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DEVELOPMENT OF SECONDARY WOOD PROCESSING INDUSTRIES

(DP/TUR/76/015)

TURKEY

Technical report: Development of the chemical wood processing industries

Prepared for the Government of Turkey
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Walter Emrich, consultant in the chemical processing of wood

United Nations Industrial Development Organization
Vienna

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Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

The monetary unit in Turkey is the lira (. During the period covered by the report, the value of the LT in relation to the United States dollar was $US 1 =

The use of a hyphen between dates (e.g. 1960-1965) indicates the full period involved, including the beginning and end years.

References to tons are to metric tons, unless otherwise specified.

Besides the common abbreviations, symbols and terms, the following have been used in this report:

BTU	British thermal units
1 acre	0.4 hectare (ha)
FRI	Forest Research Institute
QMC	Quebracho mimosa chestnut
EIU	Economist Intelligence Unit LTD.

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ABSTRACT

The Government of Turkey has decided to make fuller use of its forestry resources and wishes to develop a secondary wood processing industry. To this end, the Ministry of Forests, under whose auspices the Forestry Research Institute (FRI) is operating, requested assistance from the United Nations Development Programme (UNDP). This request was approved and an expert in chemical processing of wood was sent to Turkey on the project "Development of Secondary Wood Processing Industries" (DP/TUR/76/015). His mission started on 28 February 1977 and ended on 12 April 1977. The United Nations Industrial Development Organization (UNIDO) was the executing agency.

The long-term objective of the project is to contribute to the further development of the forest industries sector in Turkey which is a key factor in the Government's drive to generate employment opportunities and to promote exports.

The short-term objective is the establishment of a programme for the development of chemical wood processing and secondary wood processing industries.

The project also aims to improve the social and economic conditions of the forest population.

The consultant was attached to the FRI, which provided the counterpart. At the beginning of his mission, it was agreed with representatives of the FRI that, in view of the short time available, his duties should be limited to the following:

(a) Tannin extraction from red pine bark, especially Pinus brutia and Pinus protea;

(b) Extraction of naval stores (rosin and turpentine) from gum and wood;

(c) Charcoal manufacturing out of residues, after extraction of tannin and naval stores etc., and out of forestry and sawmill wastes of Rhododendron ponticum - with emphasis on the use of the excess energy generated in specially designed integrated industrial centres.

His conclusions and recommendations are as follows:

(a) The areas proposed for developing the chemical wood processing industry are the processing of bark to tannin extracts; conversion of forest

residues, wastes of the primary and secondary wood industry and Rhododendron ponticum into charcoal, chemicals and usable energy; and the manufacture of naval stores from tree gum, wood stumps and tall oil;

(b) The proposed research programmes for the development of the chemical wood processing industry are structured as intensive programmes to be conducted within a given time limit, not exceeding 18 months;

(c) It is recommended that the services of a consultant in chemical processing of wood be requested for six months to advise the programme manager. Four group leaders have to be trained outside Turkey for a period of 3-4 months each;

(d) The estimated cost of the necessary laboratory equipment is $38,000 and that of the required pilot plant $12,000.

CONTENTS

Page

Annexes

Tables

INTRODUCTION

The Government of Turkey has decided to make fuller use of its forestry resources and wishes to develop a secondary wood processing industry. The Forest Products and Forest Industry Division of the Forest Research Institute (FRI), Ministry of Forests, in consultation with a Senior Industrial Development Field Adviser attached to the office of the United Nations Development Programme (UNDP) in Ankara, identified some forest products and by-products that could be utilized industrially, processed in Turkey and commercialized. The National Five-Year Plan stresses the importance of the utilization of forest products and the development of forest co-operatives.

In September 1975, representatives of the FRI met with a consultant of the United Nations Industrial Development Organization (UNIDO) and it was recommended that preliminary studies be made to assess the appropriate technologies and manufacturing processes, and the scale of operations needed to give competitively-priced products.

The forest-based processing industries selected were:

(a) Tannin extraction from red pine bark;

(b) Utilization of rhododendron wood for particle board;

(c) Utilization of pharmaceutical trees and herbs;

(d) Manufacture of turned hardwood products (handicrafts, furniture, shoe lasts, spindles etc.) on a small-scale co-operative basis;

(e) Extraction of oleo-resin from wastes (e.g. roots) of pine-wood, and chip and charcoal production from the residues obtained after the extraction of naval stores;

(f) Production of particle board and cellulose (from the chips remaining after rosin extraction from the waste roots of pine trees).

The products from these industries, aimed at utilizing economically selected forest products, will meet domestic and foreign market demands, provide additional foreign exchange earnings, create employment opportunities in forest areas of the country and improve living standards of the population.

The Ministry of Forests, under whose auspices the FRI operates, requested assistance from the UNDP to help develop these industries. This request was approved and an expert in the chemical processing of wood was sent to Turkey on the project"Development of Secondary Wood Processing Industries"(DP/TUR/76/015). His mission started on 28 February 1977 and ended on 12 April 1977; UNIDO was the executing agency.

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Conclusions and recommendations are contained in the body of the report.

I. FINDINGS

A. Chemical wood products

Naval stores

Crude tree gum is processed in three plants that use methods of gum cleaning and steam distillation with an average yield of 20% for turpentine and 71% for oleo-resin.

The harvesting of the resin is done by scarification between March and October.

Harvest of crude resin

Year	Tons
1970	5 791
1971	6 650
1972	6 704
1973	5 572
1974	2 656
1975	1 935
1976	2 572

Trials with stimulators are being undertaken by the FRI to increase the yield, but significant response has not been established yet. One important raw material source (pinetree stumps) for naval stores in Turkey is still unexploited. The softwood clear-cutting programme of the Ministry of Forestry forsees an annual increase in the availability of these stumps (table 1).

Unfortunately, it is not possible to give an exact calculation for the value of the naval stores that could be obtained based on this inventory because the Turkish Ministry of Forests does not assess its dead stump wood.

Tannin extracts

Vegetable tannin, an essential agent used by the leather industry, is being produced in two small plants from valonia acorn of Quercus Aegilops.

Table 1. Annual clear-cutting programme of pinewood (m^3)

Area	*Pinus brutia*	*P. nigra*	*P. silvestris*	Fir	Total
Adana	419 474	229 891	-	42 668	692 033
Adapazari	6 732	4 838	1 034	16 127	28 731
Amasya	20 843	147 385	280 515	30 564	479 307
Ankara	3 719	208 420	149 598	60 213	421 950
Antalya	901 858	87 973	-	51 594	1 041 425
Artvin	-	-	101 584	140 480	242 064
Balikesir	48 990	305 443	196 100	776	551 309
Bolu	10 839	250 992	414 018	414 465	1 090 314
Canakkale	145 910	188 051	-	2 284	336 245
Denizli	223 221	299 185	480	-	522 886
Elazig	549	-	-	-	549
Erzurum	-	-	372 049	973	373 022
Eskisehir	46 826	463 277	52 799	253	563 155
Giresum	-	-	79 081	25 713	104 794
K. Maras	110 975	105 451	-	18 156	234 582
Kastamonu	6 224	424 621	369 105	443 398	1 243 348
Istanbul	-	961	52	-	1 013
Izmir	441 129	108 927	-	-	550 056
Isparta	103 945	154 864	-	2 753	261 562
Mersin	538 619	36 395	-	31 060	606 074
Mugla	708 701	164 589	-	6	873 296
Trabzon	-	-	63 983	50 453	114 436
Zonguldak	1 379	131 260	63 539	201 819	398 547
Total	3 740 433	3 312 523	2 143 987	1 533 755	10 730 698

Tannin production, 1976 (tons)

Area	Capacity	Production
Salihli	9 000	4 500
Izmir	12 000	6 700

Some basic research work has been done already by the FRI on the bark of Pinus silvestris and Pinus nigra with encouraging results. The amount of bark generated in the forests, sawmills and pulp and paper establishments is growing because of the demand in the domestic market for paper and manufactured wooden products.

Charcoal

Until now charcoal has been produced by villagers in many wooded areas of Turkey in small operations that use the earth kiln method only. Lump charcoal is the only product recovered and the yield is less than 10%. Although domestic demand is not recorded the importance of this industry for the economy of the country is recognized by the Ministry of Forests and commercial standards for charcoal were set in 1975.

The FRI has done significant work on the utilization of sawmill wastes. According to their findings the average band or frame sawmill will generate 40% of wastes in the form of slabs, edgings, ends and sawdust.

Applying this figure to the present sawmill capacity, approximately 4 million m^3 of convertible raw material for charcoal operations can be produced. This calculation does not include the wastes of other industries such as furniture, joinery, veneering, fibre, particle board and the logging residues in the forest. Although much of the wastes are consumed by the wood industry itself a research programme to find better and more economical outlets can be justified. Two areas of Turkey seem to fulfil the requirements for successful charcoal operations for the following reasons:

The Black Sea coast - north-east Turkey:

(a) There are mature stands of Rhododendron ponticum;

(b) The wood industry and the new particle board plant, that is in the planning stage, are perfectly suited to accept the excess heating gas;

(c) The proximity to a deep-water port will reduce freight costs for export goods;

Bolu - north-west Turkey:

(a) There are available hardwood forest residues and industrial wastes;

(b) The existing industry is suitable as a user of excess heating gas;

(c) The proximity to the highway system minimizes freight costs.

B. Development programme for the chemical wood industry

Tannin production

Almost every tree or shrub contains vegetable tannins in the leaves, twigs, bark, wood or roots. Therefore the traditional source for tannin is the forest. In general, vegetable tannins are able to react with gelatin to form solid, insoluble substances. This property makes tannins valuable to process hides. The increased chemical and biological stability, which leather possesses in comparison with fresh skins or hides, results primarily from tanning operations and the longest application of tannins by man has been in the leather industry.

The tanning materials of today may be natural or artificial. Besides vegetable tannins, mineral tannins are in use too. Some of the most common agents of the latter group are chrome alum, sodium or potassium dichromates.

The most important raw materials for vegetable tannins are shown in table 2. Most tanners prefer to use a blend of tanning materials. The tanning operations therefore differ depending on the tanning material applied (table 3).

The bark of Pinus brutia, a species that is common in countries bordering the Mediterranean Sea, was used for leather tanning in Algeria and Tunisia and continued to be used in Spain until 1950.

The Federal Republic of Germany and Sweden processed bark of the pinus family for tanning extracts during the Second World War and continued production until the late 1940s. The sole-leather tanners in Canada and the United States have for many years preferred bark from the hemlock (Tsuga canadensis) to all other materials.

Turkey has the advantage of having very large forest reserves (25% high forest and coppice) and a substantial forest village population. The present coniferous clear-cutting programme highlights the impressive wealth of the country. Table 4 gives an indication of world demand for such products.

Table 2. Important vegetable tannins

Part of the tree	Species	Percentage of tannin	Provenance
Bark	Oak	5 - 17	Europe
	Quercus seesiflora		
	Q. pedunculata		
	Spruce	7 - 20	Europe
	Hemlock	7 - 20	North America
	Tsuga canadensis		
	Willow	10	North Europe, USSR
	Birch	12	North Europe, USSR
	Mimosa	22 - 48	Australia, Brazil, East Africa, South Africa
	Acacia molissima		
	A. decurrens		
	Mangrove	28 - 48	Tropical countries
	Rhizophora		
	Maletto	48	South-west Australia
	Eucalyptus occidentalis		
Wood	Oak	3 - 10	
	Chestnut	6 - 15	France, Yugoslavia
	Castanea vesta		USSR, United States
	Quebracho	14 - 26	Argentina, Brazil
	Quebrachia lorentzi		Bolivia, Paraguay
Leaves, pods, fruit	Valonia	16 - 38	East Mediterranean, Turkey
	Quercus valonia		
	Trillo (scalea of valonia)	30 - 53	East Mediterranean, Turkey
	Dividivi	25 - 50	Mexico, Venezuela
	Algorabilla	35 - 52	South America
	Caesalpinia brevifolia		
	Myrobalan	25 - 48	India
	Terminalia		
	Sumac	13 - 35	Mediterranean
	Gambir	40 - 45	China, India
	Uncaria gambir		

Table 3. Flow diagram of tanning operations

Mineral tannage	Combination tannage	Vegetable tannage
↓	↓	↓
Chrome tannage	Chrome tannage, vegetable retannage	Vegetable yard
↓	↓	↓
Neutralization and fixation	Wringing and setting out	Vegetable layaway
↓	↓	↓
Colour fatliquoring	Colour fatliquoring or stuffing	Extracting in drum
↓	↓	↓
Drying to crust	Drying	Dry drip
↓	↓	↓
Sammying	Sammying	Bleaching
↓	↓	↓
Staking	Staking	Oil wheel and conditioners
		↓
		First drying
		↓
		Extra tannages
		↓
		Final drying

Source: National and Industrial statistics.

Another source of tanning extracts that has commercial importance for Turkey is Turkish valonia, the acorn extract of Quercus valonia, that yields about 5,000-6,000 tons per year, of which 1,500-2,000 are exported. The world trade in valonia declined from 14,000 tons in 1972 to approximately 7,500 tons in 1975, the latest figure available.

The market for vegetable tannins

With the end of the Second World War the extracts of quebracho, mimosa and chestnut (QMC) became available once more. Tanners reverted to their use and the production of pine extract or the direct use of spruce bark ceased. Whereas world production of QMC totalled 418,000 tons in 1948 it dwindled to a low of 227,000 tons in 1975 (table 4). During the period of 1950-1953 236,000 tons QMC were delivered to the United States stockpile of which about 73,000 tons were released commencing 1967 (table 5). As a result of these United States releases the actual world usage of QMC has not been directly related to world production.

Table 4. World production of QMO[a] tanning materials, 1948-1975[b]
(tons)

Year	Amount	Index (1948 = 100)
1948	418 040	100
1949	401 240	96
1950	506 753	121
1951	521 255	125
1952	469 993	112
1953	451 801	108
1954	409 868	98
1955	416 117	99
1956	403 801	97
1957	430 827	103
1958	405 365	97
1959	410 033	98
1960	380 751	91
1961	408 549	98
1962	373 776	89
1963	353 258	84
1964	375 532	90
1965	353 891	84
1966	356 667	85
1967	336 281	80
1968	350 208	84
1969	326 108	78
1970	278 939	67
1971	282 195	67
1972	301 708	72
1973	253 087	60
1974	265 903	64
1975	226 642	54

<u>Source</u>: National and industry statistics.

a/ Quebracho, mimosa and chestnut

b/ Including mimosa bark in terms of extract,

Table 5. Deliveries of QMC from the United States Government stockpile (Tons)

Year	Amount
1962	454
1963	1 881
1964	7 776
1965	2 596
1966	1 008
1967	290
1968	1 473
1969	9 582
1970	7 378
1971	6 176
1972	5 041
1973	10 778
1974	13 261
1975	10 000 [a/]
Total	77 694

Source: United States Government Statistics.

a/ Estimated.

It is obvious that from a great variety of vegetable tannins only three enjoy market success, the reasons for which are (a) their intrinsic characteristics, further improved by careful extraction methods, result in a light coloured and flexible leather; (b) their versatility makes them suitable to tan heavy leather as well as light leather such as split leather and sheep or goat leather; (c) they have rapid penetration; (d) they are complementary to each other when used together in blends; and (e) reliability of quality and deliveries. However, this applies only to market economy countries. It is estimated that other vegetable tannins than QMC and valonia totalling about 150,000 tons per year are produced mainly in the Union of Soviet Socialist Republics (50,000 tons), China (40,000 tons) and India (30,000 tons). These tonnages include bark and extracts of spruce and pine species. However, exact figures are not available.

Forecasts of world consumption of QMC extracts done by the Economist Intelligence Unit Ltd. (EIU) show a further drop till 1985 irrespective of the producing country (table 6).

Table 6. Forecast of world consumption of QMC extracts
(Tons)

Year	Developed countries		Developing countries		Centrally planned economies		World total	
	Total	Index	Total	Index	Total	Index	Total	Index
1975	130 383	100	86 586	100	19 673	100	236 642	100
1978	109 000	84	84 000	97	18 000	91	211 000	89
1980	97 000	74	82 000	95	16 900	86	195 900	83
1982	86 000	66	80 000	92	15 900	81	181 900	77
1985	72 000	55	77 000	89	14 500	74	163 500	69

Source: EIU estimates.

At one time, there were four factories in Turkey processing valonia extract. Only two are still operating: one at Izmir, belonging to Endustiyel Turk Anonim Sirketi and the other at Salihli, belonging to the Sumerbank. They are both working at half capacity.

Uses for vegetable tannin

Vegetable tannin is used in inks, as a preventive of steam-boiler scale and as a preservative for fishing nets. A very special application can be found in the petroleum refinery in the Shell tannin-solutizer process. In conjunction with alkylphenols or iso-butyric acid, tannin acts as an oxidation catalyst to convert mercaptans into disulphides. More than 20 vegetable tannins have proved to be effective thinners of fresh-water base drilling fluids as well as those treated or mildly contaminated. Thinners in drilling mud act to reduce its viscosity and to oppose the development of gel structure without substantially altering the hydration of clays.

The use of quebracho and quebracho mixtures in drilling fluids fell from 21,000 tons in 1954 to around 4,000 tons in 1963. Today, two functions provide the entire market for tree-derived products in oil-well drilling fluids: chemical control and lost-circulation correction. Substantial research funds will undoubtedly result in further improvement. However, the success enjoyed by forest products as an extremely useful material in oil-well drilling comes about primarily through the excellent co-operation between the petroleum drilling and forest products industries working together over the years on research.

New markets for bark extracts emerged in Australia in 1963 when trials were made at the OKAL particle board plant on an adhesive resin prepared from mimosa (black wattle). Further research and tests proved the ability of these new adhesives to meet relevant standards.

Since that time the idea has sparked research programmes in many parts of the world. Thermosetting adhesive resins with tannins, mostly mimosa, were prepared for the production of exterior grade plywood, block-board and particleboard and cold setting adhesive formulations for finger jointing and lamination of timber. Other tannin resins were used to produce semi-exterior grade plywood and tannins incorporated in base glues were applied to fully-exterior grade plywood and construction block-board.

A typical glue mix and process data for particle-board production are shown in tables 7 and 8. The main benefits derived from these adhesives are neutral glue lines and faster press cycles.

Table 7. Process variables for particle boards manufactured with tannin-formaldehyde adhesive

Boards	Press temp (°C)	Heating rate (sec./mm)	Press time (min.)	Thickness (mm)	Density (kg/m)
1.5	135	74	15.0	12	700.0
6.10	170	30	6.1	12	691.9
11.15	200	20	4.05	12	690.8
16.20	200	15	3.05	12	703.3
German Specification DIN 68761 (3) (1967) (7)				8.13 (range)	750 (max)

Table 8. Glue mix

Constituents	Parts by mass
Wattle extract	45
Water	55
Aqueous caustic soda solution (50% NaOH by mass)	4
Glacial acetic acid	3
Aqueous formaldehyde solution (40% HCHO by mass)	11.25

Technology

The raw materials used commercially for the extraction process are those that contain large amounts of tannins. If the tannins are less than 10% they cannot be economically extracted, particularly from those species that are of value for their tannin content alone.

Careful consideration has to be given to transportation and freight costs; as a rule of thumb, raw materials with a tannin content less than 20% require extraction where they are harvested.

Until recently small-scale production units, which were mainly in Europe, were not viable and a great many of them had to close, including those producing QMC extracts. However, properly designed production units attached to establishments of the primary or secondary wood industry or integrated into an industrial complex may be able to operate well above the profit margin. They can be linked with modern waste-converting and disposal technology, as applied in many carbonization processes in the United States, and deliver such valuable industrial products as charcoal and chemicals and, at the same time, discharge recoverable excess energy.

Although debarking and the storing of bark seem to be simple operations, a prior, thorough exploration and extreme care have to be taken to prevent decay and fungal attacks that gradually diminish the tannin content of the raw material.

The extraction process has four stages:

(a) Shredding and classification of the raw material;
(b) Counter-current extraction under strict temperature control;
(c) Multiple vacuum condensation of the raw extract;
(d) Spray drying of the condensed extract.

There are many factors that make a successful vegetable tannin operation. For instance, as with any organic material, tannins are sensitive to temperature, therefore, the extraction for each species requires particular temperature characteristics to maintain a high yield. Also, an increase of tannin yield of up to 60% can be stimulated by certain chemicals, such as sodium sulphite or sodium bisulphite. Other factors are the hardness of the extraction water and the design and material used for the equipment.

Objectives

The approach is structured as a growth-programme with a strict exploratory purpose for industrial and market development. It relies on the fact that the FRI has basic knowledge and experience of this research category. The programme is designed to enable the FRI to gain command of the domestic tannin resources with a minimum of time and effort, to co-operate with industry and interested groups, and to enter a competitive market.

Research programme

Research and development Phase 1	Venture planning	Commercialization	Duration (months)
Programme development			2
Exploration	First screening		12
Defining project	Second screening	Monitor research and development	4
Total duration			18
Phase 2			
Developing pilot operations	Investment proposal	Monitor market	
Produce for market	Appropriation engineering and construction	Train staff and take over market development	

Details of the research programme

Phase 1

Programme development

Determination of priorities

Literature search

Search of patents

Training helpers

Organization of laboratory services

Exploration stage — First screening

Raw material

Debarking, bark storing

Classification

Transportation

Tannin characteristics

Provenance records

Technology

Shredding, iron separation

Decontamination

Countercurrent extraction

Vacuum evaporation, multiple stage

Spray drying

Temperature characteristics

Yield characteristics

Effects of additives

Basic analysis of raw extracts

Packaging

Waste disposal

Characteristic of wastes

Calorific analysis
(Recovering of data in conjunction with charcoal project)

Extract characteristics

Tannin content, non tannins

Sugar components

Fermentation

Discolouration

Provenance records

Tanning tests

Penetration, duration

Various leather characteristics

Precipitations

Staining, colour effects

Competitive materials

Modified extracts

Blends

Chemical modification

Adhesives

Thermosetting adhesives

Unfortified tannin-formaldehyde

Phenol, resorcinol-formaldehyde

Process variables

Particle-board, plywood
Physical tests, bond quality
Bending strength, tensile strength
Swelling

Information

Publications in periodicals
Information service
Instruction manuals
Market tests
Standardization

If the first venture-screening produces promising indications, the range of process conditions should be defined to give sufficient basis and enough data for the design of a pilot plant unit (defining stage)

Defining stage

This stage involves research work on a bench-type pilot plant, to obtain reliable data for a future commercial plant

Second screening

During the defining stage a second, more thorough, screening will provide the basis for two decisions: (a) to proceed commercially; and (b) to undertake further development to provide the necessary data for the investment proposal.

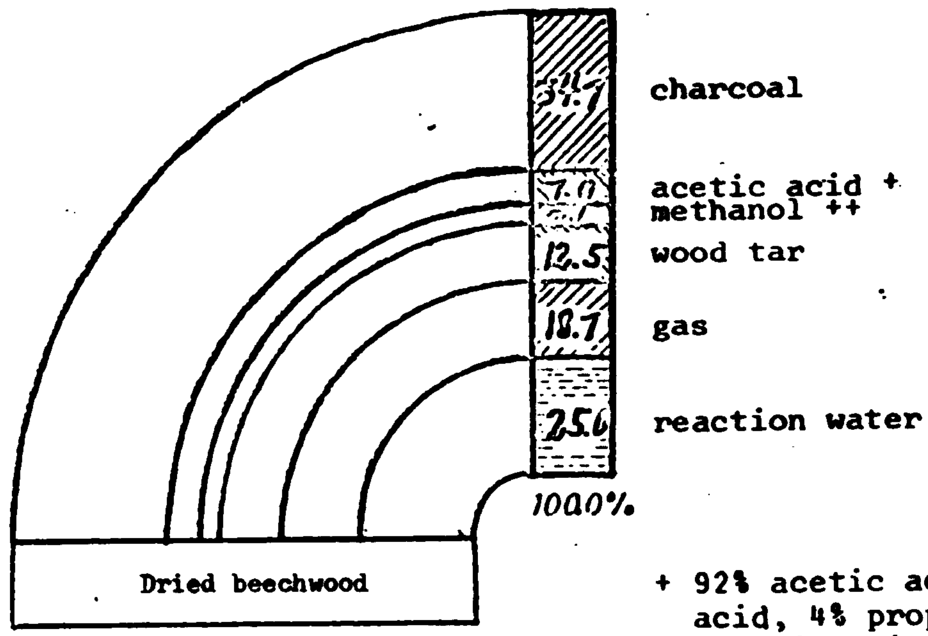
C. Development programme for carbonization (charcoal)

Production

All species of wood can be converted by carbonization into charcoal and useful by-products. In the course of history the carbonization process has undergone many changes but charcoal has always been an important commodity.

High temperature heating in airtight kilns or retorts (destructive distillation) breaks down the wood into gases, a watery tar mixture and the familiar solid carbon material. Beechwood, which is the most sought after raw material in European countries, shows a representative yield (table 9). There is a variety of over hundred products recoverable from almost any charcoal operation (table 10).

Table 9. Products of the carbonization process



\+ 92% acetic acid, 4% formic acid, 4% propionic acid and butyric acid

++ 65% methanol +15% acetone +15% methyl acetate +5% aldehyde and ketone

Table 10. Charcoal and main by-products of the carbonization process

Product	Raw material	Application
Charcoal	Beechwood	Activated carbon, ferro-silicon, grill coal, metal working, sodium cyanide, carbon disulphide, Swedish iron, silicon
Charcoal smalls	Charcoal	Activated carbon, additive to animal food, filling compound for bottled gas, hardner
Charcoal dust	Charcoal	Activated carbon, lining of moulds in metal foundries, production of briquettes, cementation granulate (Durferrit), pyrotechnique
Wood vinegar	Beechwood	Preservation and flavouring of meat and smoked fish, perfume and flavouring industry
Beechwood tar	Beechwood	Rope industry, veterinary medicine, pitch, creosote
Crude methanol	Wood alcohol	Methyl acetate
Solvent	Wood alcohol	Cellulose esters and agglutinants, synthetic materials, laquers
Methyl formate	Crude wood vinegar + crude methanol	Cellulose esters and agglutinants, synthetic materials, lacquers
Methyl acetate	Crude wood vinegar + crude methanol	Cellulose esters and agglutinants, synthetic materials, laquers
Acetic acid	Crude acetic acid	Chemical, pharmaceutical, food, convenience food, rayon, textile and film industries, vinegar
Propionic acid	Crude acetic acid	Pharmaceutical and perfume industries
Butyric acid	Crude acetic acid	Pharmaceutical and perfume industries

Modern wood-carbonizers are being used increasingly by the industry as waste coverters of forestry residues, wood industry residues, agriculture wastes and in the recycling of municpal wastes. Besides the fact that charcoal in lump or briquette form holds a firm place in a fast-growing market, the carbonization process also generates heating gas, which may be introduced as supplementary energy in adjacent operations.

Turkey has the unusual position among world forest resources in having the largest forest reserves per capita. Although figures are not available, it can be assumed that domestic charcoal is produced mostly by villagers who use the old earth kiln method as the yield of marketable charcoal is very low, and no by-products can be recovered, from the charcoal pit.

The market for charcoal

In developed countries large amounts of charcoal are used as recreational fuel and production will continue to expand as this use increases. In 1976, over two billion dollars worth of products for barbeques were manufactured by United States companies. A breakdown of dollar volume at retail prices is given below.

	Millions of $
Charcoal briquetes	145
Barbeque grills	245
Lighters	55
Barbeque utensils	18
Food	1 900
Miscellaneous supplies	9
Total consumer expenditures	2 272

Trends in the United States are likely to be adopted by the developed countries of Europe.

Three out of four United States households, involving some 155 million people, have barbeques at least once a year. Barbequeing tends to attract younger, larger households. There were some 600 million charcoal barbeques in 1976 in over 50.5 million United States households. According to the data from the Charcoal Briquete Institute of the United States, 90% of all barbequeing is done with charcoal, 7% with natural gas and only 3% with electricity.

Whereas the charcoal production in the United States is steadily increasing, both for the recreational and industrial sector, by the unusual rate of over 8% per year, demand in European countries has exceeded supply, the reason being that the steep increase in wood-waste prices during the last decade has discouraged investments. To fill this gap, the European market has received imports from more than eight countries.

There is no chance in the foreseeable future that this situation will change because such highly competitive products as particle board, fibreboard etc. will take up the raw materials that have been the traditional source of the European charcoal industry.

Charcoal is an excellent raw material for activated carbon in the powdered, extruded and granulated forms. The European market particularly requires hardwood charcoal and hardwood tar for its activated carbon plants. The biggest markets for activated carbon in 1980 can be expected to be municipal and industrial waste treatment, and the dry-cleaning, sugar and syrup, motor vehicles and air-conditioning industries.

Because of the geographical situation of Turkey, and the increasing output of its forestry and wood industry wastes, its chances of entering the charcoal market are promising.

Technology

Based on data supplied by the FRI, and local findings the expert recommends that research efforts be concentrated on waste conversion and cordwood.

Waste conversion

The FRI has identified the areas of Bolu as typifying the accrual of wastes and forest residues. Besides the large state-operated Devlet Kereste Fbrikasi Karacasu - Bolu, a fibreboard plant and other establishments of the primary and secondary wood industries utilize hardwood and softwood wastes.

The shape, type and volume of these residues demand a centralized conversion operation. Only the continuous low temperature pyrolysis process is capable of converting these raw wastes into high energy fuel and, if desired into fractionated chemicals.

The pyrolysis gas generated at the production site could be used to replace present sources of process heat, and any excess sold to industry in the vicinity of the converter unit. Considering the rising costs and decreasing availability of non-renewable energy, this approach offers a sound economic basis for any industrialized area in Turkey.

The mass and heat balance for a pyrolysis unit producing 50 tons per day of the type envisioned by this study would be:

Mass balance	lb/day
Input	100,000 of dry feed
	17,000 of air
Output	25,000 of char
	9,600 of pyrolytic oil (chemicals)
	82,400 of gas

Energy balance	Million BTU per day
100,000 lb dry feed at 9,000 BTU/lb	900
Process losses	31
100,000 lbs of water 50% (moisture of raw material) evaporated at 1,600 BTU/lb	160
Difference	709
End products	
Charcoal (25,000 x 0.89 x 14,500)	323
Pyrolytic oil (10,500 BTU/lb)	101
Heating gas (3,348 BTU/lb x 0.85)	285

In other words besides 25 tons per day of charcoal, representing a market value of $4,000 ($160 per ton in 1976) 96.5 million kcal are generated if the pyrolytic oil is used as heating oil only.

Cordwood

Within the forest region along the Black Sea Coast some 500,000 ha are overgrown with rhododendron holding approximately 100 million m^3 (stacked) of raw wood material that, up till now, has been used only as fuel wood. The goal of the Ministry of Forests is to regain valuable forest areas for reforestation with fast-growing, multiple-purpose wood species for future industrial use.

Rhododendron ponticum offers an excellent raw material for any charcoal operation. Owing to its cell structure and its particular characteristics, the charcoal produced is a valuable raw material for activated carbon manufacture.

Based on the data supplied by the FRI and on local surveys it is recommended that a single- or double-walled masonry block kiln be used as carbonizer. These types have been used successfully in many parts of the United States, especially for hardwood conversion. They have several technological and economic advantages: low investment, construction can be done locally, and capacity of a plant may be increased as demand requires by adding more units. Unlike the continuous process technology, these kilns do not require highly skilled labour.

If well-designed, the kilns can be attached to existing industrial units and provide excess energy. The recovery of pyrolytic oils would also be possible and the costs of production could then be partly defrayed by the sale of these products.

For the designer however the masonry kiln technology raises specific problems. One is that it is rather difficult to forecast the characteristics of the kiln design. When rhododendron is used, there are no known data that would ease the engineering task of designing the kilns.

It is, therefore, highly recommended that pilot plant studies be incorporated into the FRI research programme. Necessary data for a commercial charcoal project may be obtained rather quickly in comparison with other designs and results of commercial operations.

Reliable tests can be performed in a 7 cord (1 cord = 4 x 4 x 8 ft) masonry kiln. If erected at an extension office site of FRI it could later serve as a training station.

The findings of the mission indicate that the production of charcoal has merit. No monetary value was assigned to such advantages as:

(a) Conservation of resources;

(b) Generation of skilled job openings and a general upgrading of the technological capabilities of the residents of the forest areas;

(c) Stimulus to the local economy;

(d) Alleviation of the problem of waste disposal with less pollution as a result.

Objectives

This project will enable FRI to elaborate, within a short period of time, a special charcoal technology including the use of by-products by industrial centres for the manufacture of pyrolytic products at world market standards.

Research programme

Research and development	Venture planning	Commercialization	Duration (months)
Phase 1			
Programme development			
Exploration	First screening		2
Defining project	Second screening	Monitor research and development	
Phase 2			
Developing pilot operations	Investment proposal	Monitor market	
Product for market	Appropriation engineering and construction of kilns	Training staff and take-over of market development	

Details of the research programme

Programme development

Organization of laboratory personnel

Organization of pilot plant personnel

Training of helpers

Literature search

Patent search

Exploration stage

Laboratory work	Pilot plant studies	First screening
(a) Raw material (residues and waste), classification of shape, provenance, moisture characteristics, contaminants Dimensioning Transportation	(a) Same as laboratory work, but at the pilot plant stage	(a) The first screening should produce sufficient data to compile representative residue and waste samples for test runs.[a]
(b) Raw material (rhododendron) Procedure as above	(b) Same as laboratory work, but at the pilot plant stage	(b) The first screening should produce sufficient data to select representative samples for test runs[a] in the pilot plant

Defining stage

Laboratory work	Pilot plant studies	Second screening
(a) Char Classification Attrition resistance Fixed carbon content Volatiles Ashes characteristics	(a) Char Kiln charging and discharge Igniton characteristics Phase characteristics Air-flow Temperature characteristics Batch duration Yield determination Bagging	
(b) Briquetting Grinding Binder, filler Drying Burning performance	(b) Briquetting[a]	

[a] Test runs are to be conducted by the suppliers of equipment.

(c) Pyrolytic oil Tar content Acetic acid, methanol Butyric acid, tars Water content	(c) Pyrolytic oil Condensation Sampling	During the defining stage, the second screening will provide the basis for the decision whether to proceed commercially
(d) Offgas Hydrogen CO_2, CO, water BTU, characteristics	(d) Offgas Characteristic amounts Sampling	
(e) (No action)	(e) Paraphernalia Safety requirements Environmental impact studies	
(f) Information Instruction manuals Market tests Information service Standardization	(f) Same as for the laboratory work but on a pilot plant scale.	

D. Development programme for naval stores

Production

Naval stores are of four types: gum; steam distilled (S.D.); sulphate; and sulphite.

Gum naval stores are produced by scarification of pines and collection of the oleo-resin, which is then processed into rosin and turpentine.

The S.D. naval stores, though steam is no longer used in the processing, are obtained from virgin pine stumps from which the sap-wood has rotted away. The remaining stump heart-wood, which contains up to 25% extractives, is chipped, shredded, and extracted with petroleum solvents. The extract is distilled to recover the solvent, a turpentine fraction, pine oil and a crude resin. This dark red resin is further purified by selective absorption on fullers' earth or by extraction with furfural.

Sulphate and suphfite naval stores are obtained as by-products of the pulp and paper industry from tall oil. The term tall oil is derived from the Swedish word tallolja which translates as pine oil.

World-wide tall oil production and fractionation has increased five to six times within the last 20 years. One of the most promising developments results from research at the United States Forest Service naval stores and timber production laboratory. Scientists at that laboratory discovered that treatment of pines with the herbicide paraquat, stimulates extensive oleoresin formation and diffusion into the wood substance. The application will either increase yields of sulphate or sulphite naval stores or provide a new type of wood naval stores by pre-extraction of the resin saturated wood prior to pulping.

The market for naval stores

The growing concern over price and availability of petroleum and natural gas has focused attention on silvichemicals, therefore the demand for wood, particularly because of its renewable nature, seems set to increase.

Actions by technical groups especially reflect the new enthusiasm for silvichemicals. For instance the National Academy of Science in the United States has formed a committee on renewable sources for industrial materials which aims to drum up United States Government support for research on topics such as wood-based chemicals. Silvichemicals are a hot topic at meetings. At the Eighth Cellulose Conference in May 1975 at Syracuse, New York, United States, and the Wood Chemistry Committee of the Technical Association of the Pulp and Paper Industry (TAPPI), at Atlanta, Georgia, over 100 papers on the theme of wood chemicals - a future challenge were presented.

The expert's proposed research programme focuses on the three main products of the naval stores: tall oil fatty acids, rosin and turpentine.

Tall oil fatty acids

These are on the market with varying resin contents from 40% to less than 0.5%. These fatty acids are used mainly in protective coatings, intermediate chemicals, soaps and detergents, and as flotation agents. The intermediate chemicals category is meant to be used for expoxy tallates, dimer acids which, in turn, are used in polyamide resins for inks, adhesives and coatings. The distribution of applications for the tall oil fatty acids is:

	Percentage
Intermediate chemicals	35.6
Protective coatings	30.9
Soaps, detergents	13.4
Flotation	6.2
Other	13.9

Rosin

Rosin consists primarily of dipentine resin acids of the abietic and primaric type. High proportions of the conjugated abietadienoic acids are best for preparing the maleic anhydrid Diels-Alder products. Rosins are used mostly in some modified form: hydrogenated, dehydrogenated, disproportionated, esterified, polymerized, as salts, or reacted with formaldehyde or maleic anhydrid, for example. The largest use is in the sizing of paper to control water absorption. A rosin soap or emulsion is added to the pulp and is precipitated onto the paper fibres with aluminium sulphate. Rosin soaps are also important used as emulsifying and tackifying agents in synthetic rubber manufacture. The United States contributes about 40% of world production, followed by the Union of Soviet Socialist Republics, China, Portugal and Mexico respectively.

The percentage distribution of the various application is given below.

	Percentage
Chemical intermediates and rubber	42
Paper size	33
Resins and ester gums	18
Coatings	3.9
Others	3.1

Turpentine

The major use of turpentine was once as a solvent in paints, but in the past 10 years it has been used increasingly as a chemical raw material. As the fractionated components have specific uses, the composition of the turpentine is important. Of the turpentine types, sulphate turpentine can have the greatest variations because of the number of species pulped and the large geographical range from which they are taken. The major use of turpen- involves the conversion of alpha (α) pinene with aqueous mineral acids to synthetic pine oil. These pine oils are used in mineral flotation, in processing textiles, as solvents, as de-odorants, and as bactericides. Approximately 65% of the pine oil produced is synthetic, the remainder is the so-called natural pine oil that is obtained on fractionation of the stump-wood extractives.

Coupled with the increase in demand as a chemical raw material, the price of gum turpentine went up from $0.20 per gallon in 1962 to nearly $1.30 in 1974. Distribution by application is as follows:

	Percentage
Pine oil	48
Resins	16
Insecticides	16
Fragrances	9
Others	11

Most of the present production of silvichemicals relies on wood oleo-resins such as turpentine and rosin. Until 1974, when the recession softened markets, there was a critical shortage of pine oleo-resins. With the improvement of the economy, it can be expected that the oleo-resin shortage will resume.

Objectives

Since Turkey does not have the high gum and resin producing species such as slash pine (pinus elliottii) and longleaf pine (pinus palustris), research has primarily to study ways of boosting output of turpentine and rosin. The secondary target of the FRI research will consequently be the tailoring of Turkish naval stores to new applications opening up almost continuously. The research proposal therefore is structured as a growth programme and will enable FRI scientists to gain the necessary data on domestic naval stores within a short time.

Research programme

Research and Development			
Phase 1	Venture planning	Commercialization	Duration (months)
Programme development			4
Exploration	First screening		16
Defining	Second screening	Monitor research and development	6
		Duration	26
Phase 2			
Developing	Investment proposal	Monitor market	
Produce for market	Appropriation engineering and construction	Train staff and take over market development	

Details of the research programme

Phase 1

Programme development

Determination of priorities

Arranging co-operation with research facilities of Turkish pulp and paper mills

Literature search

Patents search

Training of helpers

Organization of laboratory services

Exploration stage

First screening

Raw material

Yield of gum and resin by area and stand

Use of stimulators

Application of herbicides (paraquat)

Stump-wood characteristics

Yield of resin in function of age and rotting, extraction and shredding

Tall oil characteristics

Classification of resources

Transportation

Technology

(a) Gum

Composition characteristics

Fractionation characteristics

Composition of turpentine

Composition of rosin

(b) Stump-wood

Decontamination

Resin characteristics

Yield of extraction

Composition of steam distilled turpentine

Composition of steam distilled rosin

Waste characteristics

Waste disposal by means of carbonization

(c) Tall oil

Results available from the domestic industry should be considered

Characteristics of tall oils produced in Turkey

(d) Paraquat-stimulated resin production

Tall oil characteristics

Pre-extracted resin characteristics

Cellulose effects

Waste disposal and utilization

Application research

In connection with selected companies

Elaboration of test procedures

Standardization

Market tests

Information

Publications in periodicals
Information service
Instruction manuals

If the first screening provides promising results, market testing should be maximized to produce enough data for the design of a pilot plant unit

Defining stage

Research work on a bench scale to be continued for identified areas
Target is to produce data for a pilot plant

Second screening
During the defining stage, a second, more thorough, screening will provide the basis for two decisions: whether to proceed commercially; and whether to undertake further development to provide the necessary data for an investment proposal

E. Recovery of furfural

During the course of the mission's explorations and the meetings with the staff of various departments and divisions of the Ministry of Forestry in Ankara, the recovery of furfural (via pentosan) from Turkish Rhododendron ponticum was discussed. Because of lack of time it was agreed not to extend the projects activities into this area. However, the Planlama Dairesi Baskani in Ankara furnished data (table 11) on this subject and requested the opinion of the UNIDO wood chemical expert on it, which is as follows:

Properties

Yellowish liquid with an aromatic odour; boiling point 161.7 °C; soluble in water and alcohol, but not soluble in petroleum hydrocarbons. On exposure it darkens and gradually decomposes.

Sources

Typical raw materials containing pentosan that can be used for furfural production are:

Raw material	Yield (%)	Raw material	Yield (%)
Cleaned-oat hulls	22	Bagasse	17
Corn cobs	22	Oak tar bark	13
Cottonseed hull bran	20	Rice hulls	12
Corn stalks	16.5	Flax shives	14
Buckwheat hulls	17	Peanut hulls	12

The factors influencing the choice of raw material are delivered price, availability, cost of conversion, and the value of by products. In the United States, corn cobs are the primary source; bagasse, cottonseed hulls, oat hulls, and rice hulls are also used commercially.

Table 11. Analysis of *Rhododendron ponticum*

	Rhododendron ponticum (Turkey) (%)
Alcohol/benzene soluble components	6.4
Hot water soluble components	3.8
Ash content	0.5
pH	5.2
Cellulose	37.2
Libnite	25.4
Pentosan	18.3
Furfural	13.3
	(kcal/g)
Calorific value	4541

Source: Planlama Dairesi Baskani.

Uses

The principal uses are for the manufacture of other furan and tetrahydrofuran compounds, as a selective solvent for separating saturated from unsaturated compounds in petroleum lubricating oil, gas oil and diesel fuel as well as vegetable oil; as an ingredient in resins, especially of the phenol-aldehyde types; as a decolourizing agent for wood rosin; as a resin solvent and wetting agent in the manufacture of abrasive wheels and brake linings; and in the extractive distillation of butadiene and other C_4 hydrocarbons for the manufacture of synthetic rubber.

Manufacture

Based on the following reactions:

Pentosan + Water ⟶ Pentose

Pentose ⟶ Furfural + Water

Commercially, furfural is produced in a single step operation. The raw material is charged into large rotary digesters and treated with dilute sulphuric acid. The furfural formed is removed by steam distillation. The vapours leaving the digesters are condensed and fed to a stripping column. Overhead vapours, rich in furfural, are condensed and cooled, separating into two layers. After removal of a small quantity of low-boiling heads in a methanol column, the water layer is returned to the stripping column for recovery of furfural. The furfural layer, containing about 6% water, is sent to the dehydrating column, where the water is taken overhead and dry furfural is drawn from the base. Distillate from the dehydrating column is sent to the stripping column decanter for recycling through the system.

Historical aspects. It has not been an easy task to introduce furfural into the chemical market. In 1922, the price of 1 kg of furfural was as high as $4.50. The Quaker Oats Corporation, United States, has been able, by extensive rationalization, to manufacture it at lower costs, reducing it to $0.40/kg. Since 1936, demand for furfural as a selective solvent in the petroleum industry rose. This induced the Quaker Oats Corporation to triple its capacity. However, the supply of oat hulls, up to that time the only source, was not sufficient. Therefore the company also started to use corn cobs and cotton-seed bran in a new plant. In 1948, 225,000 tons of agricultural waste were used for the furfural process in the United States, resulting in an output of 25,000 tons of furfural. It is estimated that the United States still accounts for 80% of world furfural production. Smaller plants are located in France, Italy, Spain and Sweden.

Furfural made from wood. Wood has been hydrolyzed for more than a century. The original objective of hydrolyzing the carbohydrates in wood sugar was to obtain alcohol by fermentation. Today, furfural can be produced from a variety of by-products of wood processing. The potential sources include spent sulphite liquor, liquors from the prehydrolysis of wood for kraft pulping, and hardwood wastes. Increasing furfural demand has brought some of the alternative raw materials into the picture.

In general the hydrolyzation plants, built to produce sugars for fermentation to ethyl alcohol, have proved to be uneconomical. Only plants in the Union of Soviet Socialist Republics are still in operation. Therefore, the only economical way to manufacture furfural from wood or wood residues is to use the one-step process to convert the pentosan content into furfural and to use the wastes for other commercial products.

The analytical data of Turkish *Rhododendron ponticum* indicate that this raw material should be rated medium quality. Usually, only 70% of the theoretical yield found by laboratory tests can be achieved in commercial operations. Therefore the main problem, in producing furfural economically, is to find reasonable outlets for the wastes that may run as high as 70%-80% of the total input. Quaker Oats solves this problem by converting its wastes into activated carbon by pyrolysis. The use of wastes in a particle board plant would not be sufficient and the amount of waste chips from the furfural plant that might be blended into the particle board raw material has to be determined by further research but the amount required is usually quite high and it seems unlikely that sufficient would be generated.

A well-designed industrial centre, combining furfural and particle board production with charcoal manufacturing, could generate its own energy requirements. In addition it offers other advantages: the available resources will be fully utilized; products other than furfural will be manufactured for export such as charcoal, wood chemicals and, in a supplementary programme, activated carbon that is used for many industrial purposes.

This industrial centre in which three industries are integrated will offer more and better skilled job openings and stimulate the economy of the area.

Cost estimate of a research programme

The estimate has to be based on the fact that FRI Ankara does not have facilities and equipment to conduct the proposed research programmes (annex 1).

These programmes also require the training of four group leaders and provisional expert advice to the research manager. The cost estimate of the expansion of the laboratory facilities in Ankara is not included in the survey, nor are the operational costs of the programmes evaluated.

It is recommended that international assistance be sought to provide the following estimated requirements for expert services, fellowships and equipment.

Personnel requirements	Duration	Costs
Consultant in chemical processing of wood (adviser to the research manager) a/	6	26 400
1 group leader for the tannin programme b/, c/	3	3 600
1 group leader for the carbonization programme b/, c/	3	3 600
1 group leader for the carbonization pilot plant b/, c/	3	3 600
1 group leader for the naval stores programme b/, c/	3½	4 200
Subtotal	12½	15 000

a/ For duties, see draft job description in annex II.

b/ For programme, see annex III.

c/ The group leaders should have at least one year's experience in laboratory work before training begins.

Equipment and apparatus		Costs ($)
Versatile laboratory equipment[d/] suitable for all proposed programmes		20,000
Special equipment[d/]		
(a)	Tannin programme extraction apparatus, leather tannage	8,000
(b)	Carbonization (charcoal) programme laboratory testing apparatus	3,000
	Investment cost of pilot plant, to be constructed by the FRI, blueprints will be provided by the expert to be assigned	12,000
(c)	Naval stores extraction apparatus etc.	7,000
	Subtotal	50,000
	Total	91,400

d/ For detailed specifications see annex IV.

II. CONCLUSIONS AND RECOMMENDATIONS

1. The areas proposed for developing the chemical wood processing industry are the processing of bark to tannin extracts; conversion of forest residues, wastes of the primary and secondary wood industry and Rhododendron ponticum into charcoal, chemicals and usable energy; and the manufacture of naval stores from tree gum, wood stumps and tall oil.

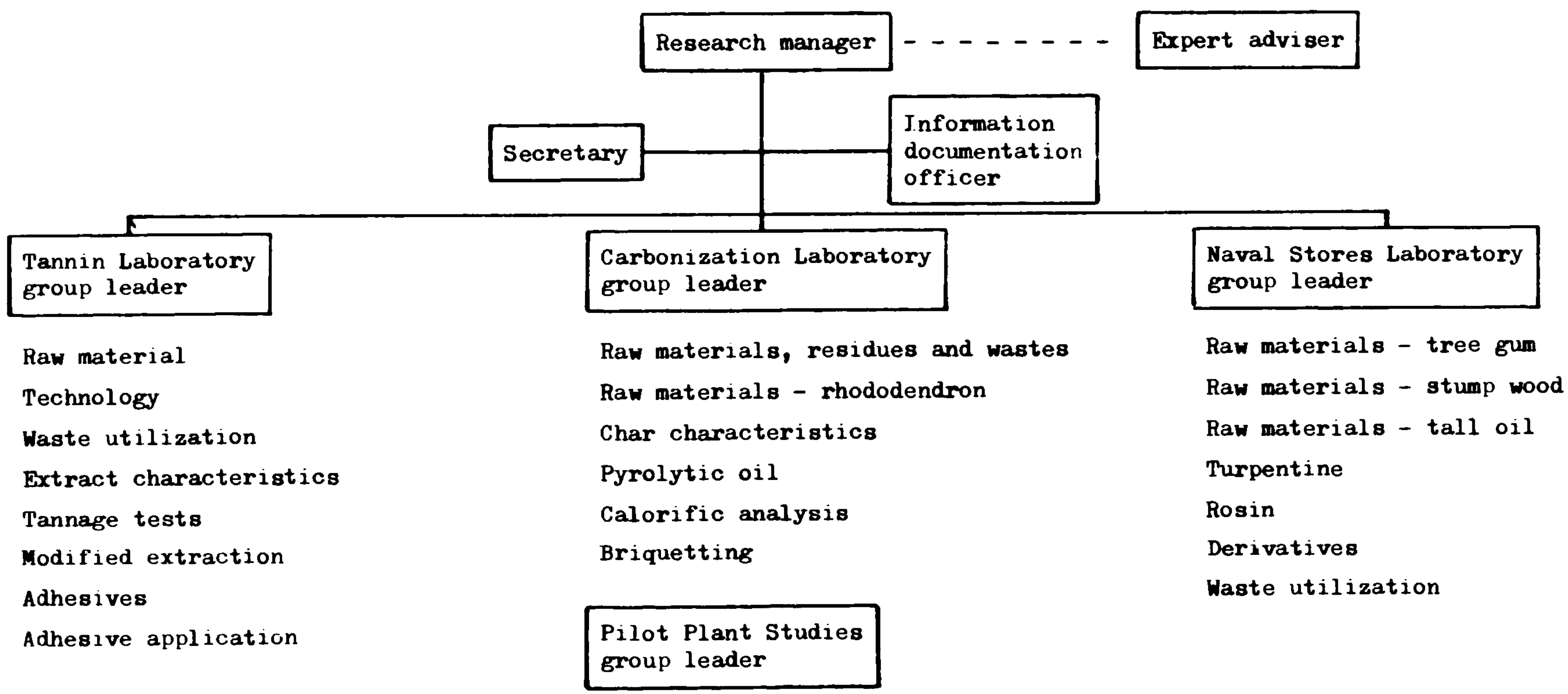
2. The proposed research programmes for the development of the chemical wood processing industry are structured as intensive programmes to be conducted within a given time limit not exceeding 18 months.

3. It is recommended that the services of a consultant in chemical processing of wood be requested for six months to advise the programme manager. Four group leaders have to be trained outside Turkey for a period of 3-4 months each.

4. The estimated cost of the necessary laboratory equipment is $38,000 and that of the required pilot plant $12,000.

Annex I

ORGANIZATIONAL SCHEME FOR RESEARCH PROGRAMMES FOR TANNIN, CARBONIZATION AND NAVAL STORES



Annex II

JOB DESCRIPTION FOR FURTHER TECHNICAL ASSISTANCE RECOMMENDED FOR TURKEY

Post title:	Consultant in chemical processing of wood
Duration:	6 months (split missions acceptable)
Date required:	As soon as possible
Duty station:	Ankara with travel within the country
Purpose of project:	To advise the Forest Research Institute in elaborating and conducting three research programmes in the field of wood chemistry e.g. tannin extracts from coniferous bark, carbonization of forest residues, waste of the primary and secondary wood industries, rhododendron, and the recovery of naval stores from tree gum, coniferous stumps and tall oil.

Duties:

The expert will be attached to the Forest Research Institute in Ankara. He will be expected to advise the research manager in developing and organizing the research programme, the compilation of the necessary data for further commercial evaluation of the results and the establishment of an information and training centre in the field of wood chemistry.

In particular he will be expected to:

(a) Assess the present situation in the industry and research institutions with respect to equipment, manpower and markets;

(b) Advise on the construction of a pilot plant for the carbonization of wood;

(c) Advise on the necessary co-ordination of work between industry and research laboratories;

(d) Assess the results of the research, the markets and, based on this, recommend industrial production programmes based on the results of the research work;

(e) Train research and plant personnel in the above fields;

(f) Recommend all further measures to be taken by industry, Government and international organizations to assure the development of this industry.

Qualifications:	Wood technologist, chemical engineer or industrial chemist with experience in research and industrial production of charcoal, wood chemicals, naval stores and the processing of forestry and wood industry waste. Experience in consultancy in this field desirable.
Language:	English

Annex III

SUGGESTED TRAINING PROGRAMMES

Group leader tannin research	Duration (weeks)
Qualitative and quantitative evaluation of vegetable tannin	
Preparation of tanning agents (quebracho, mimosa and chestnut) for the leather manufacturer	
Practical leather tanning	8
Preparation of adhesives for the particle-board and plywood industry	
Quality testing of particle-board and plywood	4
Total	12

Group leader carbonization research	
Rotary kiln technology	
Evaluation of process data	8
Missouri kiln technology	4
Total	12

Group leader carbonization pilot plant	
Missouri kiln technology	
Evaluation of process data	
Safety requirements	12
Total	12

Group leader naval stores research	
Analytical evaluation of tree gum, steam distillation resin	
Technology and application of marketable rosin products	
Processing of stump-wood	
Evaluation of process data	8
Analytical evaluation of tall oil	
Technology and application of tall oil fatty acids	
Processing of tall oil	
Evaluation of process data	6
Total	14

Annex IV

BASIC LABORATORY EQUIPMENT

Atomizer	3
Balsam bottle	10
Bell-jar	5 various sizes
Blowtorch	1
Burette	20 various sizes
Calibrated riddle	one set
Casserole	25 various sizes
Coffee-mill	20 various sizes
Claisen flask	1
Decanter	10 various sizes
Demijohn	10
Dip tubes	5
Dipper	5
Distilling flask	20 various sizes
Dewar flask	5
Dish-drainer	5
Dropper	20 various sizes
Drying basket	5
Evaporating dish	40
Filter flask with side tube	40 various sizes
Filter plain	1,000 various sizes
Filter fluted	1,000 various sizes
Funnel	50 various sizes
Funnel tubes	30 various sizes
Fermentation tube	10
Glass desiccator	10
Glass desiccator, vacuum	5
Graduated cup	15
Graduated cylinder	15 various sizes
Graduated flask	15
Grinder	1
Jar	15 various sizes
Florence flask	20
Kipp's apparatus	4
Kjeldahl flask	10

Laboratory dialyser	2
Laboratory chafing dish	3
Laboratory jug	20
Light-duty paddle	15
Ladle	10 various sizes
Liebig condenser	20 various sizes
Magnifier	2
Mercury manometer	5
Mortar with pestle	10 various sizes
Mariotte bottle	30
Petri dish	50 various sizes
Reagent bottle	40 various sizes
Refractory crucibles	30 various sizes
Pouring bucket	10
Pipette	40 various sizes
Separatoring funnel	15 various sizes
Syphon	5
Undine dropper	3
Test tubes	500
Suction filter	20
Suction pump, glass	10
Washing bottle for precipitates	10
Washing bottle for gases	25
Weighing bottle	40 various sizes
Hoses and tubes	
Connectors, glass	
Valves and cocks, glass	
Tweezers	5 various sizes
Scissors	3
Spatula	five sets
Glass-cutter	2
Tool-set	1
Stop-watch	2
Alarm-clock	3
Laboratory thermometer	five sets
Vacuum gage	4
Temperature/humidity gauge	4

Platinum crucibles	10 various sizes
Bunsen burner and tripod	10
Meker burner	5
Electric beater	3
Electric mixer	5
Electric boiler	10
Electric drying chamber	4
Hand scale	3
Tray	4
Strainer	2 sets
Refrigerator	2
Freezer	1
Centrifuge	3
Vibrator	3
Electro-timer	5
Viscosimeter	2
Westphal balance	2
Analytical balance	4
Calibrated meshed sieves	3 sets
Automatic shaker	3
Hammer mill	1
pH-meter	2
Agitator bath	2
Microscope with accessories	1
Dilatometer	1

Special equipment for the research programmes

Deionizer water system	1
Soxhlet apparatus	8 various sizes
Countercurrent extraction battery	1
Tanning drum	2
Bark shredder	1
Cylinder churn	1
Pycnometer	1
Carbon monoxide detector	2
Stack sampler	3

Calorimeter	1	
Electric thermometer	5	
Industrial back connected thermometer	5	various dial ranges
Moisture-testing apparatus	3	
Semi-micro distillation apparatus	2	
Paper chromatography	2	
Electrophoresis	3	
Hypodermic syringes	5	
Stirrup pump	3	
Metering pump	3	
Back pressure valve	3	
Take-off contact	5	

Laboratory chemicals

Acids

Hydrochloric
Nitric
Phosphoric
Sulphuric

Hydroxide bases

Ammonium
Barium
Calcium
Potassium
Sodium

Solvents

Acetone
Ether
Ethanol
Benzene
Chloroform
Acetic acid
Methanol

General reagents

Aluminium chloride
Aluminium nitrate
Ammonium carbonate
Ammonium chlorite
Ammonium molybdate
Ammonium oxalate
Ammonium sulphide, colourless
Antimony pentachloride
Aqua regia
Barium chloride
Bismuth nitrate
Cadmium chloride
Cadmium nitrate
Calcium chloride
Chloroplatinic acid
Chromic chloride
Chromic sulphate
Cobaltous nitrate
Cobaltous sulphate
Cupric chloride
Cupric sulphate

Ferric chloride
Ferric nitrate
Ferric sulphate
Ferrous ammonium sulphate
Lead acetate
Lead nitrate
Lime water
Magnesium chloride
Magnesium chloride reagent
Manganous nitrate
Manganous sulphate
Mercuric chloride
Mercuric nitrate
Nickel sulphate
Potassium bromide
Potassium carbonate
Potassium chloride
Potassium ferricyanide
Potassium ferrocyanide
Potassium iodide
Potassium nitrate
Silver nitrate
Sodium acetate
Sodium cobaltnitrite
Sodium hydrogen phosphate
Sodium nitrate
Sodium sulphide
Stannic chloride
Stannous chloride
Strotium chloride
Strotium chloride
Zinc sulphate

Special solutions and reagents

Aluminium
Bnag's reagent
Benedict's solution
Benzidine hydrochloric solution
Bertrand's reagent
Cupric acetate (Barfoed's reagent for reducing monosaccharides)
Cupric oxide ammoniacal
Cupron
Cuprous chloride, acidic (Winkler method of preparation recommended)
Cuprous chloride, ammoniacal
Dichlorofluorescein indicator
Dimetnylglyoxime
Diphenylamine sulphate
Esbach's reagent
Fehling's solution

Ferric alum indicator

Formaldehyde-sulphuric acid

Fuchsine

Fuchsine-sulphurous acid (Schiff's reagent)

Hanus solution

Iodine, tincture of

Litmus indicator

Magnesia mixture

Magnesium uranyl acetate

Mayer' reagent

Methyl orange indicator

Methyl orange indicator, modified

Methyl red indicator

Methyl red indicator, modified

Millon's reagent

Mixed indicator

Nessler's reagent

Nylander's solution

Oxygen absorbent

Pavy's solution

Phenantrolin ferrous ion indicator

Phenolphthalein

Phenol sulphonic acid

Phloroglucinol solution

Phosphomolybdic acid (Sonnenschein's reagent)

Phosphotungstic acid

Picric acid

Potassium antimonate

Potassium hydroxide

Potassium pyrogallate

Rosolic acid

S and O reagent

Soap solution (reagent for hardness of water)

Sodium hydroxide

Sodium oxalate

Starch solution

Stokes' reagent

Sulphanilic acid

Tannic acid

Titration mixture

Ortho-toluidine solution

Turmeric tincture

Wagner's solution

Wij's special solution

Zimmermann-Reinhardt reagent

Zinc uranyl acetate

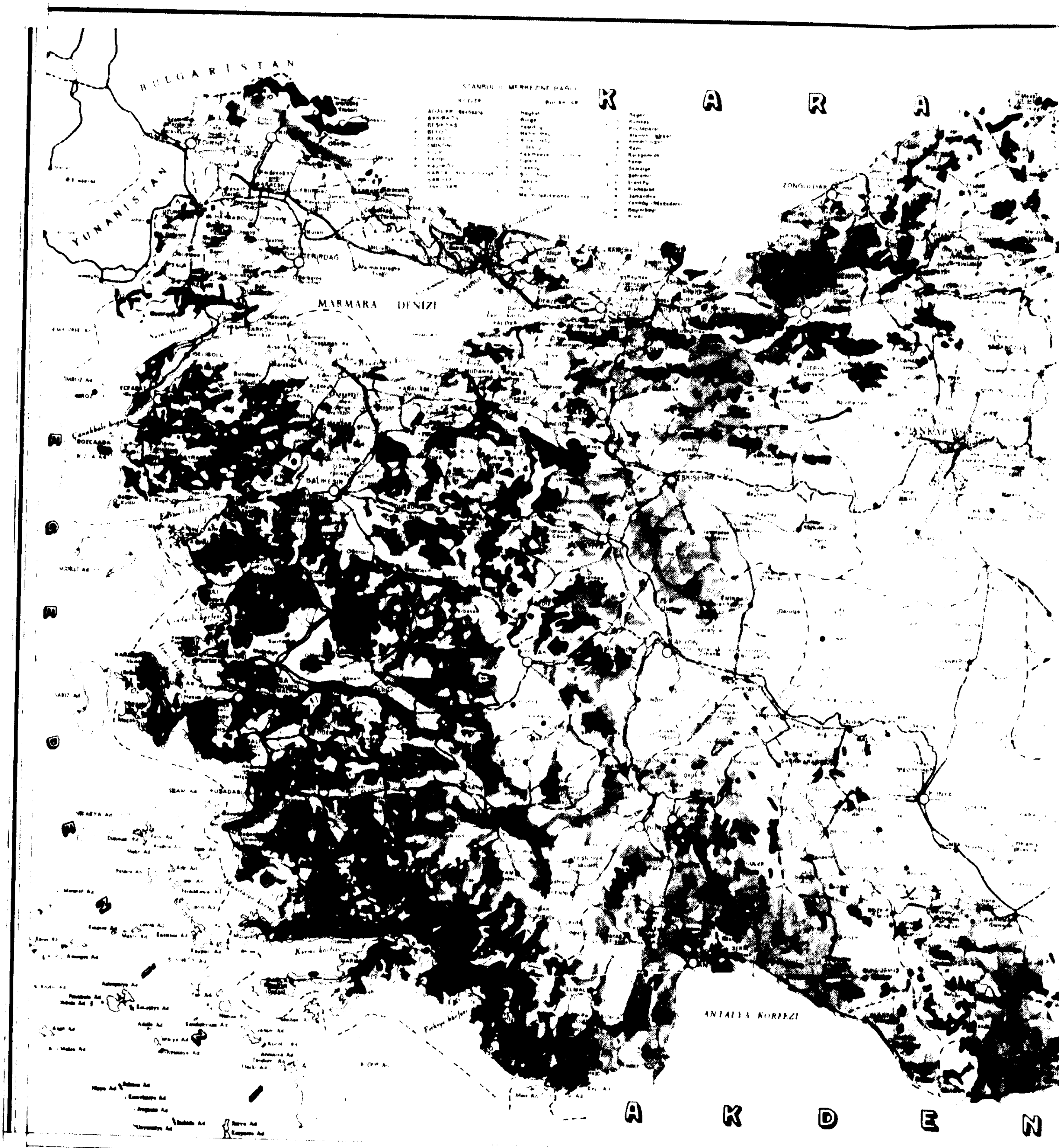
Safety equipment

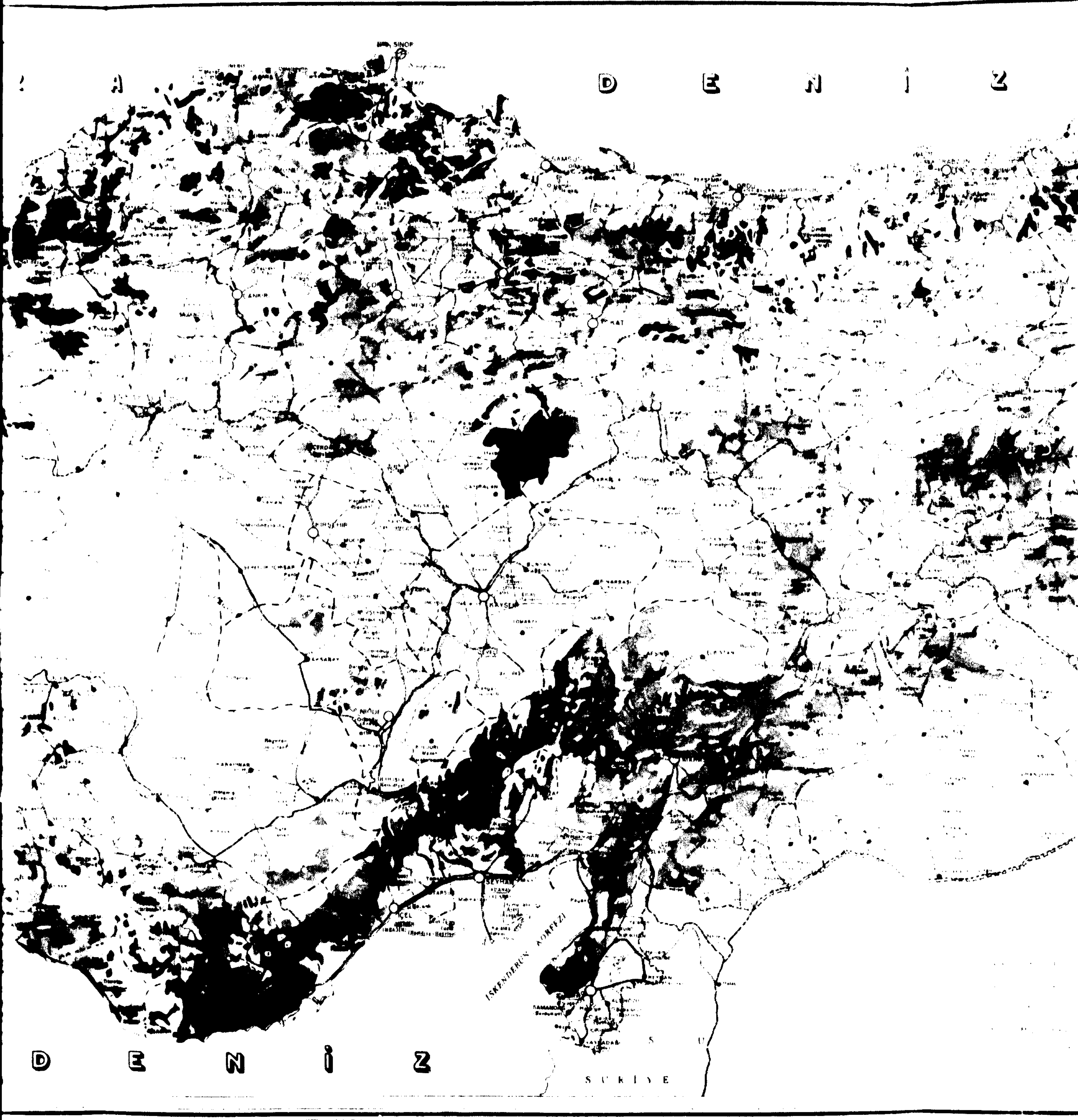
Fire extinguisher

Safety goggles

Rubber gloves

Emergency shower


BULGARISTAN
YUNANISTAN
MARMARA DENIZI
K A R A
A K D E N
ANTALYA KORFEZI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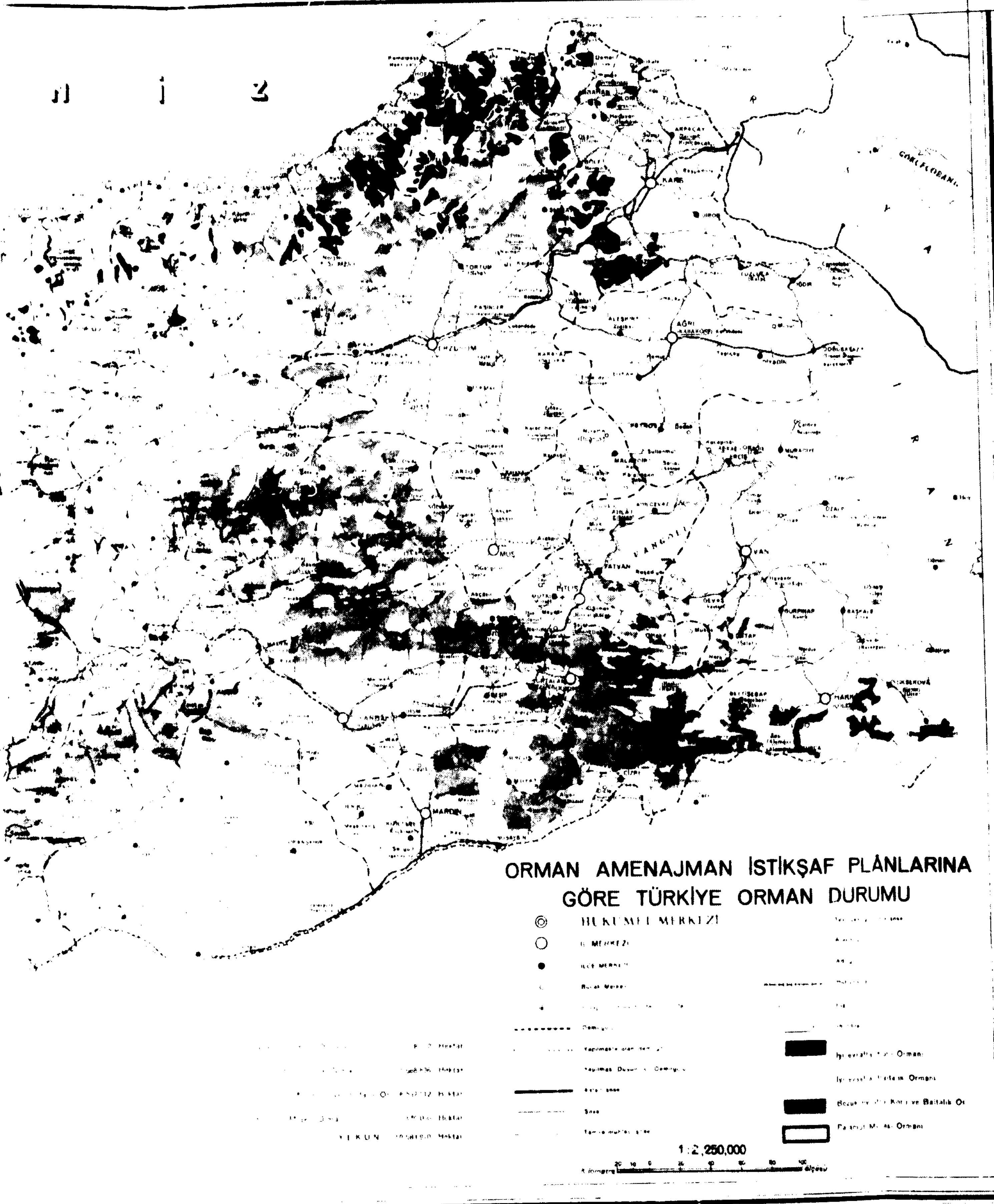
SURİYE



FOREST MANAGE
THE LOC

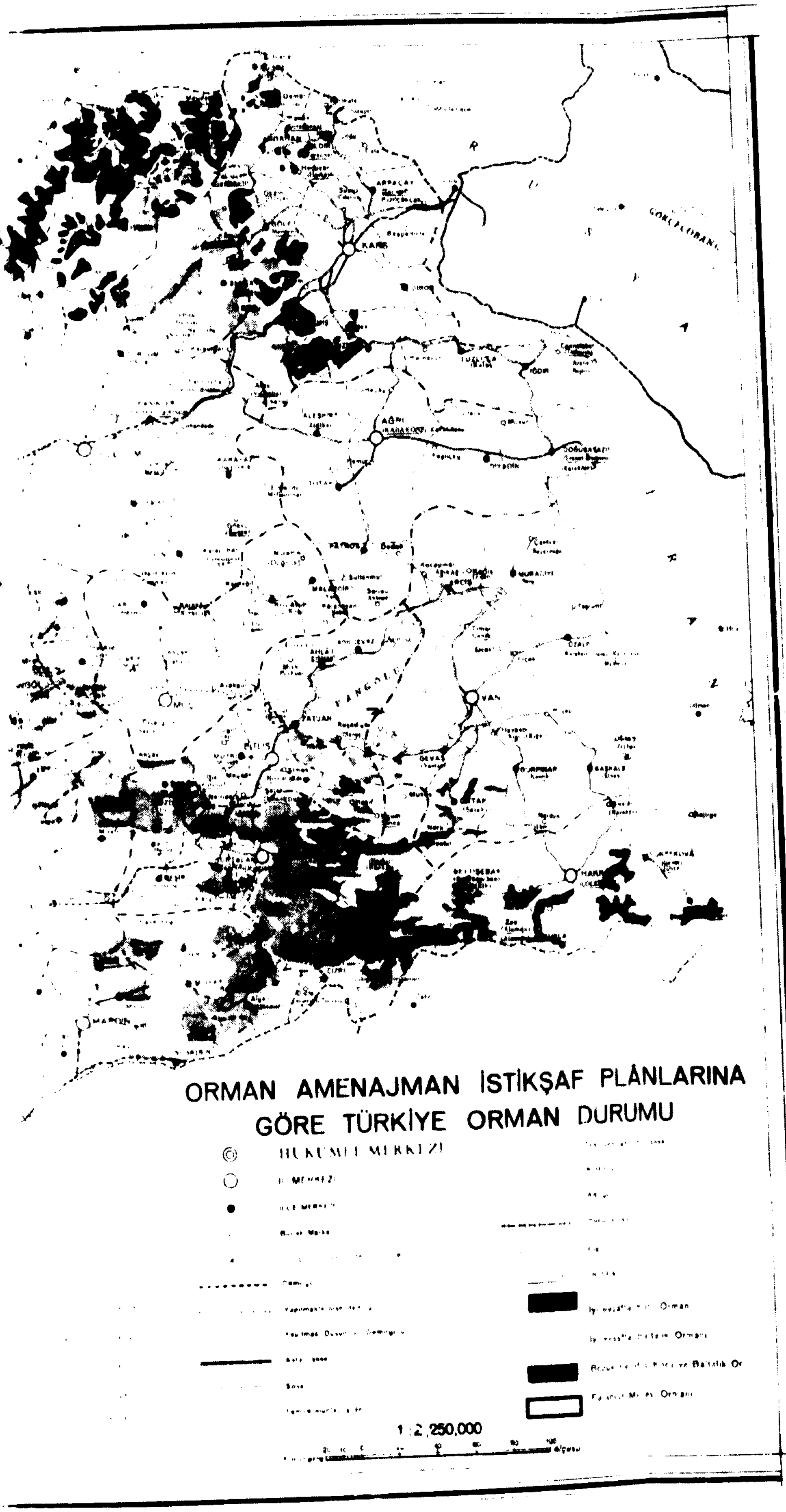
Key:

- Capit
- Provi
- Distr
- Sub d
- Centr coun
- Railw
- Railw
- Railw
- Aspha
- Non-a
- Road
- Road
- Raod
- Secor
- Bound
- Dense cor
- Matur goo
- Fores
- Oak

SECTION 3

Annex V

FOREST MANAGEMENT SURVEY PLAN ACCORDING TO THE LOCATION OF TURKEY'S FORESTS

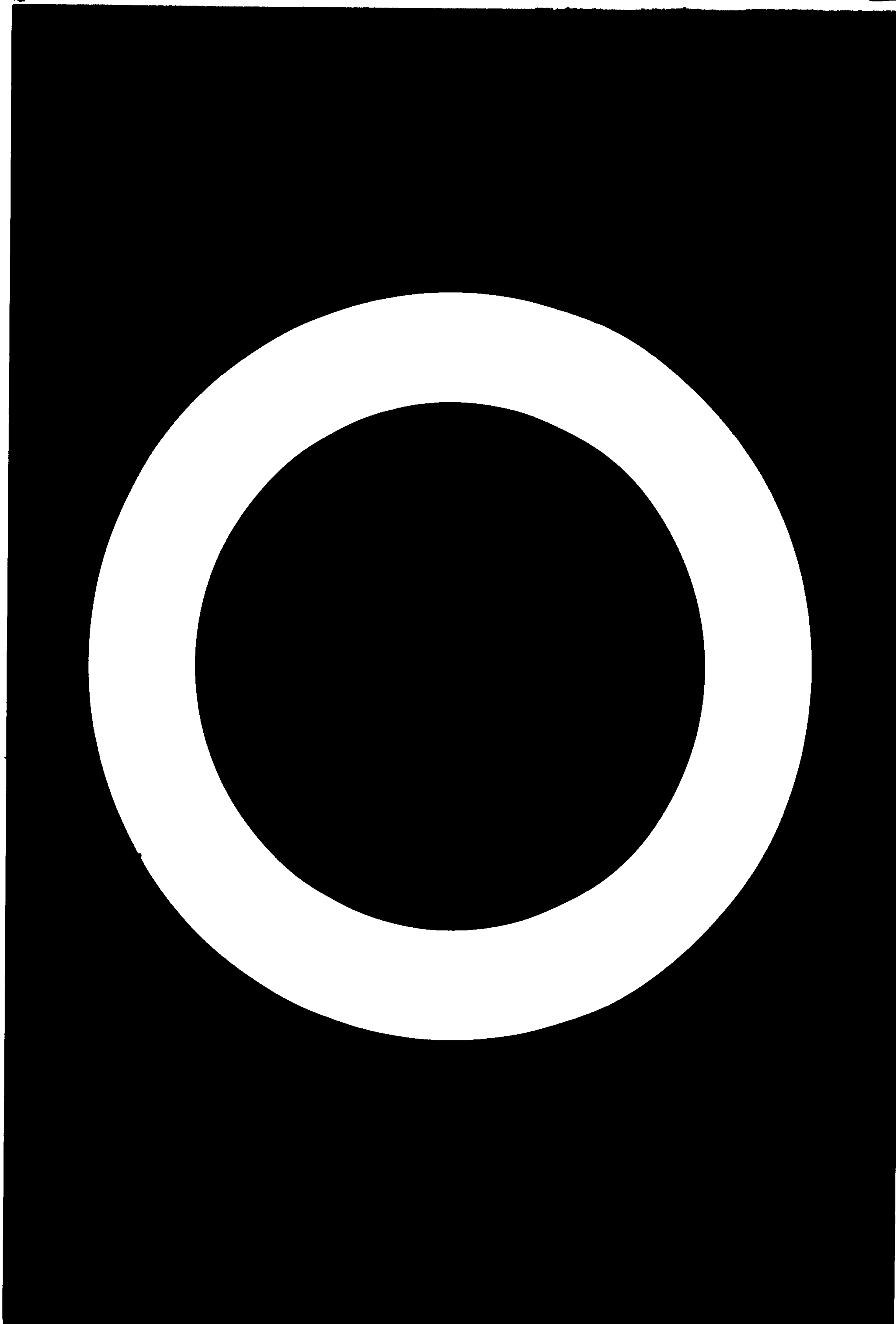


Key:

- Capital
- Province centre
- District centre
- Sub district
- Centres in neighbouring countries
- Railways
- Railways under construction
- Railways under study
- Asphalted road
- Non-asphalted road
- Road in poor condition
- Road with foundations
- Raod for carts
- Second class road
- Boundaries

Dense forests in good condition	2,208,322 ha
Mature dense forests in good condition	1,668,636 ha
Forests in poor condition	6,537,012 ha
Oak forests	170,000 ha
TOTAL	10,583,970 ha

SECTION 4



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