REPORT ON "FORESTS"

OF THE ARID AREAS

OF THE PUNJAB.

BY G.E. BROCKWAY.

Report on "Forests" of the Arid Areas of the Punjab

FOREWORD

Recently considerable attention has been focussed on the Colombo Plan meeting at Singapore and the decisions reached there. With the extension of the scheme to 1959 and ultimately to 1961 it would appear desirable that the Australian Government should have as complete a picture as possible of the needs of the various countries in their several fields. It became obvious prior to my departure from Australia that there was little knowledge or appreciation of West Pakistan's very real timber and fuel problems and I have endeavoured to give in this report as clear an over-all picture, as my observations to date permit, of the problems, and my suggestions for means by which the solutions may be approached.

The problems are not only of a technical nature but they form part of a very large sociological and economic complex involving land use for other purposes. With more people on the land than the land can adequately support and the position from that angle still further deteriorating, no solution which will provide all the people with all they need appears possible. Any scheme which can even in some measure alleviate the position, and that is all that can be hoped for, must take into account the interests of all concerned and cannot be simply treated as a purely forestry problem. Public and administrative support for measures aiming at improving the position is essential.

Not only technical advice is needed to supplement local knowledge but material assistance to enable effect to be given to that advice.

G.E.E. BROCKWAY

SUMMARY OF REPORT

(1) The amount of wood fuel and timber available per head of the population is surprisingly low - less than one cubic foot per person per annum.

(2) The Forest Authorities of Pakistan are faced with one of the most difficult tasks in the forestry world in endeavouring to improve this position.

(3) Owing to extreme aridity of the uncommanded areas and the pressure on irrigated land for the growing of food or crops which will give an early return in cash, the prospect of any spectacular increase in production is not great.

(4) The degenerate condition of the arid areas is the result of unrestricted exploitation and grazing and these factors, particularly the latter, are still operating.

(5) No improvement in the condition of the Rakh will be possible without control over the grazing. Without this technical advice is futile.

(6) Rakh rehabilitation on a broad scale cannot be treated as a purely forestry problem. Stock grazing, but under strictly controlled conditions, must be given foremost consideration.

(7) Isolated attempts to regenerate drought resistant species have been made over the last eighty years but no spectacular results have occurred. Recent work in establishment since 1944 has shown the greatest promise to date.

(8) In very arid country on the basis of transpiration equivalents no high increments can be expected irrespective of what species are used.

(9) Local species are extremely drought resistant and will stand considerable physical abuse but their slow growth renders rehabilitation a very long term project.

(10) Introduced species such as the Eucalypts may be expected to improve on the increment rates but even then no miracles can be looked for. A list of possible species is included in text.

(11) For the introduction of these species the technique of nursery treatment needs to be studied and applied.

(12) The problem is not simply one of areas with 7" rainfall and under, but it applies to the whole of the Punjab plains. To confine it to such areas narrows the scope and reduces the value of work done.

(13) To enable a rational scientific approach to be made to the control of grazing, joint investigations, both forestry and range management, are necessary.

(14) For these investigations a properly staffed research organisation with subsidiary stations is necessary in the effected areas.

(15) Research stations and subsidiary stations will require fencing material and technical equipment and unless this is forthcoming through one of the technical aid schemes it appears to me unlikely that it will be forthcoming at all.

INTRODUCTION

PART I

The Forest Authorities of West Pakistan are faced with one of the most difficult tasks in the forestry world. From Karachi, extending North East for a distance of nearly 600 miles, lies the most arid section of the Indian Sub Continent. To the North of this where the climatic conditions are more favourable for tree growth, that is in the semi arid and sub humid zones, centuries of grazing exploitation, erosion and clearing for cultivation have reduced the natural vegetation to meagre remnants both in stature and extent. The timber species of the humid zone of the northern hill country have, as a result of the steep terrain and the associated extraction difficulties, been less heavily exploited then the vegetation of the plains, and of the Sulaiman and Salt Ranges. Road development and more effective transport have, in recent years, rendered the hill areas more accessible but even there fuel prices are high, and in any case cheap fuel in that region would have little direct effect on the position some 300 or 400 miles away.

The areas covered by the extensive irrigation systems of the Punjab based on the Indus river and its tributaries, which have been considerably extended in area within the last century, have agriculturally a high productive capacity. On these has been built up a dense population which despite inadequate food supplies is still increasing. It has been estimated that the population of the Indian Sub Continent has increased three fold within the last century. The impact of this increasing population on the Rakh forests has been of a three fold nature.

1) The pressure for fuel on these forests has increased with the population increases.

2) The proportion of land under cultivation has increased at the expense of the fuel supplying areas.

3) The increased number of live-stock associated with a greater population has resulted in intense overstocking leading to a greater disturbance of the ground surface thus causing increased erosion and hindering regeneration of the perennial shrubs. The grazing of the animals results in physical damage to the vegetation either destroying it or stunting its growth, as is the case with mulga (Acacia Aneura) in Australia, where instances are on record of cattle grazing keeping mulga in the 'low' condition for a period of 40 years.

The problem is not amenable to easy solution. In brief it calls for the production, as quickly as possible, of fuel and timber supplies in quantity adequate for the needs of a dense population and at a price in conformity with their own limited purchasing power. Distance and political (or national) considerations prevent its transport from more favoured regions. It is required in a region where land under irrigation is capable of providing food for a couple of persons to the acre, but without irrigation can produce only low grade fuel and harsh grazing for the most hardy domestic animals. The factors which have contributed to the present degenerate condition of the Rakh Forests are still operating. No one can deny the importance of food and the textile

crops for the physical and economic survival of the people. Neither must one lose sight of the necessity for fuel for human existance even at a very low living standard and for timber if any appreciable raising of this standard is to be achieved, and of tree growth for the physical protection of the land and the people.

F.A.O. has recommended one cubic metre of timber and fuel per head per annum as a minimum human requirement which is approximately twice the present world consumption. It is doubtful if one twentieth of a cubic metre per head is available here as timber or even in a form which most countries would regard as reasonable fuel. This acute shortage contributes to and is indicative of the very low standard of living of the great majority of the people.

P U N J A B

Area	58042 sq.miles	(p)	(173,875)
Population	18,814,000	(q)	(33,779,000)
Urban Population	17 %	(R)	(10 %)
Area under forests 3.2 %	1872 sq.miles	(p)	(5430 - 3.1 %) sq. miles
Timber & fuel output (From Govt.forests) for 1951-52.	5,090,260 cubic feet		(19,348,842)

(Figures in brackets are for the whole of West Pakistan).

S.M.Ibaqi ____ Timber revenues of Pakistan (q)
S.A.Vahid ____ Forestry & Agriculture in Pakistan P.J.F. Vol.2 No.1. (p)
Pakistan ____ 1953-54 (R)
M.I.R.Khan____ Improvement & management of Range (Waste) land in West Pakistan P.J.F. Vol 2 No. 4.

The country's great need has given rise to endeavours to extend forestry practice into regions with rainfall far below those in which it is normally attempted or even contemplated, so that the efforts of the Punjab Authorities to establish some form of forest crop in these areas of extrme aridity constitute a marked departure from general forest practice. The arid and semi arid areas of the world have produced considerable quantities of forest produce but the low growth rates and low production per acre has discouraged exploitation on anything but a purely extractive basis. Regeneration of exploited areas for timber and fuel production has seldom been given serious consideration.

The examination of the distribution of the forest areas of any country shows a close corralation between areas of higher fainfall and the more productive forests. Consequently forest activities are, with minor exceptions, confined to areas of 30" rainfall or better. Forestry is basically a business and is expected to measure upto business requirements. If it were profitable in the lower rainfall areas it would not be neglected there. If profits are to be the primary consideration, then arid area forestry should be abandoned forthwith. If its function is recognised as a means

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of meeting a very vital need in the people's welfare and progress, its continuence is well warranted.

In areas of extreme aridity and lacking irrigation or underground water supplies within the reach of the root system of the vegetation, no spectacular increment returns can be expected. Every pound of dry matter, and that includes leaves and twigs as well as wood, requires a very much greater quantity of moisture to produce it - probably not less than 1000 pounds under arid conditions. As a consequence of this and of the other factors associated with areas of extreme aridity, such as lack of soil protection, increased evaporation, irregularity in rainfall, high temperature and low humidity, the productive potential of any area decreases with decreasing rainfall, but at a much more rapid rate than the actual proportional decrease in rainfall. On this basis the productive capacity of the more arid areas, in the natural condition, would not exceed more than about two or three cubic feet of dry matter per acre per annum. Actual quantities removed from these areas would suggest a lower rather than a higher figure, provided we omit quantities of ephemeral vegetation which may be produced in occasional years of unusually high rainfall. This marked dependence of forests on an adequate rainfall for volume production draws attention to the fallacy and the danger of attempting to express a country's forest requirement on an area basis, an approach which is frequently made in Pakistan.

Officers of the forest department with their training along the lines of conservation do not need to be told these things. Their knowledge of cause and effect in the country's ecological problems is sound and they have carried out investigation and trials, within the limits imposed on them by the social and economic conditions of the country, in endeavours to find remedies for the position.

They have published well written, well informed articles supported by convincing facts, which focus attention on the basic causes of the deterioration of the arid lands and, what is more generally apparent, the chronic condition of timber fuel famine throughout the country. However, recognition of these facts and the basic causes of the present difficulties is necessary in the administrative authorities and the public of the country before anything very concrete by way of improvement can emerge. Other interests which at times can be quite vociferous, are also at work and their opinions are frequently given considerable recognition. Thus grazing interests in a desert, to safeguard their own immediate existence, express views which can be particularly misleading but which can easily be accepted by administrative authorities. Thus we have the keepers of the flocks and herds in the Thal Desert avowing that the area once carried much better fodder than at present and that its deterioration has been due to a deterioration in the seasons. The condition is similarly reflected in a typical newspaper paragraph concerning the Chakwal district (Salt Range) in which it was claimed that a serious fuel shortage there was attributable to the restrictions of firewood cutting imposed by the Forest Department. Both statements exemplify but ignore the ecological impasse in which these two districts (in company with all the others I have seen) have found themselves as a result of the over exploitation of their natural resources; reaping but not sowing!

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I have been informed that Rakh Khanpur in the Muzaffargarh district, which is in a very degraded condition (see photo No.2) has been kept open for grazing through local pressure against the wishes and recommendation of the Forest Department.

The persons who graze stock in arid areas by overstocking the land are doing incalculable harm which is frequently described by conservationists as a crime. However, they have little alternative, being caught up in an ecological complex caused by expanding population and deminishing areas of grazing land. They are victims of circumstances not criminals. To charge them high grazing fees only adds to their difficulties and does not solve the problem. Personally I feel that grazing fees should be low in respect of those stock which constitute a reasonable minimum requirement but should rise steeply in respect of stock in excess of this.

A further problem which is exercising the minds of economists, foresters and agriculturists is how to make use of considerable areas of waterlogged country which result from seepage from the canals where there is inadequate drainage associated with the irrigation. These areas appear to be most prevalent in land previously 'worked' by the rivers. They are low lying and are under water during the rainy summer seasons while during the dry season the soil surface becomes encrusted with alkaline salts. Small shrubs such as Lai (Tamarix dioica) Jand (Prosopis spioigera) stand these conditions fairly well while occasionally Farash (Tamarix articulata), sometimes reaching a height of about 25 feet, is found there.

A number of salt resistant trees have developed in Australia which stand periodic flooding which however normally occurs during the winter, whereas here the flooding takes place during the hotter weather when the growth is active. The chances of finding Australian specific for use under such conditions are not bright. Nevertheless, several are being raised for trial. The frost tenderness of the Northern Australian species (e.g. Malaluca, Leucadendron) which receive summer flooding would probably render them unfit for the purpose.

EXISTING SUPPLIES

PART II

The Forests of West Pakistan have been broadly classified as follows:-

1) The Natural Forests, which were not originated by any effort of man, and,
2) Artificial or plantation Forests, which owe their origin to human effort.

The natural forests of Pakistan are met within the following areas:-

a) The North and West mountain and sub-mountain areas of West Pakistan. This will be about 10,00,000 acres.
b) The dry hills in Baluchistan and the Tribal areas in the West. They are about 14,00,000.
c) The wet plains forests along the valleys of the rivers in West Pakistan. Area is about 12,00,000.
d) The scrabby, dry scattered areas (Rakhs) in the plains of the Punjab in West Pakistan. They are about 2,00,000,

The artificial or plantation Forests are mostly confined to the Punjab in West Pakistan, though they are being created in increasing numbers in Sind and also in N.W.F.P. These forests have all been created in the thickly populated plains and mostly along some irrigation schemes.

"Total area under there plantation is about 100,000 acres".

(Forests and Forestry Problems of Pakistan by S.A.A. Anvery, P.J.F. Vol.1, No.1 '51).

The Civil Rakhs which aggregate some 358,000 acres are largely under the control of Civil Authorities. "These which have been taken over by the Forests Department are about 100,000". The Rakh association has been described as "tropical thorn forest" although some of the principal species are thornless. Topogrophically it consists of arid flats generally, but not always, associated with dunes of fine light-coloured sand. Irrigation has been extended over the more readily irrigable areas so that the greater part of the Rakh remaining or likely to remain as such is that in which the proportion of sand dunes (tibba) is high and the elevation and sail porosity renders irrigation difficult. Thus most of the remaining Rakhs have the typical desert or semi desert appearance with dunes well in evidence (Photo 2).

However, there are differences as one travels from place to place, with the incidence of local grazing intensity exerting a profound influence on the stability or otherwise of the dunes.

A number of typical examples are given hereunder,

i) Location Sedj Buneki — 50 miles south west from Lahore. Rainfall 13".

This area is situated between the Ravi and Sutlej Rivers. Soils are grey brown and surface is level - dunes are absent. The vegetation consists primarily of:-

Salv: oleoroides, Tamarix articulata, Prosopis spicigera, Callitropis procara, Capparis sphylla and zysiphus jujubs.

The following analyses of soil from this locality give

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an indication of the soil type.

(Pak Journal of Forestry 1951)

Clay	11 %	to	13 %
Silt	45 %	to	55 %
Sand	34 %	to	44 %
PH value	8. %	to	9. %
Total soluble matter	0.09	to	0.24

ii) Location Pirawala. Also situated between Ravi and Sutlej rivers. Rainfall 6". Topography is generally flat with some low mounds, and occasional dunes of sand, the latter occuring particularly near main centres of settlement e.g. Khanewal.

analyses of the sandier soil types here are:-

(Pak Journal of Forestry 1951).

Clay	6 %	to	10%
Silt	9 %	to	14%
Sand	70 %	to	93%
pH value	8.72	to	9.09
Total soluble matter	0.09	to	0.16

Descriptions of the Rakh in this region are given by B.H. Baden Powell and latter by A.L. McIntyre.

B.H. Baden Powell, in Sarai Sidhu working Plan 1879 gives the following:-

"In most of the forests there is an admixture of Jhand and farash. In some places farash predominates almost to the exclusion of jhand, and vice versa. Many of the compartments of Bura Kotla are of pure jhand: hardly a farash tree is to be seen.

The trees at present standing are mostly large, hollow, and, in the case of farash, wide-spreading, having stems or several branches from a very short stem. They have a bent down and straggling form which is very peculiar.

In parts, these forests exhibit quite a park-like character open glades more or less covered with grass and clumps of trees or single old trees long past the age of maturity, scattered about irregularly."

"At present the great disadvantage of the standing stock is, that it consists almost exclusively of over-mature trees.

The farash are, however, unlike the dusty oppressed objects seen by the roadsides at Lahore; they often attain a large girth (though of low stature), four or five gigantic arms stretching out, and thus cover a large extent of ground, and show a crown of vivid green foliage. The jhand is also very old in some forests, as in Bura Kotla. There is a great want of younger growth".

While A.L. McIntyre, in the South Kabirwala and Mailsi Working Plan 1899 gives the following:-

Principal Species

These are "Jhand" (Prosopis spicigera) and "Farash" or "Okain" (Tamarix articulata) and an equally important tree in point of abundance is the "Wahn" (Salvadora oleioides). Other trees are comparatively scarce; they include 'Lai' (Tamarix dioica), "Mallah" (Zizyphus nummularia), "Karil" (Capparis aphylla), "Phog"(Calligonum polygonoides), "Kikar" (Acacia arabica).

"On low-lying ground tree growth, consisting mainly of farash, is often nearly (continuous)over considerable areas, but

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elsewhere, though small areas completely stocked with jhand, tree growth is generally incomplete, only about a quarter of the ground producing scattered trees or small clumps of trees, whilst the remainder is bare or grass covered. In the worst places wahn is almost the only tree, jhand being represented only by patches of inferior growth whilst there is little or no farash of any description".

Location Rakh Khanpur near Muzaffargarh situated between Chenab and Indus rivers. Rainfall 6", Here dunes up to about 30 feet in height, of light grey sand, constitute the bulk off the area, Grazing is heavy and the soil surface unstable (See photo 2).

Main species are Salvadora alearoides, Acacia sp. Calligonum polygonoides and Prosopis spicigera.

This Rakh forms the southern extremity of a belt of country known as the Thal which extends northwards almost to the Salt Range although there is some general improvement in vegetation as one proceeds northwards, except in the extreme northern portion where cultivation for gram has bared the surface and given rise to very serious soil movement. (See photo 19). On the lower lying areas towards the rivers and in the vicinity of some irrigation channels water logging and the formation of Kallar is frequent (See photo 25).

iv) Rakh Chota Dalana (Dera Ghazi Khan) situated to the west of the Indus, consists of unstable dunes of light pinkish grey soils; seldom exceeding 20 feet in height. These are seperated by a smaller proportion of intervening flats also of sandy texture but with sufficient binding material, particularly in the surface layer, to stablize them.

Principal vegetation is Callotropis procera, Calligenum polygonoides, Koshia indica, Salzola fruticosa and occasional Acacia sp. Prosopis spicigera and Zysiphus jujubs.

v) Triman Rakh 40.50 miles north of Taunsa (Rainfall 7") Sand dunes are absent. The soil is heavy, consisting of clay and silt brought from the hills lying to the west. The heavy deposits of silt make tree establishment difficult as they tend to fill planting trenches and to fissure badly when drying.

Vegetation. Prosopic spicigera, Capparis Aphylla and Salvodora olearoides.

vi) Cholistan Desert (Bahawalpur) Rainfall 5". The greater portion of Bahawalpur State is Desert. It varies from areas in which high dunes of light yellow/grey sands form the main proportion, to areas in which vast bare plains (dahars) eroded down to a base level, are skirted and seperated by narrow lines of dune carrying Tamarix articulata. These dahars are similar to the lakes or large clay pan area of central Australia. Plain-like areas not so devoid of vegetation as the dahars carry low vegetation which includes a shrub, Haloxylon recurvum which is one of several species collected and burnt. to produce "Sajji" or crude soda ash.

The Tamarix articulata on the tibbas is similar in growth and location to the native pine, and mulga of the Australian "Lake" country and it would appear that little could be gained by introducing these Australian counterparts.

The vegetation of this Desert consists mainly of the same species as occur in the Rakhs of the Thal.

vii) The two hill areas so far examined are the Sulaiman and Salt Ranges. The rainfall of the former is about 6" and of the latter 12" to 21" (See photo 7 & 8).

Vegetation includes such species as Olea cuspidata

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Acacia modesta Dodonoea viscosa, Prosopis spicigera etc. Trees are generally small and stunted and apparently very slow growing.

The terrain is rugged and in parts precipitous. The soils are rocky with both limestones and sandstones occuring. Underlying much of the Salt Range soil is a red marl containing gypsum.

Grazing, particularly goats, is heavy and has been so for a very long time and the vegetation is degraded accordingly.

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To meet as far as possible the fuel and timber requirements a number of sources are drawn upon. However, the requirements even on a very moderate basis are far from being satisfied, despite the fact that practically everything that will burn is utilised. The various sources of fuel are:-

i) Timber and fuel from Government irrigated plantations and river forests. (Photo 9).
ii) Timber and fuel from canal side planting. Photo 10.
iii) Fuel from the natural Rakh Forests. (Photo 12).
iv) Timber and fuel private property.
v) Other organic material obtainable locally - mainly cow-dung.
vi) Imported fuel.
vii) Mineral Gas.

The sources from which fuel and timber are obtained throughout the Punjab are,

1. <u>IRRIGATED PLANTATIONS.</u>

a) <u>Canal irrigation.</u>

Several of these plantations have been developed or are in process of development and represent a total gross area of some 96,000 acres with a net area of 89,000 of which some 43,000 acres have been actually planted. The fuel and timber position of the country, bad as it is, would be infinitely the worse without these, although the gross area represents only about half of one per cent of the irrigated areas of the Punjab and the commanded portions even less than that. Under existing conditions, with low wages and high firewood prices, they can be generally considered economically successful. The total production from these forests at present represents less than one fiftieth of a cubic metre per head of the total Punjab population.

The extreme pressure on irrigable land for the production of food for the increasing population renders unlikely any spectacular increase in the area of forest under irrigation. Moreover the uncertainity of water supply which in the past has been mainly associated with year to year seasonal fluctuations has been more recently rendered much more precarious by the increased draw from the rivers to meet the requirements of projects beyond the Pakistan border. When water supply is low it is likely that authorities would use every means in their power to avert famine and these could quite conceivably include the diversion of water from forests to food crops despite the fact that the withholding of the water from the forests to could mean a serious deterioration, or possible destruction, of a crop which has taken several years to produce. Even a few weeks delay in making water available in the early summer can spell disaster to a young crop. This problem has already been encountered with serious local effects in several of the planation. However, in view of the comparative rapidity with which fuel and timber can be produced and with the need so urgent, an increase in the area of forest under irrigation, if at all possible, and certainly no production, should have the Government's

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earnest consideration.

b) Tube Well irrigation.

The extension of forest irrigation from canal supplies to tubewell supplies has more recently been introduced on a limited scale. This effort to raise what is primarily fuel forest under such a system, which involves the lifting of water from depths up to 60 feet must be regarded as an indication of the country's extreme need. This method of irrigation is too new and too restricted for it to have any present effect on the country's fuel supply.

c) Bela Forests (River Forests)

These have produced considerable quantities both of timber and fuel. Interesting work is at present being carried out in the establishment of more valuable species in these. The technique entails hand watering of trees for a period in the early life of the first rotation until such time as the roots penetrated to the fringe of the permanent water table. With additional barrages being erected and further irrigation projects developed considerable alterations in water table, drainage patterns etc. are occuring and are likely to occur and these are effecting certain of these forests. In view of the disastrous /low effects of floods on cultivated areas the use of/lying areas for forestry purposes would appear a rational development.

2. CANAL SIDE PLANTING:

Throughout the irrigated areas considerable mileages of canal lands have been planted totalling come 52,000 acres. These strips range from single lines of trees to belts several chains in width. (Photo 10) There is every reason to increase these plantings both for fuel and timber production purposes as well as their protective value. The control of this work by Irrigation and Civil Engineers is rather incongruous and I feel that tree planting and the tending should be in the hands of foresters who have been trained for such work. The timber production from this source does not appreciably affect the position. The transfer of these to the canal department was arranged some eighty-five years ago with the approval of the Forest Authorities of the day (under Brandis) who considered the attenuated distribution of the plantations unsatisfactory for administration other than in conjunction with the canals. With improved transport and better forestry techniques the position has now been radically altered.

3. NATURAL RAKH FORESTS:

There are very considerable areas of waste land and protected Rakh Forest throughout the arid and semi arid areas. In appearance some of the Rakhs somewhat resemble the Mulga association of inland Australia, others are more typically desert types. These have in the past provided a large part of the fuel requirements of the country including at one time fuel for the railways. However, during recent years considerable sections of these have been brought under irrigation and cultivation and the balance of the area has been so exploited and reduced in extent that it is now not able to meet satisfactorily even the local needs. The fuel supplies from Rakh area of poor quality and are generally used locally and represent probably less than one per cent of the country's need. (Photo 11 to 12).

4. TIMBER AND FUEL FROM PRIVATE PROPERTY:

A considerable unspecified amount of fuel is provided from private property and while much of it comes from isolated trees which are felled for sale as fuel, there is a considerable quantity in the form of small twigs cut from tree crowns or from

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low woody shrubs, or the stalks of agricultural crops etc. and this constitutes much of the fuel used by villagers. However, little attention is being paid to regeneration or conservation, and diminishing rather than increasing supplies must be expected from this source, in the more distant areas much of the timber so produced is converted to charcoal to save freight and in the case of Acacia arabica trees, the bark is removed from the billets and used for tanning purposes while the wood is used either directly as fuel or converted into charcoal. Private property supplies do not appear to have been taken into account in the estimates of timber and fuel consumption in the Punjab. I doubt if reliable records could be collected on material from this source.

5. OTHER ORGANIC MATERIALS USED AS FUEL (mainly cow-dung)

With some seven million bovine animals in the Punjab a total estimated at 35 million pounds of dry weight of such manure is produced each day. Of this, assuming that 30% is lost on grazing lands, 40% is used as fertiliser and 30% is used for fuel, about 5000 tons, or a little over half a pound per person per diem, will appear to be available. (Based on figures used by Datta). this would be well below the average daily requirement of 2 seers (4 pounds) per head suggested by S.S. Bahadur Singh as necessary in a community dependent on this fuel, which approximates to the 1 cubic metre of fuel per head per annum recommended by F.A.O. as a minimum. Datta writing of the Central provinces (of India) suggested a smaller requirement of 1 seer per head. The use of this valuable fertiliser as fuel on a large scale is a calamitous custom which can only be eliminated by removing the extreme need.

6. IMPORTED FUEL

Distances, freights and national animosities prevent this at the present time. The wooded country of the hills to the north has no surplus to supply to the more distant areas on the plains, and even here extraction difficulties make its collection expensive and transport of fuel over long distances would make its price prohibitive.

7. MINERAL GAS.

The exploitation of Sui Gas may relieve the position to some extent in the larger cities but is unlikely to have any effect in the rural areas where the great majority (over 80%) of the population live.

PART III.

The indiginous vegetation of the Rakh Forests is comparatively easily established, tenacious of life, and stands up to repeated lopping and cattle browsing, while it provides fodder as well as fuel and above all is already in possession of the site. Consequently most of the fuel to be obtained from these areas within the forseeable future will be from this native vegetation, the principal members of which are:-

a) ON PLAINS

i)	Salvadora olearoides	van
ii)	Tamarix articulata	Farash
iii)	Prosopis spicigera	Jand
iv)	Zysiphus jujuba	Behr
v)	Capparis aphylla	Karil
vi)	Calotropis procera	Ak
vii)	Calligonum polygonoides	Phog

b) IN HILLS

viii)	Acacia modesta	Phulai
ix)	Olea cuspidata	Kao

Two trees which have been introduced from America viz. Prosopis julifbora and Prosopis glandulosa, known collectively as "Velayati Jand" appear to have come to stay/under favourable/and conditions tend to spread, although their rapid widespread coverage of un-irrigated areas is not generally indicated. (Photo 14) Acacia arabica is widespread throughout the cultivated areas but can hardly be considered a Rakh species.

Acacia arabica, Populus euphratica and Dalbergia sisoo occur naturally in the Bela or river forests. The nine Rakh species listed above all occur in shrub form while all, except No.vi and vii, may under favourable conditions, develop into small trees.

In the establishment of these plants helpful investigations have been carried out by officers of the Indian Forest Service and more recently by the Pakistan Forest Service. Investigations were commenced 80 to 90 years ago into the establishment of Rakh species but very little of a practical nature appears to have been then achieved. Thus in 1879 Baden Powell in Sarai Sidhu Working Plan mentioned trials made with these species which gave negligible results. In 1899 McIntire in another Working Plan (South Kabirwala and Mailsi reserved forest) reported,

> "Jand, Vahn and Kikar have been sown broadcast and on mounds raised in depressions. But though all have germinated Jand has never apparently survived for any length of time and though Kikar has been known to live for several years the seedlings appear to be cut back every winter and none can be said to have established themselves. On the whole it would appear to be useless to attempt to sow or plant these trees. A few Vahn seedlings appear to have survived".

More recent investigations into the re-afforestation of Rakh was commenced in 1944 in what was designed to be a Post-War scheme, at Pirawala, Chichwatni, Chhanga Manga and Jallo. The average rainfalls recorded for these centres were Jallo 15.5" Chhanga Manga 14.6", Chichawatni 8.3", and Pirawala 6.0". These tried investigations were continued until 1948. Species tried were,

LOCAL	INTRODUCED
Prosopis spicigera	Prosopis juliflora (6 varieties)

Acacia arabica
Acacia Farnesiana
Acacia modesta
Zizyphus jujuba
Tamarix articulata. (Cuttings)
Prosopis glandulosa
Parkinsonia aculeata

(Photos 15 & 16)

The ground prior to sowing was cultivated. In some instances the seeds were broadcast and in others drilled. Some germination occurred each year but the drilling gave better results than the broadcasting. Subsequent mortality of the plants was heavy so that the conclusion drawn in 1951 was that "of the nine species and seven varieties of the tenth (?) species tried so far in connection with the afforestation of dry areas without artificial irrigation only Prosopis species have a chance to succeed".

Following this series of investigations a new line of approach has been followed which aims at the collection and concentration of rain water in trenches. This has the effect of allowing greater water penetration at selected points where the seed is sown or seedling planted and a significant reduction in evaporation losses. The technique involves the excavation of a trench with sloping fan shaped extensions which act as catchment areas. This approach is possible in the level alluvial soils of the Punjab plains where there is a comparative uniformity in the soils often for many feet. The concentration of water in this manner enables germination to take place during years in which the rainfall, if not concentrated in this manner, would be inadequate. Various refinements in this technique have been introduced aiming at giving greater protection from wind action and insolation and also by increasing the area of catchment. Complications may arise later as trees develop, with the accumulation of water at their bases, which has been concentrated there at the expense of the zone into which the roots would normally extend. (Photo 17-18).

The greatest problem at present is protection from grazing stock. With the dearth of fencing material this is done by continued patrol at times augmented by long barriers of brambles. This type of protection is far from complete and I have actually seen camels grazing on one of these areas and have also seen evidence of recent sheep grazing on another.

From the soil conservation angle investigations have demonstrated the suitability of certain of the Rakh species as soil binders. One of them "Phog" (calligonum polygonoides) can be readily established vegetatively on bare tibbas. (Photo 19) Kana grass (Photo 26) succharum munja has proved useful in giving protection to roads from shifting sand while a third very hardy species Ak (Callotropis procera) can be propagated from root shoot cuttings. (See photo 24).

In the hill country investigations into tree establishment commenced some seven years ago - Acacia modesta being the principal species used. The earliest work was done in the Salt Range with recent extensions to the Sulaiman Range. By the use of rectangular sowing pits 3'xl'xl' excavated in the contour, water is held and lines of stones have been used to assist the diversion and retentions of water. (Photo 4). Sowings appear advisable at two levels - one at or near the bottom of the pit and one near the rim. Light rains suit the former and heavy rains the latter.

Establishment has been successful but subsequent rate of growth disappointingly slow(See photo 7).

PART IV

Species recommended for trial and use.

Continuous efforts need to be made to encourage the growth of the indiginous species and all means by which their regeneration and their subsequent development can be accelerated, explored. The fact that they occur naturally here establishes the fact that they are able towithstand local conditions and until such time as it is thoroughly demonstrated that they can be supplanted by something better, reliance must be placed on them.

While appreciating the desirable qualities of these Pakistan Rakh species one just cannot lose sight of the drawback of their extremely slow growth which would appear comparable with that of Mulga in the low rainfall areas of Australia. Girth increment with mulga of one inch in five years would be considered fast growth. With some of the Rakh species the amount of foliage appears high in comparison with the amount of wood material produced; This is not a drawback from the browsing angle but does not help in fuel production. The time factor is important as the need for fuel is immediate and it is scant consolation to people who need fuel now to advise them that there will be some available about three generation hence. The search for more rapid growing species is needed and it is on this aspect of the problem that I have concentrated; I am aiming to establish species of Australian Eucalyptus from the most arid section of the range of this genus. While trees which occur under these conditions do not possess the increment potential of the Eucalyptus from the more humid areas they at least should surpass very appreciably that of the existing indigenous vegetation. One of the areas which appears to me to offer the greatest promise for seed supplies of suitable provenance is the isolated Comet Vale section of the Western Australia Goldfields areas where a Eucalypt outlier occurs on red brown desert sand in the Mulga zone, where the rainfall is about 7" per annum. The Eucalypts in that locality are in the tall mallee form which should when once established stand repeated cutting. They are not timber species but should providefuel of better quality than at present available in most of the Rakh country.

In the establishment of a tree crop two problems arise, viz.,

i) The initial germination of the seeds and the establishment of seedlings during the first season.

ii) The subsequent survival and development of the crop.

In arid regions germination of seeds cannot be relied upon to take place annually or even at short intervals in terms of years, while the survival of the seedlings even through the first season depends on a continuence of favourable conditions.

In Pakistan both problems need solving and already valuable data has been accumulated in connection with the first problem where it applies to indigenous species. In order that the second can be resolved within as short a period as possible, any delays associated with initial establishment under natural conditions must be eliminated by use of nursery produced plants in the investigations.

In any case, since the rainfall of Pakistan is mainly monsoonal, with the major falls occurring within a period of about two months during late summer and lesser falls in the late winter only (see table 1), only those species of vegetation can grow whose seedlings can bear severe drought immediately after germination". (M. Said, Pak Journal of Forestry Vol.1 No.4). Where species, like the inland Australian Eucalypts, have very .

Contd..../14.

small seeds which cannot stand deep covering, and seedlings which initially are very fragile, direct sowing must be still more hazardous. The hardiness, rapid, growth and adaptability of the trees of this genus as they grow older however warrant their extensive trial hereunder a range of conditions.

Several Eucalypts have grown remarkably well under irrigation in Pakistan (See Photo 23) and during the last couple of years species have been introduced suitable for semi arid conditions but I do not know of any previous work having been carried out involving the use of arid area species.

The trees of inland Australia are not generally good nursery subjects and require rather more careful handling than those of the less arid areas. My arrival in Pakistan shortly before the summer season did not enable me to make a good start in nursery establishment and although a few trees were raised, the early summer sowing then was not generally successful. Loss of one batch of plants in a disastrous flood further nullified our efforts. Recent sowing was commenced in the second half of September, a season much better suited for such a project, and continued at intervals until early November. These sowing are developing satisfactorily although I now believe that sowing before mid October is inadvisable on account of a number of factors, including,

i) High temperatures
ii) Risk of heavy late summer showers.
iii) Prevalence of ants which remove seeds and injure young plants, and
iv) Prevalence of large earth worms, at some centres, which are capable of almost emptying the pots of their soils within 2 or 3 days of sowing.

The raising of Eucalyptus in Pakistan in the past has been mainly confined to fairly good nursery subjects particularly Euc camaldulensis, Euc rudis, Euc umbellata and Euc citriodor. A number of other species have recently been raised by Officers of the Silvicultural Research Division at Lahore. Generally watering by percolation has been necessary and has practically become standard practice. Surface watering as is carried out in the nurseries in Australia has not been successful. Views of local officers on desirable potting soils were rather conflicting. Thus one officer reported success with a straight leaf mould potting soil, while another favoured pure canal silt. I found that the texture of canal silt obtained at one place, may vary considerably from that of the next, while some officers' ideas of what constituted leaf mould were very much at variance with my own. The terms "leaf mould" and "Silt" have not been used strictly in accordance with their generally accepted scientific meaning.

It soon became apparent that the high clay, silt, and fine sand content, and almost complete absence of a coarse sand fraction, results in a caking of the soils which make them unsuitable on their own as a base for potting soil where surface watering is applied. The admixture of organic animal manure did not improve the texture and it would appear that the high proportion of green feed supplied to theanimals and the consequent absence of much roughage had a bearing on this. Potting soils containing a major proportion of selected sand obtained from desert tibbas, mixed with leaf mould and canal silt in smaller proportion are proving more satisfactory and present trials are pointing the way to future practice. The use of a layer of ½" or so of sand-leaf mould mixture above the normal potting mixtures is being tried and appears to be a further improvement. The main tree species used in forestry work

Contd.../15.

here have large seeds and germinate and develop quickly and the nursery technique necessary for the raising of small seeded species is not developed in the local officers or workmen, and the training of workmen to carry out the work conscientiously and intelligently is not an easy matter. Shade houses are almost unknown and where shade is necessary for the protection of germinating seed, advantage is frequently taken of the nearest umbrageous trees. Tree-cover of this nature is not ideal e.g. shade is often too intense at one time of the day and insufficient at another. Birds from the trees remove germinating seeds, and falling leaves during the late summer have to be continually removed from seed beds.

The only containers at present available for nursery work are hand-made pots of irregular shape and size. These are large and wasteful of space and would provide considerable transport difficulties in their transfer to the field. Some of the pots in use are so badly made that it will be necessary to smash them to enable plants to be taken out without injury. Pots made to specifications I laid down are more uniform in size and of satisfactory shape. Owing to the local shortage of wood veneer or sheet metal the more compact tubes cannot be produced in quantity. Square cement, or earthern-ware, containers would appear to be the solution and I have recently been carrying out investigations into their production.

Water cans in use were found to be quite unsuited for the use with minute seeds. The sprays they provided were coarse and the practice of filing off the burred edges from around the outlet holes further interfered with the quality of the spray. I drew up specifications for a suitable rose (Holes One One thirty second of an inch in diameter spaced half an inch apart, burred projection left intact and face of rose only slightly convex) and this has largely corrected this trouble, but continuous supervision is necessary to ensure that labourers do not nullify the work by changing to the old type which are faster, or by using damaged articles.

Trees recommended for trial in arid and
semi arid areas of the Punjab.

TABLE I

Species recommended for trial in extremely arid conditions.

Species	Form	Soil type	Seed on hand or used in sowing	Source of seed supply
Euc gongylocarpa	Tree to 60 ft.	sandy & sandy loam	-	Forest Dept Perth Western Australia.
Euc ebbanoensis	mallee 25 ft.	"	2½ oz.	-do-
Euc oleosa var glauca	Tree 10ft or mallee to 30 ft	Medium loam	1½ oz.	-do-
Euc oleosa	Tall mallee to 30 ft.	Sand or sandy loam	4½ oz.	-do-
Euc Woodwardi	Tree 30 ft.	Sandy loam	-	-do-
Euc pyriformis	mallee 25 ft.	Sand and sandy loam	-	-do-
Euc Kingsmilli	mallee 20 ft.	Sand	-	-do-
Casuarina decaisneana	tree 30 feet.	Sand	3 ozs.	No known regular suppliers of this seed.
Acacia ligulata	large shrub 15 ft high & spreads widely	Desert sand	-	Mr.Martin-Tree Planting Supdt. L.F.W. establishment Woomera, South Australia.
Acacia aneura	tree to 25 ft.	sandy loam	-	Forest Dept.Perth W.A.(Forestry Commission Sydney NSW)
Callitris glauca	small tree W.A.&S.A. to 30 ft NSW to 90 ft.	loamy sand & sand	3 oz.	Forest Dept.W.A. Mr.Martin.Woomera S.A.Forestry Commission,Sydney NSW.
Brachychiton gregorii	tree 30 FT.	sandy loam	-	Forest Dept.Perth W.A.seed supplies doubtful owing to irregularity of seed years.

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TABLE II

(Arid conditions 7" to 10")

All the species listed in table I.

Species	Form	soil type	seed on hand or used sowings	Source of seed supply.
Euc dundasi	tree 45 ft	medium loam	25 oz.	Forest Dept.Perth.
Euc Clelandi	tree 35 ft	medium loam & stoney soil	18 oz.	Forest Dept.Perth.
Euc Le Souefii	tree 35 ft	-do-	1/4 oz.	-do-
Euc Brockwayi	tree 75 ft	-do-	5 oz.	-do-
Euc Salubris	tree 35 ft	heavy loam	6 oz.	-do-
Euc Salmonooholia	tree 80 ft	medium heavy loam	2 oz.	-do-
Euc Stricklandi	tree 35 ft	medium loam & sandy loam	1/4 oz.	-do-
Euc torquata	tree 30 ft	-do-	1/8 oz.	-do-
Euc Flocktoniae	tree 40 ft	sandy loam	1/4 oz.	-do-
Euc campaspe	tree 30 ft	-do-	2 oz.	-do-
Euc leptopoda	mallee 20 ft	sands	-	-do-
Euc intertexta	tree 40 ft	sandy loam	-	Forestry Commission Sydney, N.S.W.
Melaleuca pauperiflora	tree 25 ft	medium loam of high pH	1/8 oz.	Forest Dept. Perth W.A.
Callitris verrfucosa	small tree	sand and sandy loams	2 oz.	-do-
Antinostrobus juniperoides	small tree	sands of low pH.	2 oz.	-do-
Casuarina cristata (Syn cas lepidophloia)	small tree	medium loam and sandy loam	-	Forest Dept.Perth W.A. and also occurs in N.S.W.

TABLE III

(10 to 20" rainfall)

All species appearing under I and II but the more favourable conditions permit of selection for properties other than more drought resistance.

Species	Form	Soil type	Seed on trial	Source of seed supply
Euc falcata	tree 35 ft	sand loams & gravels	1¼ oz.	Forest Dept. Perth WA.
Euc Gardneri	tree 30 ft.	Loams and gravels	7 oz.	-do-
Euc reduaca	tree 80 ft.	gravel with clay subsoil	-	-do-
Euc astringens	tree 70 ft.	well drained loams and gravels	4 oz.	-do-
Euc longicornis	tree 80 ft.	medium loam with high pH	-	-do-
Euc gracilis	tree 35 ft.	-do-	4 oz.	-do-
Euc melliodora	tree 70 ft.	light to medium loam	2 oz.	Forestry Commission Sydney N.S.W.
Euc sideroxylon	tree 80 ft.	---	-	Forestry Commission Melbourne Victoria.

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STONEY HILL COUNTRY (SULAIMAN & SALT RANGES)

I have given some consideration to possible Australian trees for these areas. Owing to the lack of any high ranges in the more arid parts of Australia I doubt if species are available suitable for the higher altitudes of these hills. However several species appear to be possibilities for the first two or three thousand feet.

The rainfall in the Sulaiman ranges is low but by paying due attention to water conservation measures the technique of which has already been worked out satisfactorily it should be possible to establish some useful trees as set out in table IV.

TABLE IV

Euc torquata	Euc Brockwayi
Euc stricklandi	Casuarina cristata
Euc Le souefii	Brachychiton gregorii

Rather more doubtful are the following which nevertheless be tried on account of their valuable tan barks and tough timber suitable for light construction work and with occasional small mill logs.

1) Euc Gardneri. (2) Euc falcata (3) Euc astringens

SALT RANGE

All these species for the Sulaiman Range can be considered for the Salt Range but greater emphasis should be laid on the three "mallets". The dark red clay underlying much of this range appears rather similar to the clays underlying the mallet hills in Western Australia. The most likely species (the hardiest)is Euc. Gardneri,

Note:-

Euc Gardneri .... Blue mallet

Euc falcatta .... White mallet

Euc astringens.... Brown mallet

AREAS WITH HIGH WATER TABLE (Generally with Kallar formation)

These conditions are not generally considered conducive to tree growth. However while only a limited number of trees with special adaptations to their root systems can function with their roots below the water table, a number of trees have developed in the salt lake country of inland Australia in areas where the water table is at shallow depth and with limited periods of waterlogging. These exhibit a considerable degree of salt tolerance, in some cases at least comparable with Tamarix articulata. Unfortunately water logging in the Punjab takes place during the summer period when trees are in active growth and it is highly probable that trees which will stand waterlogging during winter may be adversely affected during the summer months.

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TABLE V.

Tree for areas of high water table.

a) Salt tolerant.

Euc sargenti	tree 30 ft.	sandy loam	1/4 oz.	Forest Dept. Perth, W.A.
Euc annulata	mallee 25 ft.	heavy clay loam	" "	-do-
Euc spathulata	tree 35 ft.	medium to heavy loam	-	-do-
Euc gracilis	tree 40 ft.	sandy loam	4 oz.	-do-
Euc occidentalis	tree 60 ft.	sand or loam	5 oz.	-do-
Euc Kondininensis	tree 50 ft.	light to medium loam	-	-do-
Euc rudis	tree 60 ft.	loams & clay loams	-	-do-
Casuarina glauca	tree 30 ft.	sands and loams	4 oz.	-do-
(Melaluca pauperiflora)	tree 20 ft.	-do-	1/4 oz.	-do-

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b) Species which will stand a high water table but lack the salt tolerance of the foregoing.

Melaleuca leucadendron	tree to 100 ft.	sands & loams	-	Forestry Co mmission, Sydney N.S.W.
Melaleuca parviflora	tree to 30 ft.	sandy swamp areas.	1 oz.	Forest Dept. Perth, W.A.
Melaleuca violacea	tree to 20 ft.	-do-	1/2 oz.	-do-
Euc megacarpa	tree to 80 ft.	-do-	-	-do-

I have been surprised at the almost complete lack of conifers throughout the Punjab plains and am instituting small scale trials with the following:-

Pinus radiata	Pinus caribbaea
Pinus pinaster	Pinus coulteri
Pinus pinea	Pinus canariensis
Pinus halepensis	

SUGGESTED FUTURE POLICY

PART V.

Future policy in respect of the Rakh area should be guided by sound scientific findings based on well planned investigations, careful observations and faithful recordings and will need to form part of an overall plan for the use of the Rakh areas on a rational basis. Assumptions or opinions not based on sound premises can be misleading and costly. To treat Rakh improvement as a purely forestry problem and forestry as the sole purpose of the arid areas is not an approach I could fully support. The Rakh areas even under the absence of control are feeding thousands of head of stock and thereby providing the owners with a living. To totally close them indefinitely against grazing would have little justification on either economic or humanitarian grounds. To place them under sound management to ensure continuence of grazing on a controlled basis and at the same time improve the "Health" of the Rakh could automatically provide a greater productivity of woody material suitable for use as fuel and would be thereby serving the country in the fullest measure.

There are three interests to be served.

i) The conservationists who wish to improve the condition of the Rakh, and this does not include only foresters, but all persons interested in soil conservation and sound range management.

ii) The fuel getters (and consumers) who are concerned with their own immediate needs.

iii) The graziers who require fodder for the maintenance of their existing flocks and herds.

Any scheme which does not take these three main interests into consideration has little chance of ultimate success.

The importance of developing the waste land was repeatedly emphasised by the Royal Commission on Agriculture in India in 1928, Imperial Council of Agricultural Research, India, All India Silvicultural conference of 1929, 1934 and 1939 and later by the Central Fodder and Grazing Committee of the Imperial Council of Agricultural Research which came into being in 1937".(M.R.Khan, P.J.F., Vol II No.4).

In spite of these findings resolutions etc. any effective control on conservative lines still appears very remote. The Rakh country has been and is subject to excessive unregulated grazing and before any work of a constructive nature can be carried out it is necessary to put some check on the destructive agencies. There is no purpose in endeavouring to establish plant growth when there is little doubt that it will be destroyed by unchecked grazing. The cause must be dealt with before the condition can be cured. As has been demonstrated in areas which have been protected from grazing for a few years the recovery of the indigenous vegetation can be rapid although at the outset the vegetation may not be of the most desirable species. Over the broad acres of the arid lands it is the native species already on the area which must play the major part in their rehabilitation.

To endeavour to raise forests anywhere on the plains & minor ranges of the Punjab on anything but a pocket handkerchief pattern without adequate control over grazing would be futile.

The expressed desire to afforest areas lacking irrigation and which receive below 7" rainfall would suggest that all is well in regions of 7" rainfall and over but my own

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observations do not lead me to believe that such is the case. I have not been made aware of any results which could be considered grounds for complete satisfaction in unirrigated sections of the 7" to 14" rainfall zone. There are certainly schemes there for irrigation from tube wells with water pumped from 60 feet and reticulated through trenches. While investigation at Sadj Buneki (rainfall 13") has been rationally laid out and well handled.

I do not suggest that the scheme to improve the condition of the arid country should be abandoned ; Far from it ! But it needs to be broadened in its scope to make it more realistic. For this it needs to take into account all interests likely to be affected and it should take in a greater climatic range.

The Indian Desert Research Station at Jodhpur is in a 14" rainfall zone and I understand the problems there are far from being solved.

I am of the opinion that a properly planned and equipped research station should be established in the vicinity of the 10" isohyet e.g. at Jauharabad to work on the Rakh areas with subsidiary stations in both higher and lower rainfall areas to study a range of conditions both on the plains and in the hills (Sulaiman and Salt ranges). The sub stations need consist of little more than well fenced enclosures to permit complete control of grazing on a seasonal or rotational basis and these would be among the first essentials. They would need to be of sufficient size to avoid side effect drift sand etc. and to justify the employment of a supervisor to protect fences, control grazing intensities etc. and not so big as to cause a major disorganization of the pastoral economy of the locality. I would suggest as a compromise areas of 200 to 300 acres at at least 12 points - each area to be divided into four or six 50 acre paddocks. To ensure the success or even the introduction of any scheme aiming at the control of grazing over extensive areas it will be first of all essential to provide evidence that such control can be applied in a manner which will not be ecologically and economically unsound. Such evidence can only be obtained and demonstrated from suitable pilot areas and ultimately over all control can, I believe, only be ensured by fencing and subdivision on an extensive scale. Desirable as it might appear from a conservationists view point, the summary exclusion of grazing from extensive areas at short notice could not be seriously contemplated.

The staffing of such[a] research organisation would consist essentially of a director who should be a professional forester with an ecological and botanical background, a pedologist, a plant physiologist, a range management officer, with the requisite assistants, clerks, junior field staff and menials. The director would need to be sufficiently well remunerated and carry sufficient status to make it worth his while to remain in the job and not endeavour to work his way back into the general fabric of the Department. Such an organization would well be made a subject for an international body, e.g. F.A.O., or Colombo Plan or U.N.E.S.C.O. on the advisory committee of which Pakistan has a representative. It is of course desirable that such an institution should be staffed if not at the outset at least as soon as men are available with Pakistani Officers.

The establishment of a station through a range of climatic zones and under different site conditions should make a much wider choice of species possible with the possibility of something more than fuel being produced e.g. small timber, tanning material, essential oils.

Contd..../23.

Without such a range of investigations, species which might fail in a 6" rainfall and yet be suitable with twice that amount could be discarded and all value from the trials with them lost.

I have discussed the possibility of instituting trials in enclosed areas of Rakh country, with officer of the Thal Development Authority and the Department of Agriculture and they inform me nothing of the sort is at present being undertaken in this country.

There appears to me to be a noticeable lack of co-operation between the various schemes. Advisors coming under one scheme have little knowledge of what others are doing or contemplate doing and some coordination of efforts would appear a primary consideration.

I have referred to the need for enclosures. These require material (principally fencing wire), not readily available, and in view of the import position not likely to be available in this country in the forseeable future. For the establishment of a research station a wide range of technical equipment would be required.

The project of fencing a dozen pilot areas of 300 acres each and subdividing into 50 acre paddocks would require slightly over sixty miles of barbed wire fencing (4 wires) i.e. 240 miles of single wire.

The provision of this under the Colombo Plan or one of the other technical aid schemes is I think essential to enable a start to be made with something effective. No 'up-to-date' Australian pastoralist would attempt to manage a station without a boundary fence to keep out foreign stock and subdivisional fences to control his own. Here there are neither, and graziers go where they please. The consequences are precisely what one would expect under such conditions and rather than marvel at the mutilation of the vegetation one must marvel that there is any vegetation at all.

With such a set up technical advice unsupported by means of ensuring that such advice can be put into effect is rather futile. Unless some other technical aid scheme has plans for the provision of such material I feel that Colombo Plan aid in this direction would be well placed and would go far towards demonstrating in a practical way the means which will have to be employed to halt the continuing degradation of the Rakh country and start it on the road back to recovery. Control is an essential and without it any scheme must fail.

Introduction of controlled rotational or seasonal grazing on a broad scale would need to be introduced progressively and would take a number of years.

Distribution of Station and subsidiary stations as suggested are:-

Salt Range	2
Jauharabad (Main Station)	1
Bhakkar (Menkera)	1
Leiah (East)	1
Rakh Khanpur	1
Chota Dalana	1
Triman	1
Sulaiman range	1
Miranpur	1
Chelistan Desert	2

Contd.../24.

There is a surprising lack of sound knowledge with respect to the vegetation of the arid areas not only of Pakistan, but of much of the rest of the world. As far as the local problems are concerned a wide range of investigations are necessary, both fundamental and applied. A range of these, possibly far from complete, is set out hereunder. For such investigations suitable staff as well laboratory facilities are seential.

(1) Data is required re-physical responses and physiological processes of Rakh species and their relationship to their environment (soil, moisture, aspect atmospheric condition, mutual protection).

a) Growth rate of Rakh species.
b) Transpiration rates of Rakh species.
c) Time of leaf shed and longevity of leaves.
d) Wilting coefficients for various species according to season and soil.
e) Root distribution pattern (and desirable spacing distances).
f) Rate of response to precipitation and duration of response.

(2) Water conservation in so far as it is effected by intensity of precipitation, soil and air temperature insolation, wind action, soil texture, surface cultivation, surface gradient, and weed growth. Investigation might be designed to ascertain:-

a) Moisture distribution in the soil at intervals after precipitation.
b) Rate of run-off from soil surface of different gradients, soils, texture, and surface treatments.
c) Evaporation losses from different soils and with different surface treatments - cultivation, mulching, weeding.
d) Precipitation from dew.

(3) Effect of insolation on soil. This would be considered in its effects on soil temperature, for different seasons, different soils and under various degrees of shading mulching and surface cultivation, aspect and gradient.

(4) Methods of establishment in the field of a range of desirable species both indigenous and exotics, both by sowing, planting and vegetative reproduction.

a) Effect of sowing(or planting) of seeds or plants at different seasons.
b) Effects of setting of cuttings at different seasons.
c) Pre-treatment of seeds.
d) Depth of sowing.
e) Application of various quantities of water at the time of sowing or planting in the field.
f) Type of water catchment trenches sowing pits etc.
g) Relative positioning of seeds or plants with respect to the water collecting points.
h) Effect of protection from sun and wind.
i) Effect of complete, partial, or non-removal of original vegetation.
j) Effect of weeding.
k) Effect of cultivation.
l) Effect of mulching.
m) Effect of planting with planting stock of various sizes.

Contd.../25.

(5) Nursery establishment. Method of investigation.

a) Time of sowing.
b) Losses in nursery - pricking out etc.
c) Type of container used.
d) Raising plants open rooted.
e) Direct sowing into container or raising in seed pots or seed boxes and subsequently pricking out into containers.
f) Nursery soil of various textures and composition.

(6) Effect of grazing and conversely of protection on succession in general and on the fuel and fodder producing species in particular. Investigations might follow the following lines:-

a) Effect of total protection for varying periods and rate and nature of succession under such protection.
b) Effects of different grazing intensities on the composition of the vegetative association and on the stability of the soil surface.
c) Effect of closure at selected seasons.
d) Comparative effects of grazing by different species or combination of species of domestic animals particularly in its effect on the growth habits and form of fuel producing species.
e) The re-introduction of species which have disappeared from the association under the effect of intensive grazing.
f) The introduction of exotics.

A number of these matters mainly some of these listed in groups 4 and 5 are at present under investigation but facilities are primitive and systematic examination of the whole range would only be possible if a properly equipped and staffed laboratory were available.

PART VI

My own assignment under the Colombo Plan was primarily as an advisor (variously described as Consultant, and Expert) responsible to the Chief Conservator of Forests West Pakistan and with duties pertaining to the most arid areas of the Punjab.

As these areas lie mainly within the Multan Circle my associations have been primarily with the Conservator of Forests Multan rather than with the Chief Conservator. However, I have appreciated the opportunities of visiting by invitation, semi arid areas (in Rawalpindi Circle) and also irrigated plantations. The irrigated plantations I have visited as an observer only, and while I have undertaken no projects in the semi arid areas I have recommended to interested officers appropriate Australian species for their conditions and lines of investigation they might follow with them.

Investigational work in the arid areas in the past has been almost wholly confined to the use of the local species. Before exotics can be introduced the production of suitable planting stock is essential and I have devoted much of my time to work on techniques for raising these. Thanks to assistance from Australian foresters and others with whom I have been associated I have had available seed of arid area species from that country which is undoubtedly unique in any projects undertaken overseas. Senior Australian foresters have also supplied me on request with information on their own current work and with data applicable to special sets of climatic conditions comparable with those in specific areas in their own respective states and of which they have specialised knowledge.

It is regrettable that although several representations have been made no local officer of adequate status has been available as an associate in this work. The various professional officers of the regular staff are helpful and interested in the work and it is a pleasure to work with them but they are of necessity primarily concerned with normal administration and the regular duties pertaining to their various charges. Moreover the system of comparatively frequent transfers makes specialisation difficult.

The position has been rendered rather difficult by the uncertainty associated with plans for the unification of West Pakistan and the subsequent disorganisation and readjustment associated with the resulting transfer of the Departmental staffs.

In summing up the position I feel that the work on which I have been engaged, necessary as it is, is too limited in its scope to make me feel that my time and knowledge is being used to the best advantage. Efforts confined to the most arid areas could well be extended to the greater climatic range outlined in Chapter 5. As has been further outlined in that chapter advice and knowledge are of little avail when the means for implementing any plans which may be formulated are lacking.

Unless material is available for enclosures there is a big possibility of anything which might be achieved coming to nought. The provision of the requisite fencing material as the initial step would cost much less than the expenditure on my own assignment but it would go a long way towards making my advice (and work) here effective.

STATEMENT SHOWING TEMPERATURE AND RAINFALL VALUES.

M_U_L_T_A_N

	Temp. in °F				Rainfall in inches.		
	Mean daily Max.	Highest Max.	Mean daily Min.	Lowest Min.	Mean Monthly.	Highest in a month	Lowest in a month
Jan.	68.0	83	42.0	29	0.37	2.38	0
Feb.	72.8	93	46.8	31	0.38	1.95	0
Mar.	83.9	109	57.2	40	0.40	2.81	0
Apr.	95.3	115	67.5	48	0.27	1.15	0
May.	104.8	122	77.4	59	0.33	2.27	0
June.	106.6	121	84.8	59	0.55	2.61	0
Jul.	102.4	120	85.5	71	2.01	11.53	0
Aug.	98.9	113	82.9	70	1.82	10.26	0
Sep.	98.7	112	77.7	65	0.54	5.27	0
Oct.	94.9	108	63.7	50	0.08	1.15	0
Nov.	82.9	97	50.9	41	0.06	0.90	0
Dec.	71.7	85	43.4	32	0.24	1.62	0

L_A_H_O_R_E.

Jan.	68.0	82	40.1	28	1.04	3.91	0
Feb.	72.1	90	44.5	30	0.97	4.37	0
Mar.	82.6	106	53.2	39	0.79	5.37	0
Apr.	94.5	112	63.2	46	0.57	2.99	0
May.	103.7	118	72.2	59	0.59	4.38	0
Jun.	10.59	119	79.0	65	1.64	7.54	0
Jul.	99.6	118	80.1	69	5.45	16.47	0.32
Aug.	97.0	112	78.7	67	5.15	20.39	0
Sep.	97.3	110	73.1	63	2.20	10.72	0
Oct.	94.0	106	59.8	46	0.24	2.27	0
Nov.	82.9	94	47.3	36	0.10	0.52	0
Dec.	72.3	87	40.6	29	0.47	2.51	0

STATEMENT SHOWING TEMPERATURE AND RAINFALL VALUES

S I A L K O T

	Temp: in °F				Rainfall in inches.		
	Mean daily Max.	Highest Max.	Mean daily Min.	Lowest Min.	Mean Monthly.	Highest in a Month.	Lowest in a Month.
Jan.	65.6	79	42.2	28	1.96	8.12	0
Feb.	69.4	88	45.5	27	1.67	5.78	0
Mar.	88.1	104	54.2	35	1.51	7.38	0
Apr.	92.4	111	64.7	47	1.00	4.68	0
May.	102.2	116	74.3	55	0.99	4.06	0
Jun.	105.0	119	80.3	65	2.39	12.88	0
Jul.	97.4	110	79.6	67	8.35	23.30	1.36
Aug.	94.2	110	78.2	66	9.30	30.60	1.25
Sep.	94.6	108	73.8	59	3.43	13.84	0
Oct.	91.4	104	62.1	45	0.34	3.14	0
Nov.	80.6	95	49.1	34	0.17	3.39	0
Dec.	69.4	82	42.2	29	0.72	3.94	0

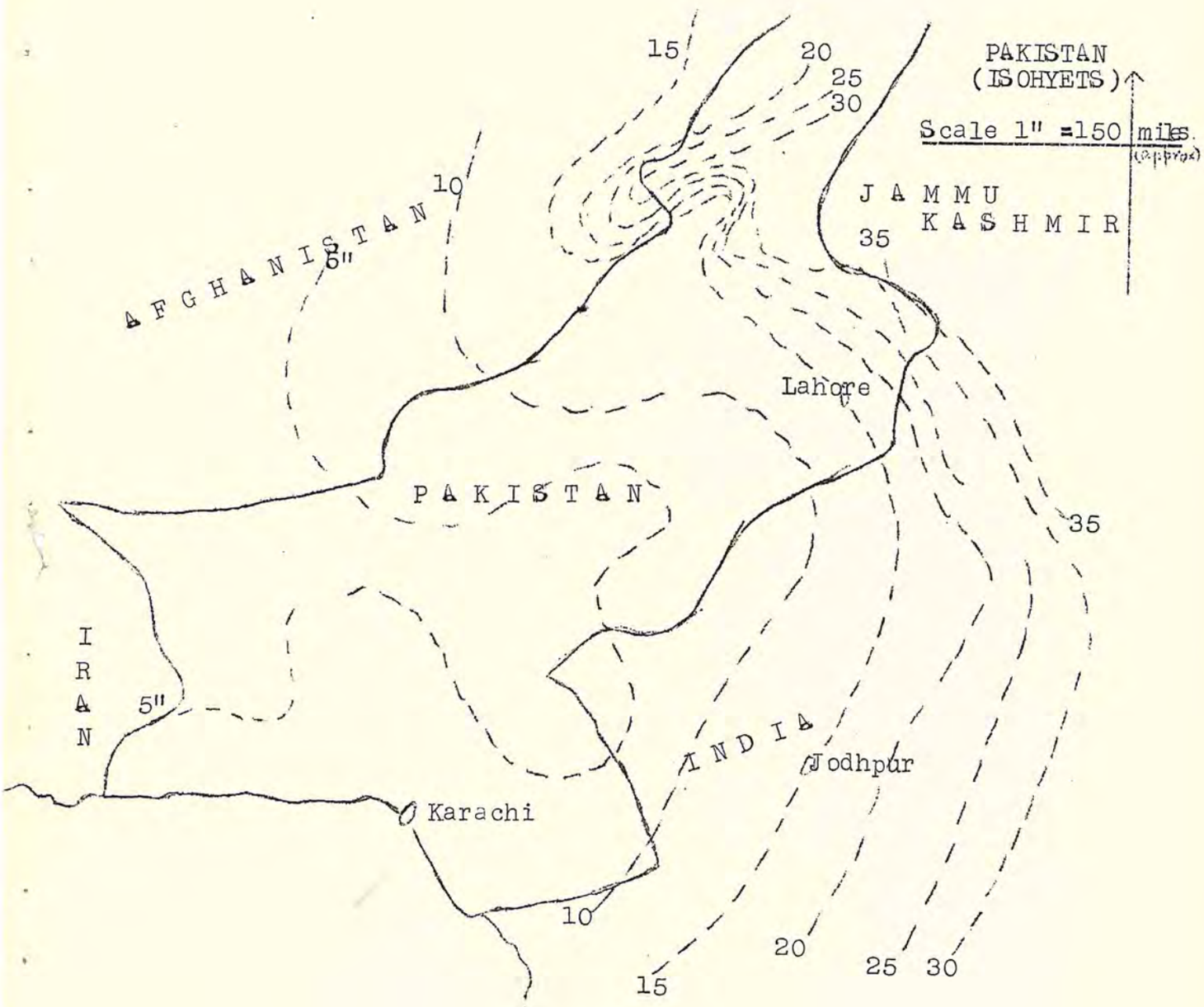
R A W A L P I N D I

Jan.	62.3	80	37.9	25	2.49	8.41	0
Feb.	65.2	85	41.7	27	2.48	7.84	0.01
Mar.	75.1	96	50.4	34	2.67	11.35	0
Apr.	86.2	106	59.3	41	1.92	6.13	0
May.	97.7	114	68.7	43	1.25	8.24	0
Jun.	103.5	114	75.9	60	2.31	13.55	0
Jul.	97.8	117	77.1	64	8.07	21.06	0.58
Aug.	93.7	111	75.5	63	9.17	23.58	1.92
Sep.	93.4	107	69.3	53	3.89	11.34	0.01
Oct.	88.6	100	57.0	42	0.60	5.35	0
Nov.	77.7	92	44.4	31	0.28	3.42	0
Dec.	66.8	82	37.8	27	1.24	4.47	0

STATEMENT SHOWING TEMPERATURE AND RAINFALL VALUES.

M U R R E E.

	Tem: in °F				Rainfall in inches.		
	Mean daily Max.	Highest Max.	Mean daily Min.	Lowest Min.	Mean Monthly.	Highest in a Month.	Lowest in a Month.
Jan.	45.2	65	30.7	12	3.79	10.65	0
Feb.	46.7	71	31.1	13	4.31	16.70	0
Mar.	55.6	79	31.1	20	4.81	18.82	0.56
Apr.	55.3	85	46.9	29	4.13	13.69	0.13
May.	75.1	95	55.6	39	2.62	11.46	0.06
Jun.	80.7	95	60.5	42	3.98	13.97	0.03
Jul.	76.2	95	58.9	46	12.40	25.75	2.35
Aug.	73.2	87	57.4	46	13.81	33.68	4.87
Sep.	72.3	82	54.8	41	5.42	14.71	0.25
Oct.	67.6	79	49.3	32	1.56	13.77	0
Nov.	59.5	77	41.0	30	0.73	5.41	0
Dec.	50.7	69	34.9	20	1.80	7.84	0


PAKISTAN
(ISOHYETS)
Scale 1" =150 miles.
(approx)
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30
35
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5"
AFGHANISTAN
JAMMU
KASHMIR
Lahore
PAKISTAN
IRAN
5"
INDIA
Jodhpur
Karachi
10
15
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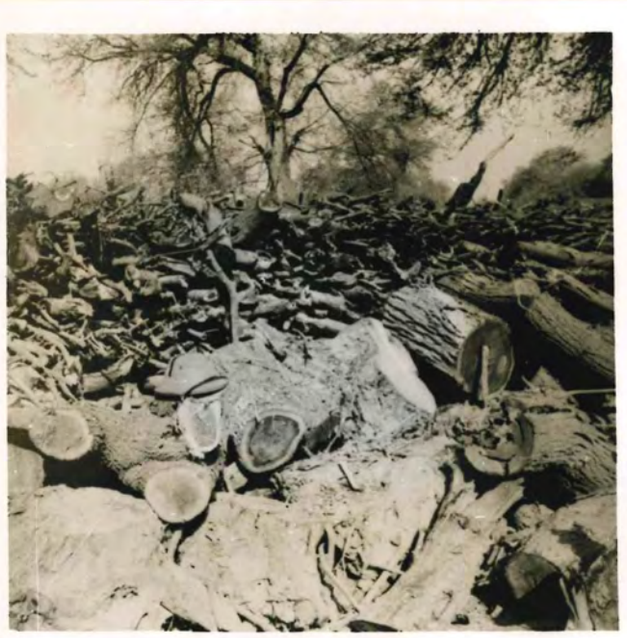

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