus nudiflora*	0.10	1.00	10.00	9745.4	1.25	3.23	36.05	40.53	0.10
16	*Macranga peltata*	0.10	1.00	10.00	49.72	1.25	3.23	0.18	4.66	0.10
17	*Butea monosperma*	0.10	1.00	10.00	962.61	1.25	3.23	3.56	8.04	0.10
18	*Ziziphus glabrata*	0.20	2.00	10.00	644.39	2.50	3.23	2.38	8.11	0.20

MATURITY INDEX = 17.22
CONTINUUM INDEX = 1481.92
DIVERSITY INDEX = 1.9618
CONCENTRATION OF DOMINANCE = 0.25

Appendix 3

MEAN PERCENTAGE FREQUENCY OF SPECIES

Sl. No.	Species	PF
1	*Actinodaphene indica*	5.00
2	*Adina cordifolia*	5.00
3	*Alstonia scholaris*	5.00
4	*Artocarpus hirsutus*	10.00
5	*Atalantia rotundifolia*	5.00
6	*Baccuria courtallensis*	10.00
7	*Bombax malabarica*	15.00
8	*Buchanania axillaris*	5.00
9	*Butea monosperma*	5.00
10	*Calophyllum inophyllum*	5.00
11	*Chukrasia tabularis*	5.00
12	*Cinnamomum verum*	5.00
13	*Dillenia pentagyana*	5.00
14	*Grewia tilliifolia*	5.00
15	*Haldinia cordifolia*	15.00
16	*Holigarna beddomei*	5.00
17	*Hopea parviflora*	5.00
18	*Hydnocarpus pentandra*	10.00
19	*Lagerstroemia lanceolota*	5.00
20	*Lagerstroemia reginae*	5.00
21	*Macranga peltata*	5.00
22	*Mallotus philippensis*	15.00
23	*Mangifera indica*	5.00
24	*Mesua nagasarium*	20.00
25	*Myristica attenuata*	5.00
26	*Myristica malabarica*	20.00
27	*Polyalthia longifolia*	5.00
28	*Schlechiera poovam*	5.00
29	*Schleichera oleosa*	15.00
30	*Streospernum tetragonum*	5.00
31	*Vateria indica*	5.00
32	*Xylia xylocarpa*	35.00
33	*Ziziphus glabrata*	15.00
34	*Olea dioica*	5.00
35	*Terminalia bellarica*	10.00
36	*Tetralmelus nudiflora*	5.00

Appendix 4

MEAN DENSITY OF SPECIES

SL. No.	Species	D
1	*Actinodaphene indica*	0.05
2	*Adina cordifolia*	0.05
3	*Alstonia scholaris*	0.05
4	*Artocarpus hirsutus*	0.10
5	*Atalantia rotundifolia*	0.05
6	*Baccuria courtallensis*	0.15
7	*Bombax malabarica*	1.85
8	*Buchanania axillaris*	0.05
9	*Butea monosperma*	0.05
10	*Calophyllum inophyllum*	0.15
11	*Chukrasia tabularis*	0.05
12	*Cinnamomum verum*	0.05
13	*Dillenia pentagyana*	0.05
14	*Grewia tilliifolia*	0.05
15	*Haldinia cordifolia*	0.20
16	*Holigarna beddomei*	0.05
17	*Hopea parviflora*	0.05
18	*Hydnocarpus pentandra*	0.15
19	*Lagerstroemia lanceolota*	0.05
20	*Lagerstroemia reginae*	0.05
21	*Macranga peltata*	0.05
22	*Mallotus phillipensis*	0.55
23	*Mangifera indica*	0.05
24	*Mesua nagasarium*	0.40
25	*Myristica attenuata*	0.10
26	*Myristica malabarica*	0.40
27	*Polyalthia longifolia*	0.05
28	*Schlechiera poovam*	0.05
29	*Schleichera oleosa*	0.20
30	*Streospernum tetragonum*	0.05
31	*Vateria indica*	0.05
32	*Xylia xylocarpa*	0.60
33	*Ziziphus glabrata*	0.25
34	*Olea dioica*	0.05
35	*Terminalia bellarica*	0.10
36	*Tetralmelus nudiflora*	0.05

Appendix 5

ABUNDANCE OF SPECIES

SL.No.	Species	AB
1	*Actinodaphene indica*	0.50
2	*Adina cordifolia*	0.50
3	*Alstonia scholaris*	0.50
4	*Artocarpus hirsutus*	1.00
5	*Atalantia rotundifolia*	0.50
6	*Baccuria courtallensis*	0.75
7	*Bombax malabarica*	6.17
8	*Buchanania axillaris*	0.50
9	*Butea monosperma*	0.50
10	*Calophyllum inophyllum*	1.50
11	*Chukrasia tabularis*	0.50
12	*Cinnamomum verum*	0.50
13	*Dillenia pentagyana*	0.50
14	*Grewia tilliifolia*	0.50
15	*Haldinia cordifolia*	0.67
16	*Holigarna beddomei*	0.50
17	*Hopea parviflora*	0.50
18	*Hydnocarpus pentandra*	0.75
19	*Lagerstroemia lanceolota*	0.50
20	*Lagerstroemia reginae*	0.50
21	*Macranga peltata*	0.50
22	*Mallotus phillipensis*	1.84
23	*Mangifera indica*	0.50
24	*Mesua nagasarium*	1.00
25	*Myristica attenuata*	1.00
26	*Myristica malabarica*	1.00
27	*Polyalthia longifolia*	0.50
28	*Schlechiera poovam*	0.50
29	*Schleichera oleosa*	0.67
30	*Streospernum tetragonum*	0.50
31	*Vateria indica*	0.50
32	*Xylia xylocarpa*	1.65
33	*Ziziphus glabrata*	1.75
34	*Olea dioica*	0.50
35	*Terminalia bellarica*	0.50
36	*Tetralmelus nudiflora*	0.50

Appendix 6

MEAN BASAL AREA OF SPECIES

SL. No.	Species	BA
1	*Actinodaphene indica*	287.39
2	*Adina cordifolia*	397.77
3	*Alstonia scholaris*	322.20
4	*Artocarpus hirsutus*	1988.87
5	*Atalantia rotundifolia*	35.80
6	*Baccuria courtallensis*	40.73
7	*Bombax malabarica*	48.73
8	*Buchanania axillaris*	438.55
9	*Butea monosperma*	481.31
10	*Calophyllum inophyllum*	336.68
11	*Chukrasia tabularis*	2486.10
12	*Cinnamomum verum*	572.80
13	*Dillenia pentagyana*	572.80
14	*Grewia tilliifolia*	621.50
15	*Haldinia cordifolia*	211.98
16	*Holigarna beddomei*	2486.10
17	*Hopea parviflora*	1591.10
18	*Hydnocarpus pentandra*	526.10
19	*Lagerstroemia lanceolota*	2486.10
20	*Lagerstroemia reginae*	895.00
21	*Macranga peltata*	24.86
22	*Mallotus phillipensis*	40.73
23	*Mangifera indica*	3579.95
24	*Mesua nagasarium*	446.94
25	*Myristica attenuata*	157.88
26	*Myristica malabarica*	274.01
27	*Polyalthia longifolia*	35.80
28	*Schlechiera poovam*	724.95
29	*Schleichera oleosa*	883.00
30	*Streospernum tetragonum*	1838.70
31	*Vateria indica*	1082.95
32	*Xylia xylocarpa*	1006.87
33	*Ziziphus glabrata*	777.61
34	*Olea dioica*	143.20
35	*Terminalia bellarica*	1591.10
36	*Tetralmelus nudiflora*	4872.70

Appendix 7

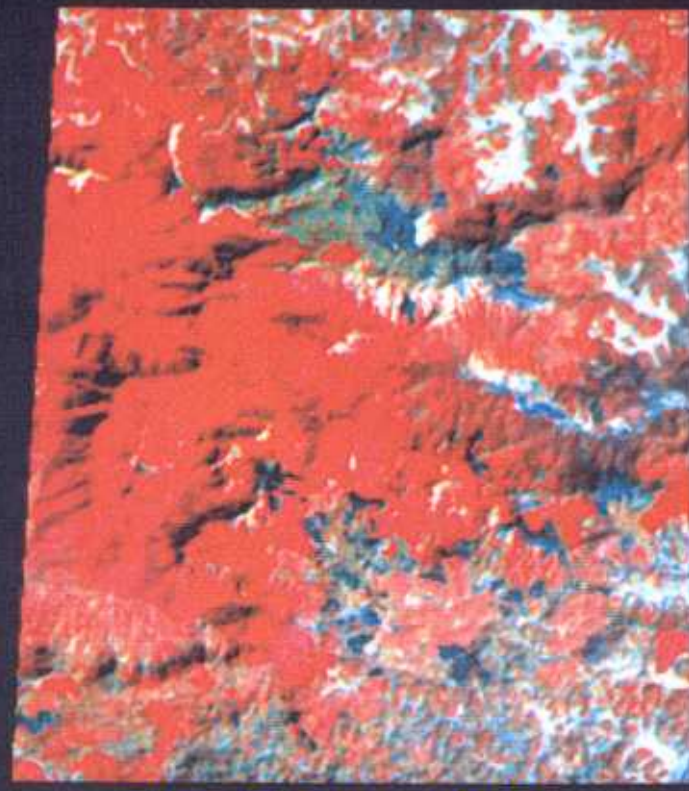
MEAN IMPORTANCE VALUE INDEX OF SPECIES

SL. No.	Species	IVI
1	*Actinodaphene indica*	3.31
2	*Adina cordifolia*	3.67
3	*Alstonia scholaris*	3.43
4	*Artocarpus hirsutus*	20.47
5	*Atalantia rotundifolia*	2.37
6	*Baccuria courtallensis*	6.59
7	*Bombax malabarica*	28.15
8	*Buchanania axillaris*	3.76
9	*Butea monosperma*	4.02
10	*Calophyllum inophyllum*	5.69
11	*Chukrasia tabularis*	8.68
12	*Cinnamomum verum*	4.08
13	*Dillenia pentagyana*	4.08
14	*Grewia tilliifolia*	4.54
15	*Haldinia cordifolia*	8.13
16	*Holigarna beddomei*	8.68
17	*Hopea parviflora*	6.53
18	*Hydnocarpus pentandra*	7.75
19	*Lagerstroemia lanceolota*	8.68
20	*Lagerstroemia reginae*	5.55
21	*Macranga peltata*	2.33
22	*Mallotus phillipensis*	11.87
23	*Mangifera indica*	11.31
24	*Mesua nagasarium*	16.22
25	*Myristica attenuata*	4.17
26	*Myristica malabarica*	15.81
27	*Polyalthia longifolia*	2.79
28	*Schlechiera poovam*	4.45
29	*Schleichera oleosa*	10.61
30	*Streospernum tetragonum*	9.04
31	*Vateria indica*	5.31
32	*Xylia xylocarpa*	23.24
33	*Ziziphus glabrata*	11.64
34	*Olea dioica*	2.77
35	*Terminalia bellarica*	10.36
36	*Tetralmelus nudiflora*	20.27

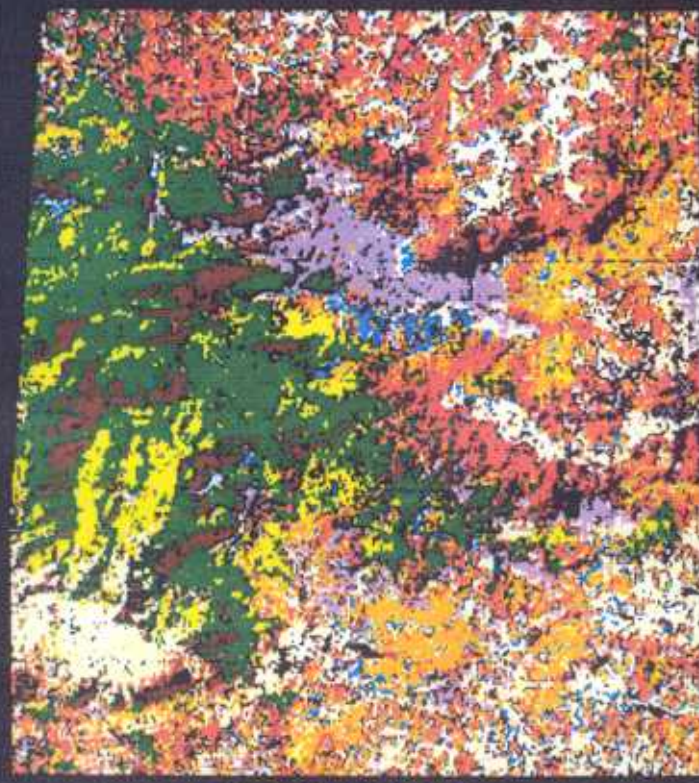
Plate 1

ARALAM WILDLIFE SANCTUARY

KERALA STATE



FALSE COLOUR COMPOSITE



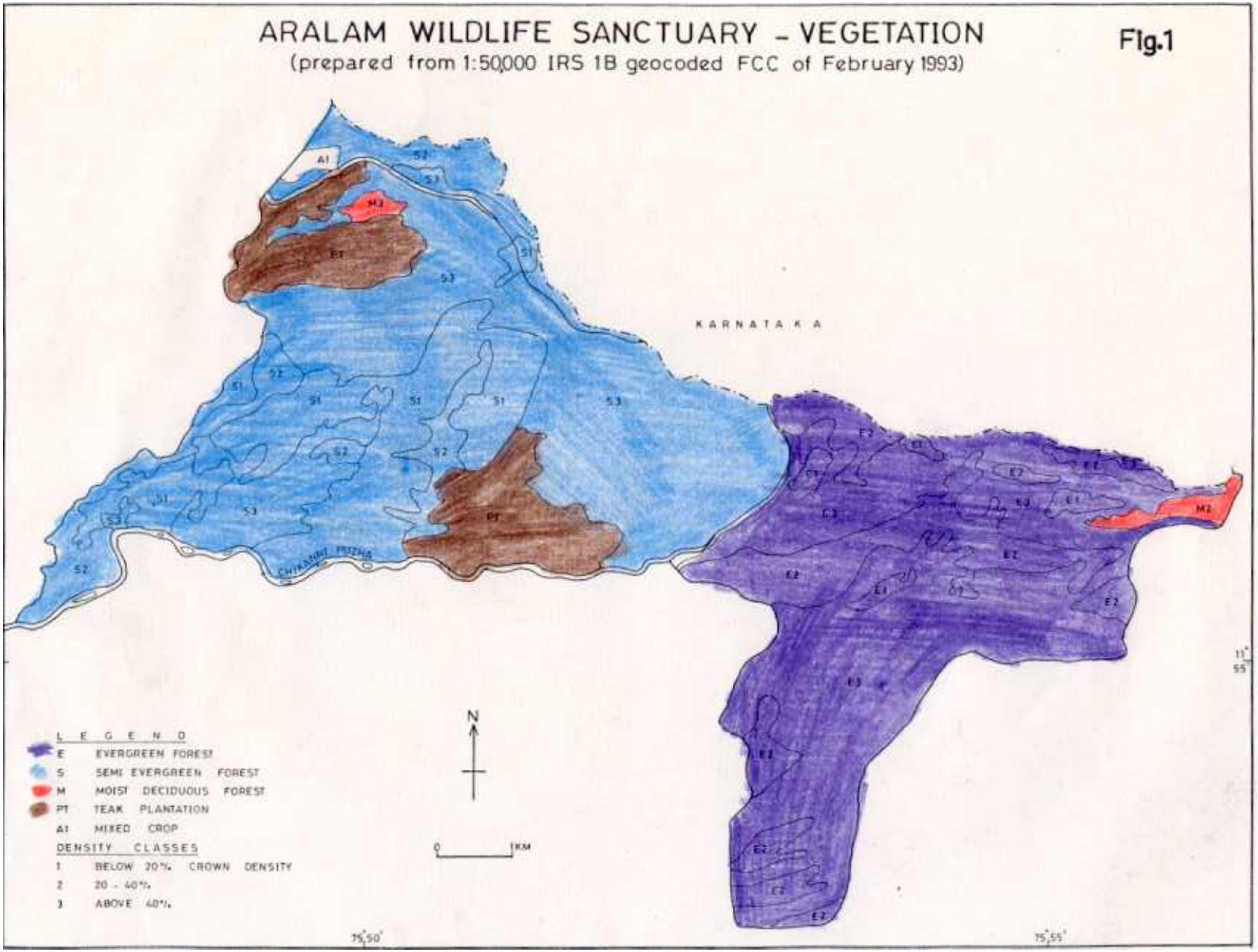
EVERGREEN
SEMI-EVERGREEN
GRASS LAND
SCRUB LAND
TEA PTN.
COFFEE PTN
AGRICULTURE
SHADOW

CLASSIFIED IMAGE

ARALAM WILDLIFE SANCTUARY - VEGETATION

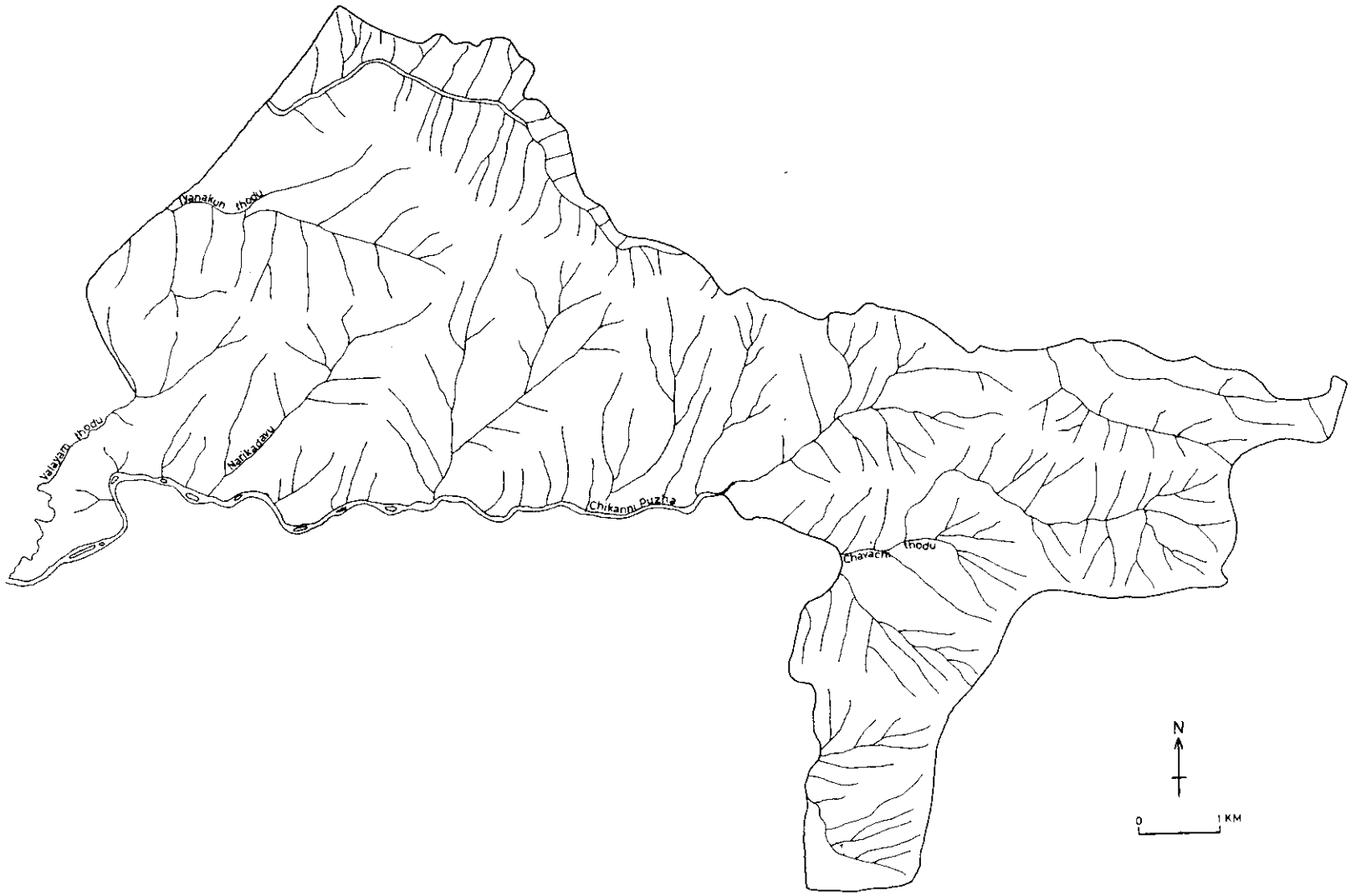
(prepared from 1:50,000 IRS 1B geocoded FCC of February 1993)

Fig.1



ARALAM WILDLIFE SANCTUARY - DRAINAGE

Fig.3



ARALAM WILDLIFE SANCTUARY - CONTOURS

Fig.4