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TROPICAL FORESTRY ACTION PLAN
SOMALIA

REPORT II

ESTIMATION OF FOREST RESOURCES

AND

SOME CONSIDERATIONS REGARDING

FOREST MANAGEMENT AND PLANTATIONS

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(UNDER ASSIGNMENT FROM
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Mogadishu, October 1, 1989

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SUMMARY

The total tree covered area, measured as the vertical projection of the tree crown (crown cover), has been estimated to be 2.07 million hectares with a corresponding growing stock of 70 million m^3.

If crown cover densities of more than 10% only are considered, and areas of sand dune, rock, lava, swamp and cliff are excluded, the "accessible" area is estimated to be 733,000 hectares with a corresponding growing stock of 36.9 million m^3. This growing stock will be exhausted in 6 years time if the current population is 8.5 million and the annual wood consumption of nomads, rural and urban dwellers is 0.91, 0.51 and 0.41 m^3 per capita respectively.

It is recommended that the management practice of the natural resources (trees, bush, shrubs, etc.) be designed for the mutual benefit of trees, livestock and people. The wood volume produced from these areas could not justify the exclusive production of timber. Only amenity and shelterbelt/windbreak plantations should be established in these areas.

Irrigated plantations should be established on marginal areas only. Field trials of alley cropping should be carried out.

Sand dune stabilization through plantation establishment should not be attempted. Current establishment costs range from US$ 2,800 to 5,000 per hectare, excluding the expatriate contribution. The value of the land which the sand may engulf cannot justify the investment costs. Other means of sand dune stabilization must be found.

1.0 FOREWORD

This consultancy work has been carried out within the framework of the Tropical Forestry Action Plan (TFAP) launched for Somalia in the second half of 1989 and under assignment from the African Development Bank.

The consultant spent one day in Rome for briefing and three weeks in Somalia, i.e. September 10 - October 1, 1989.

Due to security reasons, the mission was confined to the Mogadishu area. Only two short field visits were made, one at Afgooye concerning nursery, species elimination trial plots and education/training, and the other one was made to the sand dune areas around Merca and Shalambood.

The mission was limited to a literature review and discussions with expatriate colleagues. There was no opportunity given to discuss the content of this report with the appropriate Somalian authority(ies).

It would not have been possible to complete this assignment without the generous assistance from the British Forestry Project, and particularly the bibliography and corresponding library prepared by Mr. M. R. Bowen, to whom I am very grateful.

2.0 FOREST RESOURCES

2.1 Available Information

There are some quantitative statements of the forest resources in Somalia in some of the reference literature in spite the fact that, to-date, no reliable national forest inventory has been carried out. The only country wide survey of tree covered areas is the one carried out by Resource Management & Research (ref.[1] 43,44,45), but the focus of the survey was on the rangelands, i.e. the estimation of the number of livestock, wild animals and other relevant parameters and <u>not</u> the tree coverage of the country.

Two local inventories have been performed recently (ref. 1,5) in the southern part of the country. The results of these inventories cannot be extrapolated to cover the Nation.

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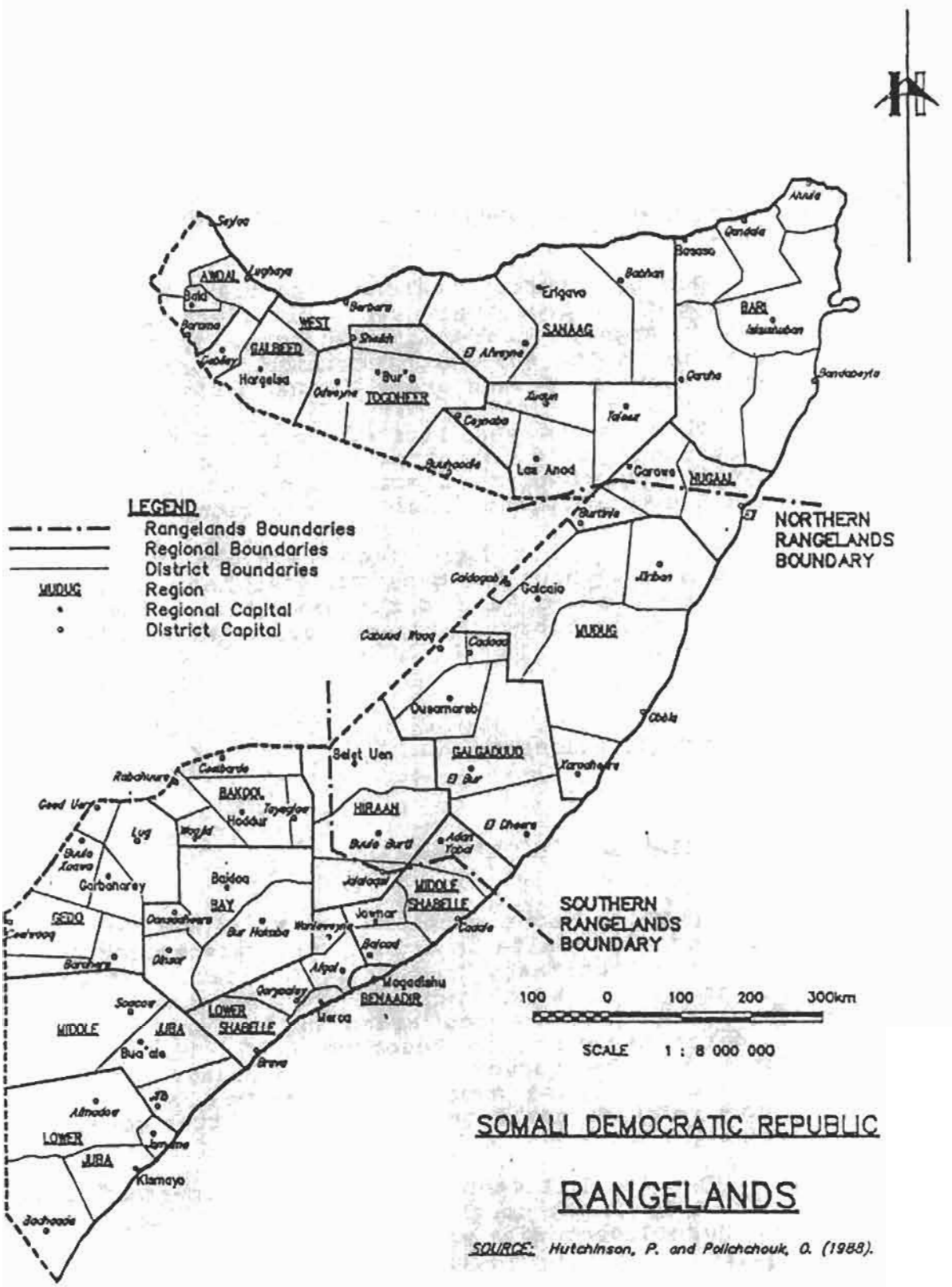
[1] Numbers in brackets refer to the Bibliography

Map 1: Approximate Boundary of Rangelands



Based on the above, it is not surprising that there is a wide range in the quantitative statements of Somalia's forest resources. Furthermore, there is no uniformity in the nomenclature used by the different authors, making a direct comparison somewhat cumbersome. Nonetheless, everyone is referring to the aerial (crown) coverage of the forest/tree/ woodland resources. There is only one case where there was an attempt to estimate the growing stock and its increment. The quantitative information of the sixteen references is contained in Appendix 1.

Appendix 1 shows that the aerial coverage of the forest/tree/woodland resources in Somalia ranges from 7.5 million hectares to 34.9 million hectares, or a difference of 465 percent! No doubt any attempt at national or regional development planning is bound to fail using this data base.

The volume of the total growing stock is estimated to be 808 million m_3 and its annual increment as 20 million m^3.

2.2 Estimate Made in September 1989 (Methodology)

It is obvious that available information does not provide a reliable base for sustained yield forestry development in Somalia. Therefore, an attempt has been made to estimate the areal coverage and corresponding growing stock at the time of the rangelands survey (see Map 1), i.e. 1979-1985. The following method was applied:

- References 43, 44 and 45 were used as the data base.
- The following parameters were studied:
  - geomorphology of the Land System Units (LSU) (See Appendix 2 for definition);
  - area;
  - important or indicative tree species;
  - growing pattern;
  - tree crown cover percentage;
  - average tree height, and;
  - timber and wood fuel volume (given for Southern Rangelands only).

Appendix 3 contains information regarding accuracy of the different parameters.

- Density classes (tree crown cover closure as a percentage of area by LSU). An analysis of the different parameters indicated that accuracy would increase if the LSUs were grouped by tree crown cover density classes. It was decided to establish the following classes: < 1%, 2-5%, 6-10%, 11-20%, 21-30%, 31-40%, 41-50%, 51-60%, 61-70% and 71-80% as being the most dense class.

- Calculation of the aerial coverage of the trees. For each LSU, the tree crown cover percentage was given from 0.01 and upwards. Using the total area of the LSU and multiplying by the crown cover percentage, the areal coverage of the trees was calculated. In some LSUs, the crown cover percentage was given as a range. In this case the lower value of the range was used in the calculation. By adding the areal coverage of the trees per each LSU, the total tree covered area was calculated. It should be borne in mind that the method does not take into consideration the spatial distribution of the trees, i.e. the scattered trees have been pulled together to an imaginary continuous aerial coverage.

  Furthermore, it was decided that some of the LSUs should be excluded from intervention/exploitation as they were:

  - stabilized sand dunes;
  - semi-stabilized sand dunes;
  - beach dunes;
  - unstable sand dunes;
  - lava;
  - rocky mountains;
  - cliffs;
  - steep slopes;
  - swampy areas, and;
  - Baobab trees.

  Deducting the LSUs containing any of the above criteria, the net aerial coverage of the trees, based on vertical projection of the tree crowns, was calculated.

- Calculation of the Standing Volumes

  The average volume of the growing stock (timber and wood fuel volumes) per hectare is given for

the Southern Rangelands. (The calculation of the timber and wood fuel volumes is explained in Appendix 3.) Using tree covered areas calculated above and multiplying by the average volume per LSU, the total growing stock was calculated for the Southern Rangelands.

The average height (arithmetic) was calculated by density classes for the Northern and Southern Rangelands. The average volumes were calculated for the Northern Rangelands by using the average ratio, H-north/H-south, by density classes, and multiplying by the weighted average volumes per hectare by density classes for the Southern Rangelands. The Central Rangelands were excluded from further calculations because of the harsh growing conditions. It should be noted that the "Rangelands" boundaries do not coincide with the former Regional Boundaries (see Map 1).

Finally total gross and net volumes were calculated for the entire country.

2.3 Current Growing Stock and Areas of Trees in Somalia

The gross total of tree covered area is estimate to be 2.07 million hectares, and the corresponding growing stock as 70 million m^3. However, only part of this area and/or volume is "available" due to reasons given above. The net available tree covered area is estimated to be 1.8 million hectares and the corresponding growing stock is estimated to be 58.7 million cubic meters. Details of the net areas and volumes are included in Table 1.

In comparison with Appendix 1, the net area is between 5.2% and 24% of the highest and lowest previous estimates respectively, and the net growing stock is 7.3% of the only available previous estimate!

Density classes of less than 10% and the remaining relics of the gallery and/or riverine forests should be excluded from intervention for practical/financial reasons. Thus the elimination of these categories from Table 1 would reduce the practically/financially accessible areas to 733,000 hectares and the corresponding growing stock would be 36.9 million cubic meters!

It should be borne in mind that above calculations are based on aerial photographs taken in 1973, with some complementary photographs taken during the 1979-1985 survey. According to one source, the annual degradation/ depletion of tree covered areas proceeds at a rate of

Table 1: Utilizable Timber Resource in Somalia

Distribution of Area and Total Tree Volume by Tree Crown Cover Class

Tree Crown Class	Rangeland[2]				Country Total		Reverse Cumulative Totals			
	North		South							
% Crown Cover	Area '000 ha	Volume mil. m^3	Area '000 ha	Volume mil. m^3	Area '000 ha	Volume mil. m^3	Area '000 ha	%	Volume mil. m^3	%
< 1	112	.5	26	.2	138	.7	1,776	100.0	58.7	100.0
2 - 5	295	3.8	260	4.6	555	8.4	1,638	92.2	58.0	98.7
6 -10	29	.7	315	9.4	344	10.1	1,083	61.0	49.6	84.5
11-20	7	.3	512	22.6	519	22.9	739	41.6	39.5	67.2
21-30	116	6.0	52	3.4	168	9.4	220	12.4	16.6	28.2
31-40	36	4.1	12	1.3	48	5.4	52	3.0	7.2	12.3
41-50							4	.2	1.8	3.0
51-60							4	.2	1.8	3.0
61-70			2	1.0	2	1.0	4	.2	1.8	3.0
71-80			2	.8	2	.8	2	.1	.8	1.4
TOTAL	595	15.4	1,181	43.3	1,776	58.7				

200,000 hectares! Another source estimates it to be 400 hectares per annum for the lower Jubba areas.

3.0 FACTORS AFFECTING FOREST MANAGEMENT AND PLANTATION DEVELOPMENT

Natural tree growth and species distribution is determined, among other factors, by the interaction of climate, soil type (geological parent material), rainfall, availability of ground water and land relief.

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[2] No utilizable timber within the Central Rangeland

3.1 Climate

Somalia is one of the hottest countries on earth. The average mean temperatures varies from 18° C to over 30° C, while the annual rainfall ranges from almost zero to 700 mm. The annual evapotranspiration ranges from 1460 mm/year to 2886 mm/year, which means that there is a large water deficit all over the country. A detailed description of the climatical parameters is contained in Appendix 4.

3.2 Ground Water

It is assumed that some 400 mm of annual rainfall is needed to support an acceptable level of tree growth in properly managed natural forest. Map 2 indicates that some 117,000 km^2, or only 18.3% of the country's surface, receives more than the required minimum.

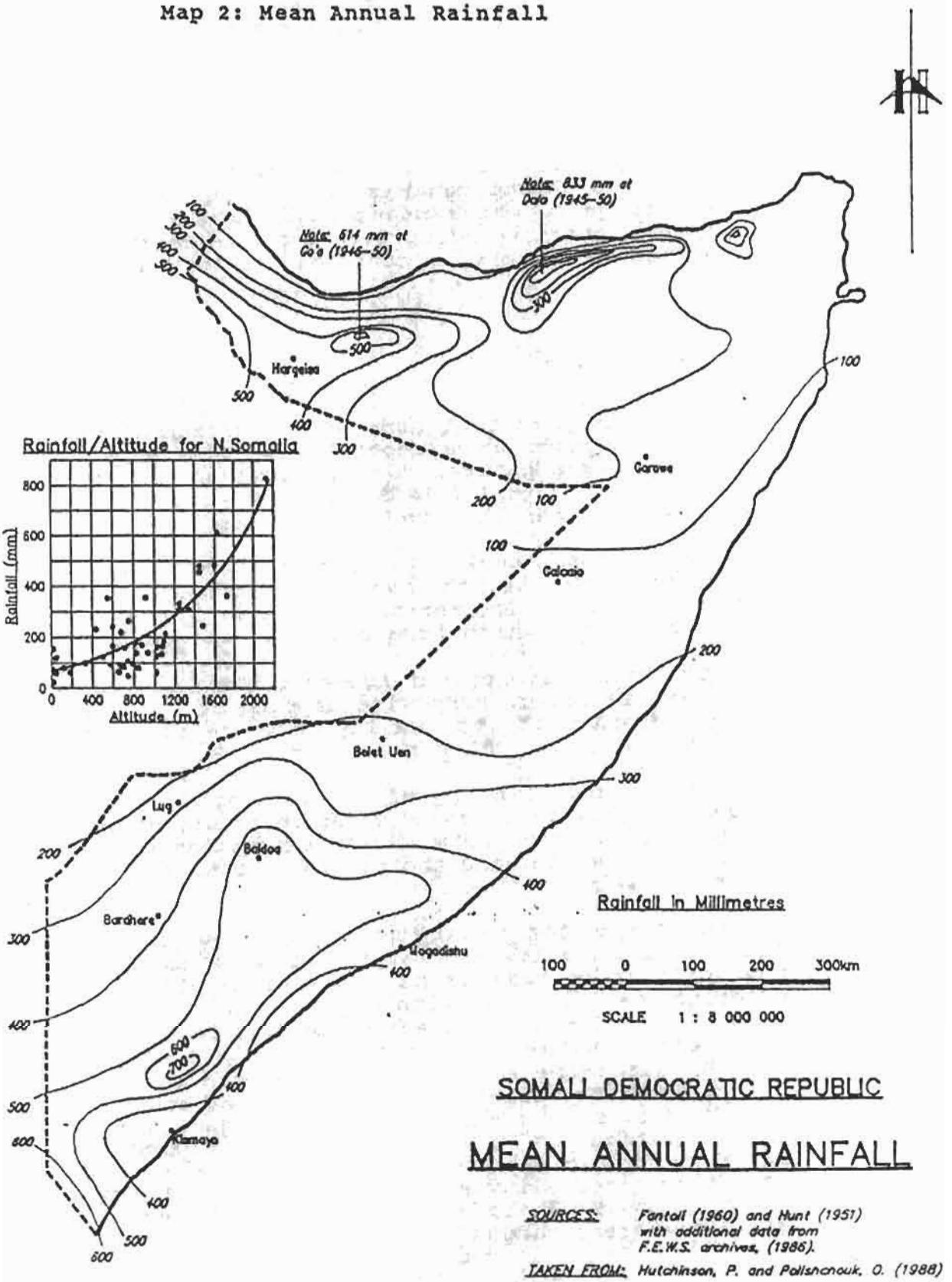
Tree roots seek the ground water table thereby supporting tree growth even if rainfall is below the required minimum. However there is a maximum depth of some 15 meters beyond which tree roots cannot penetrate.

The Water Development Agency of Somalia, supported by GTZ, carried out country wide mapping of the ground water table and analyzed its quality from the point of view of the development of water resources.

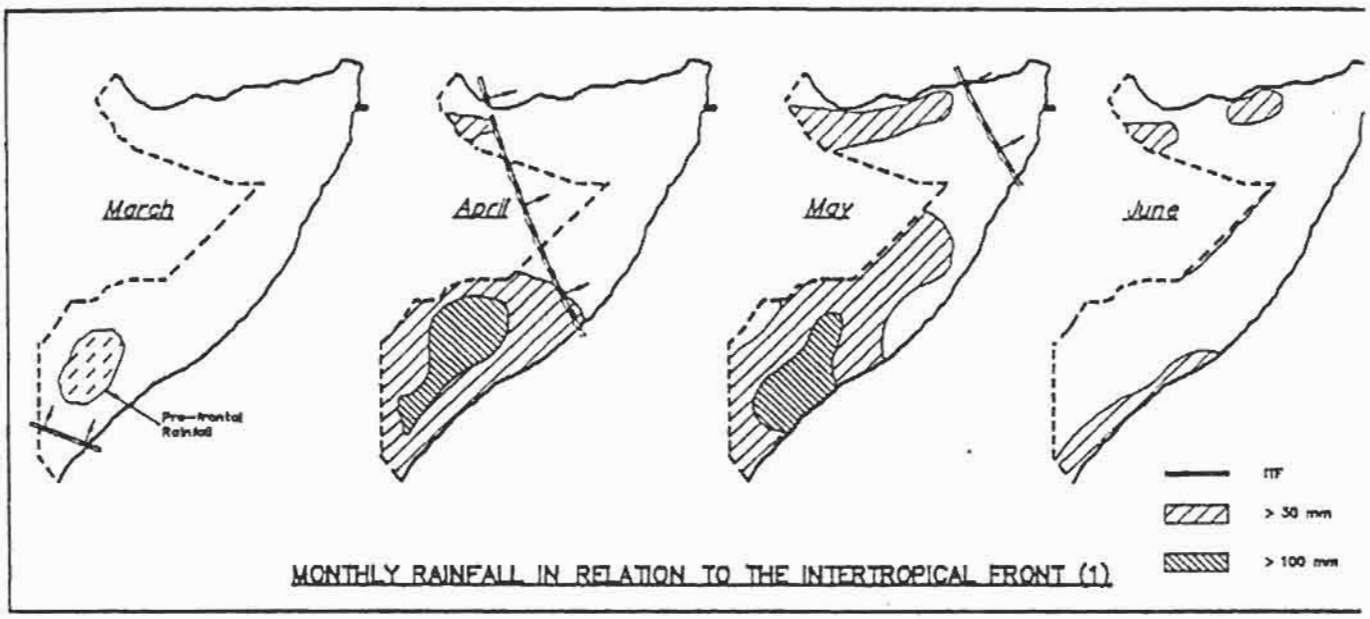
The general finding of the mapping exercise was that there is an abundant ground water reservoir of good quality throughout the country with the exceptions of the coastal areas in the south, and the central parts, where the ground water is saline.

Depth to the water table varies with land relief. Aquifers are shallow and water is found within 5 to 20 m in the north in coastal areas and sloping plains. There are numerous small springs with high yields in the mountainous zone, indicating development potential. In central Somalia, the depth to water is more than 100 m (100-250 m) in most places, with some exceptions. Water can be found in the Shabeelle river valley within 20 to 50 m, but a depth of 80 to 120 m is more common. Well yields generally are high. The situation in the south is more complicated. The aquifers are close to the surface in the Jubba and Shabeelle river alluvial areas, while well depth is 100 to 150 m in the Baydhabo and Damassa areas. Depth to water in the other areas ranges from 30 to 150 m.

Map 2: Mean Annual Rainfall

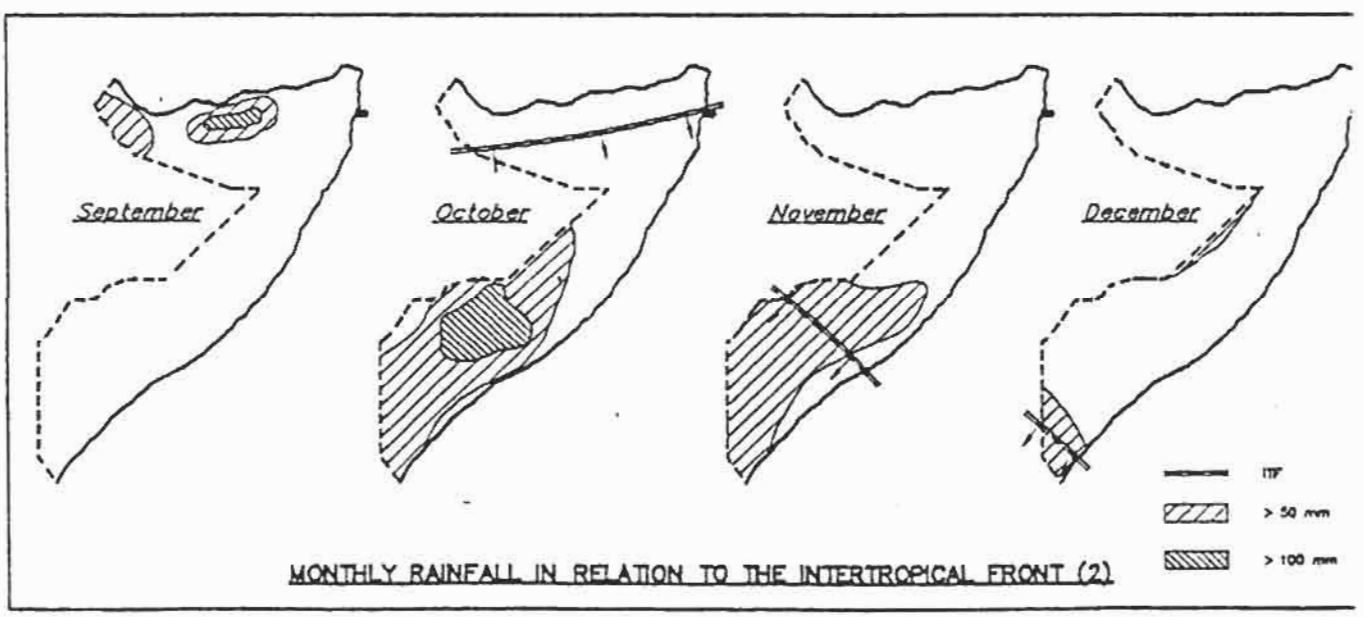


Map 3: Monthly Rainfall Pattern



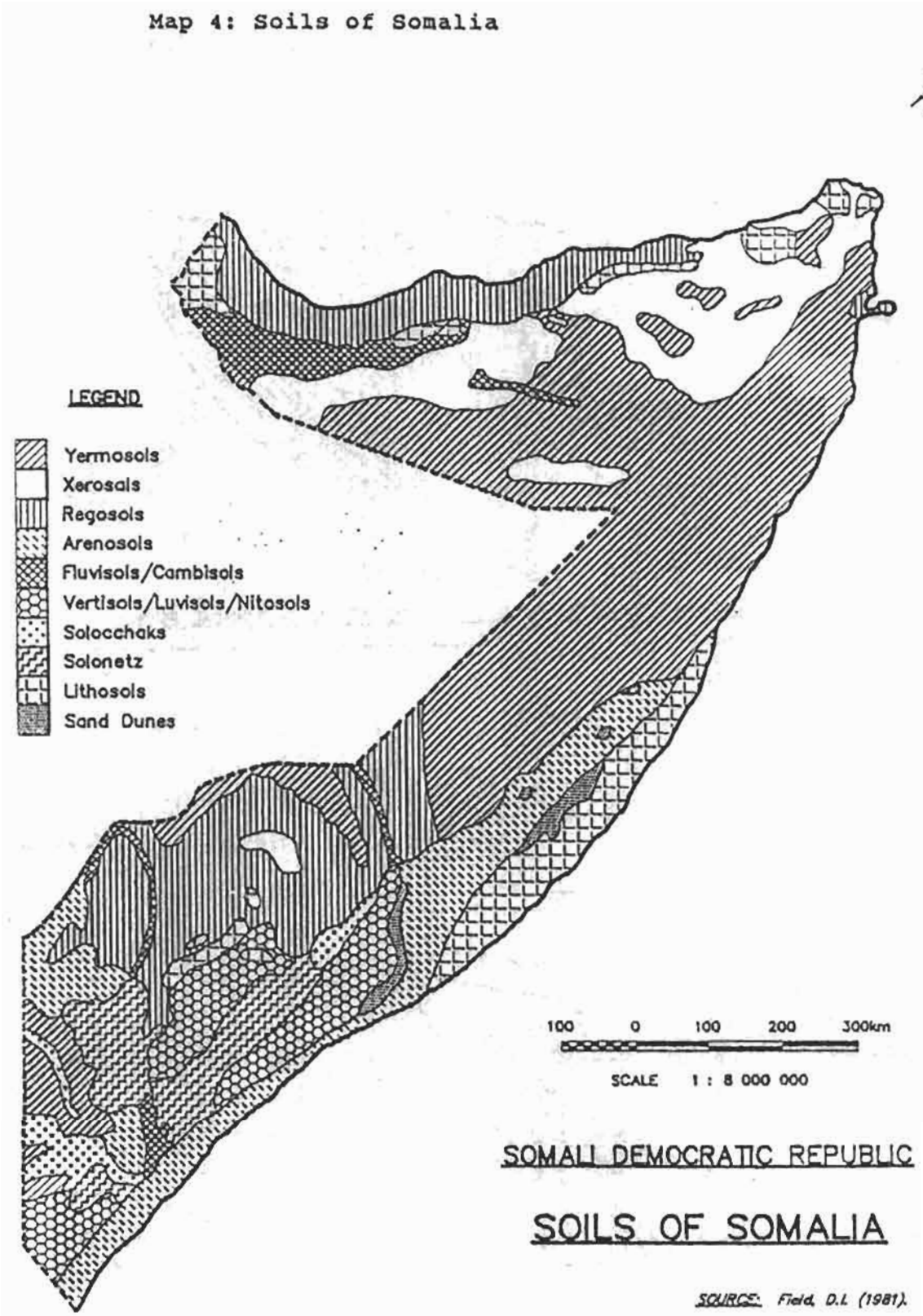
MONTHLY RAINFALL IN RELATION TO THE INTERTROPICAL FRONT (1)

SOURCE: Hutchinson, P. and Pollshchouk, O. (1988)



MONTHLY RAINFALL IN RELATION TO THE INTERTROPICAL FRONT (2)

Map 4: Soils of Somalia



3.3 Soil

From the growing tree's perspective, the soil should be coarse, aerated, have high organic content and moisture retention capacity and be fertile. The soil should contain essential micro-elements. These conditions are rarely found in Somalia.

The two major soils of Somalia, Yermosols and Xerosols, constitute some 50% of the land area. These two soils are associated with acidic moisture regimes and have usually less than 1% organic matter. Other soils of interest include: Arenosols which are coarse textured unconsolidated materials associated with sand dunes along the eastern coast line; Lithosols, shallow soils overlying hard rock Regosols, which are unconsolidated soils mainly associated with mountains in the north.

The cultivated areas of the country are generally associated with soils having higher clay contents, eg. Vertisols and Fluvisols, which were formed from recent alluvial deposits, and the Hydromorphic Solonetz soils in the Southern part of the country. Map 4 depicts the soils of Somalia.

3.4 Growth Rate and/or Production

At least five attempts have been made to estimate the standing wood and/or biomass quantity of different ecotypes in Somalia (ref. 1,9,17,26,40). The results of these findings are summarized below.

3.4.1 Production

- In 1937, the Italians studied one ha of relatively dense woodland and found 413 m^3 of total biomass, including 317 m^3 of usable biomass. Another area of one hectare of woodland of good stocking yielded 71.7 m^3 of charcoal and 11.3 m^3 of branches for a total output of 83.0 m^3/ha. (Species composition: Acacia benadicensis, Dobera glabra, Salvadora persica and Terminalia ruspolii). The location of the sites is unknown.

- In 1987, base line studies were carried out in the Mogadishu-Merca area. The standing wood crop of trees was estimated to average 38 t/ha, with the following ranges: Acacia nilotica, 3-21; Balanites aegyptica, 5-61; Cordia simensis, 0-4; Dobera glabra, 0-24;

Salvadora persica, 0-2, and; Thespesia danis, 0-9.

- In 1989 the total woody biomass in the Jubba area was estimated to be: forest, 130t/ha; dense woodland, 45 t/ha; medium woodland, 20 t/ha and; open woodland 8 t/ha.

In an international comparison, the yields of some equivalent forests are: Queensland in Australia, a semi-arid forest of Acacia harpophylla, 84 t/ha; Northern Ivory Coast and the Sudan savanna woodland, 54 t/ha; a 6 year old plantation of Prosopis juliflora at Mombassa in Kenya, 126 t/ha; NE Namibia, Burkea africana - Terminalia sericea savanna, 22 t/ha, and; Zimbabwe, miombo woodland, 22 t/ha.

3.4.2 Natural Forest Growth Rate

- The most comprehensive study was carried out in Bay region concerning Acacia bussei (ref. 17,18). This study suggested the growth rate to be four years per one cm of radius growth, that is, an average of 5 mm increase in diameter per year.

- The Mogadishu - Merca study indicates that the mean annual increment (m.a.i.) was 5 t/ha/year in some locations. The m.a.i. in degraded areas is expected to be lower, but could possible be raised through improved forest management techniques.

- In the study (ref. 40) made in 1982, an annual yield of woody biomass of 2.5 percent of the growing stock was applied.

- Ref. 9 indicates that the growth of moderately degraded xerophilous woodland is between 0.5 and 1.2 m^3/ha/year and that a rotation period of 15 to 20 years should be applied for a charcoal, fuelwood and polewood regime and a rotation of 40 to 60 years should be used for a construction and/or furniture timber regime.

- The Jubba study made the following growth predications:

Forest		0.60	t/ha/year
Woodland	- Dense	0.43	"
	- Medium	0.28	"
	- Open	0.14	"

- Figure 1 contains a comparison of growth predications from East African countries.

- In Senegal, Acacia seyal bushland produced a maximum of 4 m^3/ha/year. It was managed such that 500 ha blocks were clear-cut for charcoal on a 20 year rotation. Regeneration was through coppicing.

- In Kenya, Marsabit district, Acacia reficiens is expected to yield 375 kg/ha/year.

- In Table 1, the growing stock of utilizable areas by crown cover density class is given. The corresponding average volumes per ha are given in Table 2.

Table 2: Average Volume per ha by % Crown Cover

Tree Crown Class % Crown Cover	Average Volume m^3/ha	
	Northern Rangelands	Southern Rangelands
<1	4.9	7.3
2- 5	12.9	17.5
6-10	24.2	30.0
11-20	42.8	44.2
21-30	51.3	65.9
31-40	112.4	112.4
Average	25.9	36.7

The average figures indicate some 30 to 50 t/ha of wood.

- The British Forestry Project inventoried part of the Bay region and developed regression equations for Acacia bussei and Acacia seyal to estimate the oven-dry weight of wood based on crown and/or stem diameter.

3.4.3 Plantation Development

The first attempt to grow trees in Somalia was in 1925. Some 200 trees species have been tried since with little success. Unfortunately most of the records or plots have been lost. Very few records/plots can be found which had appropriate monitoring and those plots that can be found are very young, 5 years old or less.

Figure 1: Growth Predictions from East Africa

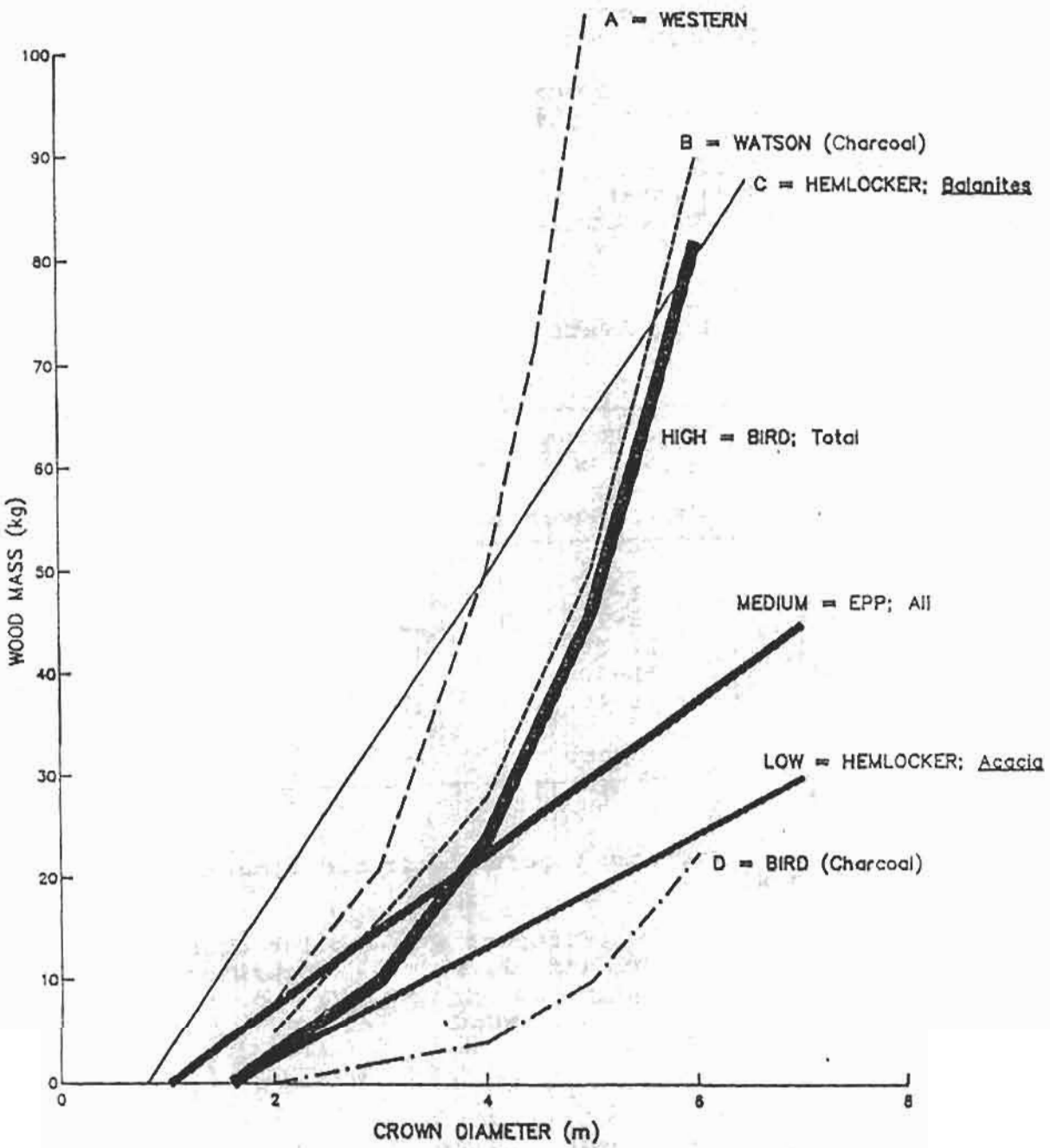


Figure 1: Comparison of several regression predictions relating dry mass of individual trees and shrubs in East Africa to their crown diameter.

SOURCE: Jess (1989).

The large number of species tried gives an indication that what and when to plant in arid and semi-arid regions is unresolved.

Plantations established up to March 1986 is summarized as follows (ref. 7):

Rainfed plantations	1,696 ha
Irrigated plantations	87 ha
Sand-dune plantations	1,562 ha
Total	3,345 ha

In addition, some 1,800 km of shelterbelts/windbreaks have been planted. Some 3.6 million seedlings have been distributed for amenity and agroforestry plantations.

Growth rate information is sparse. It is believed that most species did not pass the nursery stage, e.g. at Luuq, of the 101 provenances tried, only 57 passed the nursery stage (ref.21). Tree species which seem to have succeeded (without knowing survival rates and work inputs) are:

- Conocarpus lancifolius in the north;
- Azadirachta indica throughout the country;
- Casuarina equisetifolia, Acacia spp., Opuntia spp., Europhorbia spp. and Commiphora spp. on sand dunes, and;
- Casuarina equisetifolia, Eucalyptus spp., Parkisonia aculeata and Prosopis spp. on irrigated farmland in the south as windbreak/shelterbelt.

Fruit trees such as mango, papaya and various citrus species are very popular among villagers.

It can be concluded that only the native species survive in the vicinity of refugee camps in rainfed and dry areas as is shown by the findings of the recent plantations activities by different donors agencies. These species are: Acacia bussei, A. holosericia, A. senegal, A. reficians, A. tortilis, Albizia anthelmintica, Balanites aegyptica and Cordia sinensis. The exotic species which have so far survived well for the first 2 to 5 years are: Caesalpina eriostachys, C. velutina, Prosopis chilensis, P. juliflora, Parkinsonia aculeata and Senna atomaria.

In the "tugs", i.e. dry river beds with sub-surface water courses, or irrigated plots, the performance of both local and exotic species is much better. Financial circumstances and land use planning will determine whether these areas are used for timber or food production.

Attempts have been made to establish irrigated plantations but either the plans were abandoned, or the project halted, because of the experienced high production/plantation costs, the scarcity or non-availability of water and land ownership conflict.

4.0 SOME PROPOSALS REGARDING FOREST MANAGEMENT

According to the Five Year National Development Plan, 1987-1991 (ref. 48), the objectives of the forestry sector are to ensure a constant and adequate supply of forest products, secure the active participation of the public in conservation efforts and increase the area under plantation. To that end, the Government plans to spend So. Sh. 2.6 billion over the FYDP, representing 1.9% of the PIP (Public Investment Programme).

The annual per capita consumption of wood is 0.51 m^3 by rural people, 0.46 m^3 by urban dwellers and 0.9 m^3 by nomads according to another official publication (ref. 49).

The current population has been estimated to be between 4.8 and 8.5 million and is expected to increase to between 6.7 and 11.7 millions by the year 2,000.

Corresponding wood consumption levels are calculated to be between 3.0 and 5.7 million m^3 in 1989 and between 4.5 and 7.9 million m^3 in the year 2,000.

The available volume is given in Chapter 2.3 as 36.9 million m^3. Based on the above consumption levels, the industrial (charcoal and building poles) wood supply to the population of Somalia will be exhausted within 6 to 12 years. The growth rate of the natural forest, see Chapter 3.2, has been found to vary between 0.5 to 5 m^3/ha/year. A very optimistic average of 1.5 - 2.0 m^3/ha/year could be assumed. Even at this rate, the incremental growth is not sufficient to replace annual wood requirements.

4.1 Natural Forest/Woodland

It is the consultant's opinion that there is no place in the country where there can be economic justification for the use of tree covered land solely for timber

production in view of Somalia's agro-climatic and socio-economic setting. In 1986 there were 4.5 million cattle, 6.1 million camels, 11.2 million sheep and 18.9 million goats (ref.26) foraging on tree covered land. In view of the importance of goats and camels in the livestock economy, and their reliance on forage, forest and water resources, there is a clear need to carry out research to establish the productivity characteristics of browse producing plants. One estimate indicates (ref. 1) that the annual biomass production of leaves and twigs was 19 kg/ha in the Mogadishu-Merca area. Assuming livestock were allowed to forage in this area, thereby increasing meat production and somewhat reducing wood production, the combined financial yield could be expected to be higher than if the area was to be managed for single use. Therefore, appropriate management techniques for the multiple-use of forest, forage, water and wildlife should be developed and instituted, with assistance from rural people and nomads throughout the process, where all involved benefit from the multiple-use approach. To physically or legally exclude anyone who uses any given area would be counter-productive.

The consultant would like to suggest that the northern Juniperus areas and the relic gallery and/or riverine forests in the south be set aside as national forest and fauna reserves where some felling may be permitted under the auspice of a responsible authority. Cutting of tree anywhere in the country should be done with great care to avoid the desiccation of soil and vegetation.

4.2 Plantations

4.2.1 Rainfed Locations

Previous attempts at plantation establishment have been failures except when carried out close to population centres or when intercropping was practised among a few seedlings.

It is the consultant's opinion that there is no prospect for establishing any sizeable plantations on rainfed lands. He believes that amenity and shelterbelt/windbreak plantations around population centres could be increased if established by village people who receive the financial benefit of the plantation products.

Intercropping among trees should be promoted. The land tenure situation may mitigate against wide-spread acceptance of the practice. The planting of windbreaks should also be promoted, i.e the establishment of 3 to 5

rows of trees along farm boundary lines, where both work input and product benefits are shared by the neighbours. There is no doubt that windbreaks of a suitable species would increase agricultural yield. They also could provide cash flow through the sale of forest products at the cyclic time of financial need. The biggest obstacles to successful rainfed tree establishment would seem to be the land/product tenure system and the self-centred belligerent attitudes of the people involved.

It is thought that if there were to be a well working extension system in operation, staffed by people who had the confidence of the population, the above programme could be implemented.

4.2.2 Irrigated Locations

It was calculated in one of the proposed irrigated projects that the production of Mogadishu's charcoal requirements from irrigated plantations would cost 60 So.Sh. per kg, a totally uncompetitive price. The daily water requirement was estimated to be 2.2 million litres(!), a supply that had to be maintained throughout the life of the tree. The water flow in the Shabeelle river is not enough to maintain this level of supply. The approach of drilling new wells to supply the required water is cost prohibitive. It should not be planned to establish irrigated plantations for the purpose of charcoal production.

It is the consultant's opinion that small scale irrigated plantations of up to a maximum of one hectare per farmer could be established on farm land providing that the farmer(s) is (are) willing to do so. Locations for potential plantation establishment are:

- along canal banks, providing canal maintenance is ensured;
- field corners where there is irregular water supply;
- saline areas;
- fields that are seasonally inundated, and;
- farm extremities where it is too far to walk on a daily basis.

Care should be taken to avoid selecting species that will attract birds to the area.

Intercropping or alley cropping should be promoted amongst selected farmers. The site specific economics of alley cropping should be determined before this system is recommended for farmer implementation.

4.2.3 Sand Dunes

The extent of the Somali destabilized sand dunes has not been defined. There is estimated to be 5,000 km^2 destabilized in the central part of the country and 556 km^2 in the south. This is less than 0.9% of the country.

The cost of establishing plantations on destabilized sand dunes in the south ranges from US$ 2,800 to 5,000 per hectare excluding expatriate contributions and annual maintenance costs! Plantation establishment on the central destabilized dunes will cost much more or, more likely, prove to be infeasible.

It is the opinion of the consultant that plantation establishment as a sand dune fixation measure should be rejected. What is Somalia is going to loose if nothing is done to stabilize these active sand dunes? The present use of the adjacent areas that are threatened by the active dunes is for marginal agriculture and forage for nomadic livestock. The socio-economic yield from these activities is very low and cannot justify the massive investment costs needed.

There are many scientists who believe that these dunes are essentially site limited in that they will not migrate far as they are under the influence of seasonal, directionally opposed winds. Should the dunes threaten to engulf an individual farm or bit of infrastructure, it would be cheaper to relocate the farmer(s) or road(s) etc. to other safer locations rather than to fight against nature while incurring these massive costs without receiving tangible benefit. It would be more judicious to motivate villagers to alter their animal husbandry practice in order to protect these dunes for their own benefit.

5.0 RECOMMENDATIONS

Based on the findings contained in this report, it is recommended:

- To carry out a comprehensive all species natural resource management inventory designed for acceptable management options in selected areas using the LSU's

of the Rangelands survey as the basis of stratification (ref. 43, 44, 45). The forests of southern Somalia should be given immediate priority for a reconnaissance level forest inventory in order to confirm the impending wood scarcity;

- To prepare and implement management plans for tree covered areas at district to regional level. The management options chosen must be acceptable to the local people and balance the use of forage, forest, water and wildlife to the mutual benefit of all who are affected by the management plan;

- To promote field scale trials and conduct socio-economic studies of intercropping and alley planting on irrigated farm land;

- To dedicate the Juniperus forests in the north and the relic gallery and riverine forests in the south as national forest and fauna reserves. The required vigilant protective policy will only be successful if the concept of the reserves is accepted by the local people and there is a highly visible presence of dedicated principled staff, and;

- To promote the establishment of amenity and shelterbelt/windbreak plantations within and around population centres of all sizes. The people will need assurances of property and product rights before their full participation can be expected.

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APPENDICES

AVAILABLE INFORMATION ON FORESTS AND/OR VEGETATION TYPES

Based on a thorough literature search, it was found that sixteen publications contained some kind of information concerning the subject. Quantitative information together with their data source is summarized below.

Anam (Ref. 2)

i) Claims that 13.8% or 88,000 Km^2 have some form of forest vegetation, of which 62,000 km^2 are degraded scrub composed mainly of Acacia spp. (no source is given)

ii) Based on estimates made by Forest Department in the North, there are 100,000 ha of dense and commercial forests, of which 60,000 ha composes the northern juniper zone and 40,000 ha the deciduous high forest in the inter-riverine area.

iii) NRA in its Development Plan for 1980s give the following estimate for all Somalia:

Montane forest	11,000	km^2
Woodland/Bushland/ Shrubland	76,000	"
Riverine Forest	500	"
	87,500	km^2

Anon (Ref. 3)

No source is indicated, but coincides with (Ref. 27)

Forest Types		
Juniperus	600	km^2
Riverine	400	"
Dense savanna	25,000	"
Bush and scrub	61,970	"
Trial plantations incl. shelterbelts	30	"
	88,000	km^2

Brookman-Amissah (Ref. 1)

No source is indicated but FAO is highly likely.

Distribution of natural woody formations, km^2

FORMATION TYPE	ZONE 1	ZONE 2	TOTAL
Closed forests			
Broad-leave	7,000	1,500	8,000
Coniferous	-	12,000	12,000
Open forests and Woody savanna	-	23,000	23,000
Tree savanna	46,000	-	46,000
Forest fallow			
Broad-leave	4,600	2,300	6,900
Shrubby formations	200,000	-	200,000
	257,600	38,800	295,900

Field(Ref. 6)

i) No source is given.

Present land use in Somalia:

Cultivated	6,500 km^2	1 %	
Riverine forest	500 "	-	
Montane forest	11,000 "	2 %	88,000km^2
Woodland/Shrubland	76,500 "	12 %	
Rangeland	503,000 "	79 %	
Sand dunes	5,100 "	1 %	
Rock and barren land	35,000 "	5 %	
Urban	200 "	-	
Water	200 "	-	
	638,000 ha	100 %	

ii) Bioclimatic zones according to the Hendrikson Planning Group, 1973

Desert to sub-desert	87,000 km^2
Sub-desert	221,000 "
Arid wooded savanna	313,000 "
Mile sub-arid wooded savanna	17,000 "
	638,000 km^2

FAO (Ref. 15)

No source is given. Estimated areas of various forest types in the country as follows:

Acacia etbacia/A. bussei	- Open woodland	84,000 km^2
Buxus, Cadia, Euphorbia	- Forest land	9,500 "
Juniperus excelsa	- Forest	1,200 "
Conocarpus lancifolius	- Forest	130 "
		94,830 km^2

Karani (Ref. 27)

No source is given.

Forest types	
Juniperus forest	600 km^2
Dense savanna	25,000 "
Bush and scrub	61,970 "
Riverine forest	400 "
Trial plantations including shelterbelts	30 "
	88 000 km^2

Lanley, Clement (Ref. 28)

FAO, most probably is based on country response to an FAO questionnaire.

Estimate of woodland	
Closed forest (Juniperus and Jubba, Shabeelle rivers)	14,800 km^2
Productive open broadleaved forest	100 "
Unproductive open broadleaved forest	75,000 "
Fallow	500 "
Shrub	530,000 "
	620,400 km^2

Openshaw (Ref. 40)

Sources of information are given, (43,44) and Western et al.

Evergreen forest	344 km^2
Riverine forest	45 "
Plantations/shelterbelts	30 "
Mangroves	100 "
Woodland	74,116 "
Wooded bushland	170,300 "
Bushed/woodland	19,400 "
Bushland	127,178 "
Total wooded area	391,513 km^2

Persson (Ref. 41, 42)

Most probably FAO survey based on responses from individual countries.

i) FAO yearbook 1971

Land use	
Arable land, land under permanent crop	9,570 km^2
Permanent meadows and pastures	205,680 "
Forest land	144,010 "
Other land	278,400 "
Land area	637,300 "
	637,760 km^2

ii) World Forest Resources in the early 1970s

Vegetation type	
Forest mountainous vegetation, partly dense	9,000 km^2
Savanna	23,000 "
Steppe forests	316,000 "
Desert and sub-desert	278,000 "
Other dense forest	1,000 "
	627,000 km^2

Resource Management and Research (Ref. 43,44,45)

Country wide survey was carried out between 1979-1985. Forest was not estimated, only crown cover percentages by vegetation types (trees, bush, shrubs, etc.)

No summary is given regarding tree and/or bush cover types. However, these surveys are used for the present woodland estimation and the methodology is discussed in the text.

Somali Democratic Republic (Ref. 48)

Partly, it refers to (Ref. 40 but no source is given for the following information:

Dense forest	520 km^2
Woodlands	74,000 "
(Low density cover 57,000 km^2)	
Various types of dense bush	317,000 "
	391,520 km^2

White (Ref. 54)

Vegetation mapping of Africa by UNESCO/UNSO/AETFAT

Vegetation type	
Acacia Commiphora deciduous bushland and thicket	424,000 km^2
Semi-desert grassland and shrubland	176,000 "
East African coastal mosaic	24,000 "
Evergreen/semi-evergreen bushland and thicket	9,000 "
Absolute desert	2,000 "
Undifferentiated mountain vegetation	1,000 "
Coastal desert	1,000 "
	637,000 km^2

DEFINITION OF "LAND SYSTEM UNIT" (LSU)

Based on N. M. Bird (1988) from a personal communication with R. M. Watson.

"A land system unit is determined primarily on geomorphological criteria, i.e. major features of the land erosion/construction cycle. These can be observed on remote sensing imagery at a scale of 1:100,000 and, most importantly, from aerial observation at heights of 300 to 2,000 m above the ground.

Secondary features of the land surface may be used to divide the initial geomorphological classification. These features, in order of importance, are:

1. Land use, chiefly crop production, occasionally occupation;

2. Soil type;

3. Drainage development and erosion, and;

4. Statuary features.

The decision of whether the secondary feature is powerful enough to override the geomorphological unit depends on the benefits likely to be gained in terms of:

1. Stratifying the area for sampling, i.e. reducing the variance of the sampling errors, and;

2. Presenting and understanding the data collected in census.

Examples of these secondary features leading to the creation of separate LSU's are:

1. Irrigated estates in a flood plain where there is sporadic subsistence irrigation;

2. Forest relics;

3. Eroded and densely-drained "badlands" on a silty peneplain;

4. National park boundary, and;

5. The combination of two diverse geomorphological units having similar soils and land-use patterns, where the similarity dominates the way in which the area is used and might be managed.

Clearly the objectives of the survey will influence the final determination of a LSU. In extreme cases LSU's may be used with almost no relation to natural systems, in which case the term "sampling stratum," should be used. In general, the intention in surveying natural resources is to create units with maximum long-term utility for understanding natural and land-use systems and for guiding future use of resources."

ACCURACY OF ESTIMATION OF DIFFERENT LSU PARAMETERS[1]

Area:	1:250 000 LANDSAT images 1:100 000 Survey Department maps Reconnaissance verification and improvement of boundaries by aircraft.
Growth:	Reconnaissance level information from both aerial and ground observations.
Pattern:	Reconnaissance level information from aerial observations.
Crown Cover:	Combinations of photogrammetric analysis of woodlands with transect sampling at monitoring sites, with oblique reconnaissance aerial photography and with aerial reconnaissance notes. Because each layer of vegetation has an independent areal value, an overall value in excess of 100% is possible.
Height:	Estimated from photogrammetric information and from records made at monitoring sites. It has reconnaissance levels of accuracy. Height estimates were made on the 1973 aerial photography (1:30,000) during the production of the 1:100,000 maps, and shown on these maps.
Tree Volume	Timber + wood fuel in m^3/ha. Timber volume of Acacia growth style tree = 0.004 X tree height X tree crown diameter to the power 1.68 (Developed from calibrations in Southern Sudan by Watson, et al.)

[1] Ref. 43, 44, 45

Wood fuel volume is based upon the following features:

i) 5% of the wood volume if the tree is too small for charcoal production and becomes wood fuel;

ii) The wood fuel from an average bush was estimated in Tsavo National Park in 1966 to be about 0.25% of the actual bush volume;

iii) The volume of bush covering an area of ground is the same as the volume of a complete cover of hemispheres with the same basal cover, with radius equal to the bush height;

iv) The volume of wood fuel in m^3 per ha from shrubs is equivalent to the area under shrub cover times 0.00013, being based on the observation that the shrubs of average height of 1 m have a volume of wood suitable for fuel equal to about 0.013% of their volume.

Wood fuel in m^3/ha = addition of the residue from trees cut for charcoal + stems which can be cut from bushes + stems which can be cut from shrubs.

THE CLIMATE OF SOMALIA

Natural tree growth and species distribution is determined, among other factors, by the interaction of climate, soil type, availability of ground water, rainfall and land relief. In the following, the climatical parameters will be described briefly. For details, see (Ref. 24,25).

1. Climate

Traditionally, the year is divided into four seasons:

Jilaal = December to April, usually dry;

Gu' = April to June, a wet season;

Xagaan = June to September, a mainly dry season with sporadic showers, and;

Der = June to September, a wet season.

1.1. Sunshine

In the southern part of the country, sunshine varies from 5.2 to 10.2 hours per day in July and February, respectively. No observation have been made in the north, but extrapolating the figures from the south, the north seems to receive a very high level of sunshine hours.

1.2. Cloudiness

In general, cloud amount is less in the afternoon than in the morning. Information regarding the height of the cloud base indicate that very little cloud occurs below 600 m in the north, while in the south, significant amounts occur below 600 m, but very little below 300 m.

1.3. Air Temperature

Somalia rates as one of the hottest countries on earth. Annual mean temperatures vary from 18° C in Erigavo in the north at an altitude of 1,800 m to over 30° C in Luuq in the south.

There is a drop in temperature of 6.4° C per 1,000 m elevation rise in the north, while in the central and southern parts of the country, temperature increases gradually away from the coast despite a gradual rise in altitude.

The diurnal variation of temperatures is small, at the coast not more than 5° C. In semi-arid and arid areas, the variation should be high, but it is not primarily due to the generally high humidity coupled to sparse vegetation and a low soil moisture level.

The extreme temperature of 50.2° C was recorded at Luuq, and maximums are over 45° C in Belet Weyn, Berbera and Galcio. The lowest temperature, -3.3° C, was recorded at Erigavo, but even Hargeisa has recorded -1.1° C.

1.4 Relative Humidity

Relative humidity ranges from 37% to 86%, but because of temperature variations, it is not a good indicator of actual air moisture.

Dew points rise during the onset of the Gu' season and fall off with the retreat of the Der.

1.5 Wind

The Horn of Africa is unique in the world as its eastern cost is the only major land mass not to receive reasonable amounts of rain from the Indian Ocean. It is the only tropical continental east coast that is dry. The reason for this unusual situation is that the low level air flow from the Indian Ocean is stopped by the interior highlands, and diverted towards the north. Having previously dropped its load of rain over equatorial areas, it becomes dissecting dry as it crosses the Horn as an offshore, and not as an onshore, wind.

Winds are strongest during the southwesterly monsoon in May/June and decrease as it moves east to north east in August/September/ October. Weakest winds occur during the inter monsoonal periods of April/May and October/November.

In general, wind velocity does not seem to have a negative effect on tree growth but ref. 43,44,45 report serious wind erosion. Also ref. 12 reports that wind was found to be the major erosive factor throughout most of the Central Rangelands. Furthermore, wind plays an important role in maintaining the unstable character of the sand dunes. Thus, wind should be given more attention when planning any kind of management activities. Positive reports of windbreaks with regard to yield have been observed (e.g. Ref. 6)

1.6 Rainfall

There are two rainfall seasons and in the south there is a marked dry season between them, while in the north the dry season is not pronounced. Also, the second wet season in the coastal areas is small compared to the first, and the total amounts vary over the country. Map 2 and 3 contain the distribution of the mean annual rainfall and the monthly pattern, respectively.

There are large variations in the rainfall from year to year, monthly or even at ten day intervals. For example, the mean annual rainfall value for Mogadishu is 426.1 mm over 70 years of records, but a minimum of 56.7 mm was received in 1915 and a maximum of 997.2 mm in 1923.

It is important to know about rainfall variations from a forestry perspective in order to design a match of management practices, e.g. plantation work, to water availability. In Somalia, the variations are high and increasing with decreasing annual rainfall. Even in comparison with other tropical areas and similar rainfall regimes, rainfall variation in Somalia is high, causing serious management problems.

1.7 Evaporation and Water Balance

The annual evapotranspiration ranges from 1,460 mm in Jonte in the south, or 4 mm each day, to a maximum of 2,886 mm Berbera on the northern coastline, or 8 mm each day. The range of annual rainfall is from almost zero to 700 mm. Not surprisingly, there is a large water deficit all over the country.