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Full Length Research Paper

Assessment of forest roads and firebreaks in Turkey

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This paper describes the situaiton and assessment of forest roads and firebreaks in context of forest transportation and forest fire prevention in Turkey. In recent years, Turkey has lost many forest areas to forest fires, and this not only results in loss of life, property, and infrastructure, but also causes deterioration in the natural environment and degrades ecosystems. According to current status of Turkey, the numbers of forest fires and the areas that are burnt fluctate widely from year to year. In the last decade, the number of forest fires has increased, but the area burned per forest fire has decreased. The Turkish General Directorate of Forestry spent $82.92 million to fight forest fires in 2003 and $677.71 million over the last decade. As of the end of 2006, the total number of forest fires in Turkey since 1937 is 80 011, giving an average of 1143 fires per year. For the same period, the total forest area burned is 1 571 607 ha and the mean forest area burned per fire is 19.64 ha.

Key words: Forest fire, forest road, firebreaks, forest conservation, forestry.

INTRODUCTION

Forest fires are one of the most disturbing factors affecting natural ecosystems. Currently devastating wildfires affect vast regions (FAO, 2001) throughout the world, in particular the fragile ecosystems of the Mediterranean basin (Portugal, Spain, France, Italy, Greece and Turkey) that are known to be at high risk of desertification (UNCCD, 1994). Human activities (livestock grazing, logging, and fire suppression) have resulted in the exclusion of fire from these forests for the past century, and this exclusion has caused changes in forest structure and composition (Sakulich and Taylor, 2007). Every year, wildland fires reduce the forested areas across southern Europe at a remarkable rate. Forest fires are a major source of CO and other air pollutants (Crutzen et al., 1985; Greenberg et al., 1984) and the recent increase of fire activity on a global scale (Central America, Amazonia, Africa, Boreal Regions of North America, and Eurasia) has contributed to the widespread increase of greenhouse gas emissions such as CO_2 and CH_4 (Guido et al., 2004). Forest fires can cause the destruction of a large number of trees and the death or displacement of wild animals. Intense combustion not only burns forest and plants on the ground, but also changes forestry structure, forest biology, climate, and soil performance (Zhong et al., 2003). In recent years, substantial efforts have been made towards characterizing, forecasting, modeling, planning, and managing forest fires in several Mediterranean countries. Turkey has experienced intense forest fires with increasing frequency since the early 1970s. Recently, efforts were undertaken with a view to studying forest fires in Turkey in the context of fire management. Forest fire management involves fuel management, fire detection, communications and reporting systems, fire weather forecasting, fire danger and behavior indices, initial attack systems, identification of fire-sensitive resource areas, standby systems, training and organization of teams, suppression resources and capability, and knowledge of fire and its ecological implications (Dimopoulou and Giannikos, 2004; Vakalis et al., 2004). A relationship between socio-economic

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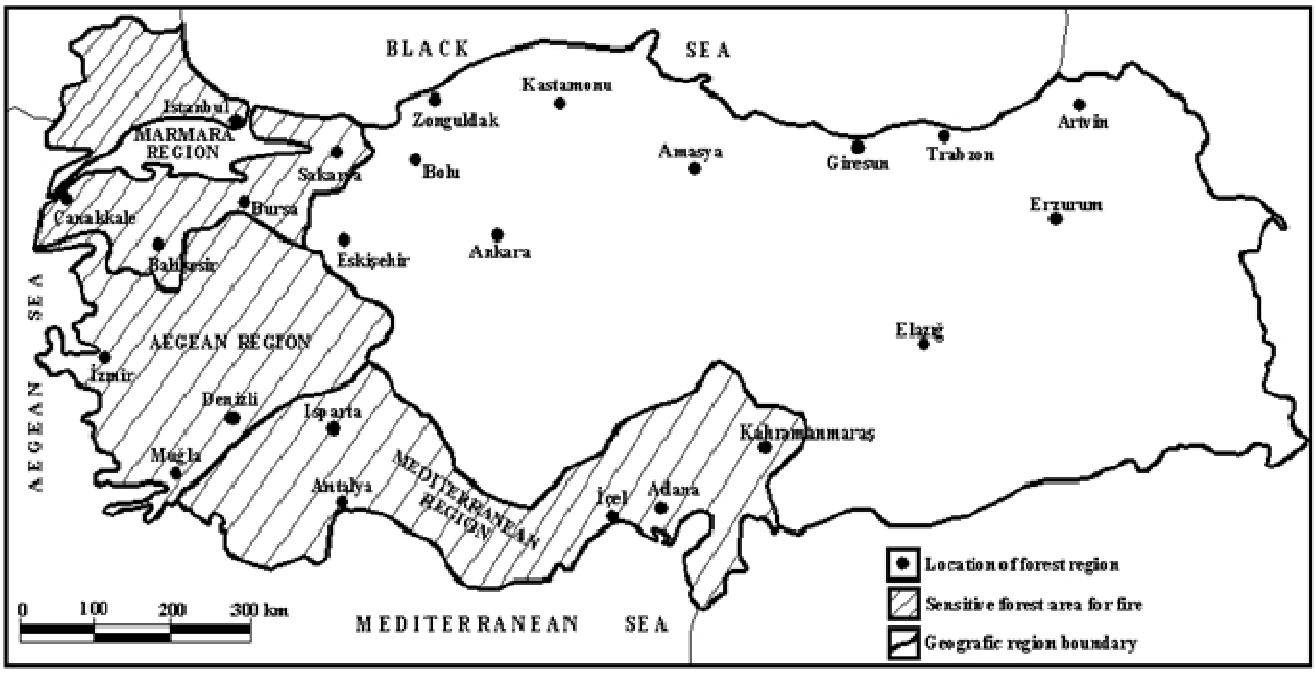

Figure 1. Forest fire sensitive areas of Turkey (Mol and Kucukosmanoglu, 1998).

factors and the number and types of forest fires has been proven to exist. Most of the Mediterranean region suffers from extensive forest fires, and in some cases socioeconomic factors are key determinants in wildfire causality classification. Determinants are those components within the forestry environment that help explain the intensity and spread of wildfires. The module developed here incorporates five factors representing forestry profitability, demographic pressure, social tension, forestry culture, and organizational thinking. These factors are sufficient to explain the increase or decrease of fire risk. These factors can be modeled by considering variables which describe the behavior of the socioeconomic fire risk (local permanent population, tourists, domestic animals, houses, type and height of vegetation) and constructing transformation functions that will determine the final value of fire risk (Boazountas et al., 2005).

A firebreak is a strip of bare land or vegetation that slows down fire. Firebreaks help protect soil, water, air, plant, animal, and human resources by preventing the spread of wildfires or controlling prescribed fires. Firebreaks may be temporary or permanent and consist of fire-resistant vegetation, non-flammable materials, bare ground, or a combination of these. Generally in forest fire fighting, forest roads and firebreaks are more important than the contributions of new technologies such as computer programs. For example, forest fire fighting with aircraft cannot continue at night. Forest roads and firebreaks may be necessary to gather data to construct computer-based simulation models. Forest maintenance, wood harvesting, fire control and safety, game control, recreational activities all require the accessibility provided by a suitable road network (Demir, 2007; Janowsky and Becker, 2003; Lugo and Gucinski, 2000).

MATERIALS AND METHODS

Site description

Turkey, with 97% of its land area in Asia and 3% in Europe, is located between 42° 06'-35° 51' N latitude and 25° 40'-44° 48' E longitude. Turkey, surrounded by the Mediterranean, the Black Sea, the Sea of Marmara, and the Aegean Sea, has an area of 7784 6000 hectares and 8333 km of coastline. This substantial size, along with large distances of over 1600 km from east to west and from 475 to 650 km from north to south, as well as properties such as location, relief, and climate, has caused the formation of different geographical regions within the country's boundaries. As at the end of 2004, the total forest area in Turkey was 21188747 hectares, or 27.22% of the country's area. Timberland (productive) forests occupy 15439595 hectares and account for 73% of the total forest area, while coppice forests occupy 5749152 hectares and account for 27% of the total forest area (Anonymous, 2008; Turkish General Directorate of Forestry, 2007). According to 2004 data, coniferous forest occupies 53.9% of total forest area and deciduous forest 46.1%. Sensitive regions of Turkey against fore fire are given in Figure 1, especially Aegean and Mediterranean regions of Turkey which are very sensitive against forest fire (Demir, 2007; Demir and Hasdemir, 2005; Turkish General Directorate of Forestry, 2007).

Forest road and firebreak standards in Turkey

When forest road and firebreak planning activities in other countries are examined, it is clear that every country has adopted different implementations depending on that country's geography and social

Table 1. Forest road standards in Turkey (Turkish General Directorate of Forestry, 2007).

Technical specifications		Road types			
		Main forest road	Secondary forest roads		Skid roads
			Type A-forest roads	Type B-forest roads	
Road bed wide	m	7	6	4	3.50
Maximum slope	%	8	10	9-12	18
Minimum curve radius	m	50	35	10-12	8
Number of Band	Number	2	1	1	1
Band wide	m	3	3	3	3
Shoulder wide	m	0.50	0.50	0.50	-
Ditch wide	m	1	1	1	-
Pavement wide	m	6	5	3	-

Table 2. Forest road density and spacing in Turkey (Turkish General Directorate of Forestry, 2007).

Volume of asset (m^3/ha)	Road density (m/ha)	Road spacing (m)
> 250	20	500
< 250	10	1000

Table 3. Required asset volume and choice of forest road types in Turkey (Turkish General Directorate of Forestry, 2007).

Road type	Volume of asset (m^3)
Main forest road	> 50000 m
Type A forest road	50000 m^3-25000 m^3
Type B forest road	< 25000 m^3

conditions. As is clear from the previous discussion, preparation of a forest road network plan and constructing the planned roads involves more than merely road construction techniques. The preparation and implementation of such plans requires knowledge not only of all the economic, technical, and management characteristics of the forest enterprise involved, but also of the relationships involved in production, transport, and utilization of the forest resource. In order that the services associated directly or indirectly with the forest roads and firebreaks which significance and functions have been summarized above can be implemented in a rational way, the site of the planned facility must be provided with standards and planning criteria appropriate for the contemplated purpose. Type B forest service roads constitute a major part of the existing forest road network in Turkey. Three types of forest roads (main forest, Types A and B service roads and skid roads) are constructed to support the management of forest units. As stated in Table 1, these roads are constructed on a 7, 6, and 4-m width platform respectively. Where such roads are built depends on the load the roads are intended to carry, using the figures given in Tables 2 and 3 as criteria. Generally firebreaks are established on both sides of forest roads. Firebreak is fire suppression zone adjacent to forest roads or fire prevention strip perpendicular to forest road.

In Turkey, the surface of firebreaks can be cleared, vegetated, plowed, disked, or grazed. Firebreaks should be located to minimize risk to the resources being protected. The width of firebreaks may be increased to enhance wildlife habitat. The selection of plant species should be based on their ability to retard fire, their potential for wildlife habitat enhancement, and their ease of maintenance. Where possible, constructed firebreaks should tie into existing natural barriers. Natural barriers include lakes, streams, ponds, roads, cultivated fields, pastures, and utility rights-of-way. Firebreaks should be located on ridge tops, on the contour, and through the forest at intervals of 250 to 600 m. Closer spacing may be used in areas of high risk or for purposes of controlling prescribed burning. Firebreaks should be constructed parallel to public roads, forest roads, and railroads that are adjacent to forest land boundaries, forest land property boundaries, and within forests where necessary. Firebreaks should be at least 5–6 m wide, but no more than 20 m, and may be used for access. In Turkey, typical types of firebreaks are access roads, vegetated firebreaks, plowed or disked firebreaks, and grazed firebreaks. Plowed or disked firebreaks should be limited to soils with low erosion hazard. Access roads, vegetated firebreaks, and pasture firebreaks may be used on any soils provided erosion control measures such as water breaks or broadbased drainage dips are used when erosion hazard is moderate to severe. Vegetated firebreaks can be constructed by bulldozing, plowing, or disking and then vegetated to either perennial grasses or perennial grasses and legumes. The firebreaks may be overseeded in each fall with legumes, small grains, or ryegrass (Turkish General Directorate of Forestry, 2007; Mol et al., 1997; Mol and Kucukosmanoglu, 1998).

Methodology

In this paper, forest fires between 1937-2006 years in Turkey are described and examined. Besides, progress in forest fire fighting techniques and forest management is evaluated between 1937 and 2006, and influence and assessment of forest roads and firebreaks on forest fire fighting are determined.

RESULTS AND DISCUSSION

Situaiton and assessment of forest fires prevention in Turkey

Forest fire fighting techniques and forest management in context of forest resource conservation are insufficient in

many countries. The reasons for this insufficiency are social, cultural, economical, scientific, and technical. Many factors, especially climate, influence the fire danger. For example, climatic factors such as air temperature, low relative humidity, and dry winds may reduce the moisture content of flammable materials. Forest vegetation also has a great influence on the extent of damage from forest fires in Turkey.

Coniferous trees, which cover 53.9% of the Turkish forests, are much more sensitive to forest fires than deciduous trees. Turkey has two characteristic fire season types: a short fire season (in the Black Sea and Sea of Marmara regions) and a long fire season (in the Mediterranean and Aegean regions). The critical forest fire season in Turkey is the six months from May through October (Turkish General Directorate of Forestry, 2007). Human activities (smoking, carelessness, accidents, or deliberate fire setting) are very important causes of forest fires in Turkey. These risky human activities should be decreased by using both forest fire suppression techniques and social, cultural, and economic preventative measures. Forest fire prevention activities should be based on interdisciplinary studies (forestry, sociology, economics, administration, etc.). The absence of any one of these relevant disciplines will lead to decreased success in fire fighting. For example, quick and early intervention is very important in forest fire fighting, but lack of access opportunities (forest roads, firebreaks, etc.) will decrease success. Forest engineers, when planning forest roads, should make forest fire fighting one of their priorities. According to the literature, it is very important to get equipment and forestry workers quickly to a forest fire to impede its spread. This is made possible by suitably planned and constructed forest roads and firebreaks. However, current planning in Turkey does not include implementation of forest roads and firebreaks. For this reason, standards for the functions of forest roads and firebreaks in Turkey should be determined according to interdisciplinary studies. According to statistical data, the number of forest fires in Turkey and the area burned fluctuate widely from year to year, as indicated in Table 4 which shows total forest fires since 1937. It can be seen that the number of forest fires per year increased, but forest area burned per forest fire (ha) decreased. As of end 2006, there had been 80011 forest fires since 1937, giving a mean of 1143 forest fires per year.

Total forest area burned was 1571607 ha between 1937 and 2006. For this period, forest area burned per forest fire was 19.64 ha/fire. Table 5 shows the dispersion of forest fires in Turkey in 2006 according to forest management type. It can be seen that the total number of forest fires in 2006 was 2226, the forest area burned was 7760 ha, and there were many more forest fires in timberland forest (91.08%) than in coppice forest (4.3%) or in forests under other management types (Turkish General Directorate of Forestry, 2007).

Examining of the causes of forest fires in Turkey

The classification of forest fires is based on the degree to which fuels from mineral soil upward to treetops are involved in combustion. So, forest fires are classified as ground, surface and crown fires. In Turkey, there are surface and crown fires.
Forest fires in Turkey have many causes, such as:

- Human activities (smoking, negligence, carelessness, accidents, or deliberate fire setting)
- Shortage of basic equipment for fire fighting
- Climate and weather variation (lightning, etc.)
- Unknown reasons.

Causes of forest fire by year as reported by the Turkish Ministry of Environment and Forestry are shown in Tables 6 and 7 and Figure 2. The annual statistical data indicate that most forest fires (51.41%) are caused by negligence, carelessness, and accidents. The second main cause of forest fires is unknown reasons (28.53%), followed by deliberate fire setting (12.91%). The conclusion can be drawn that the main causes of forest fires in Turkey are related to human activities, while natural causes such as lightning make up a relatively small portion of the total.

There are 19020 forest villages in Turkey. It is emphasized that the socio-economic level of the people which are living in or near the forest, is highly below the standart of living. According to statistical data, 7.1 million forest villagers live there. On average, 60% of Turkish forest villagers are unemployed, and the average income of forest villagers is $200 per month, mainly from forestry work and farming (Turkish General Directorate of Forestry, 2007). Forest villagers regularly clear fields from forest land for subsistence farming. So, these villagers would like to use the forest without limitation for their survival. This brought out the forest-human activities relationship. Furthermore, this helps to explain why the first three causes of forest fires are negligence, carelessness and accidents, unknown reasons, and deliberate fire setting (Tables 6 and 7).

In the last few decades, the Turkish General Directorate of Forestry has been working to raise the level of economic development of forest villagers. The Turkish General Directorate of Forestry has been providing supplements every year (total $410.72 million in 2006) to forest villagers' income through forestry and harvesting work (Figure 3) (Turkish General Directorate of Forestry, 2007). However, there is no obvious relationship among forest fires, level of economic development of villagers, and agricultural production.

According to statistical data, between 1997 and 2006, the average forest area burned per year has been 8325 ha and the average number of forest fires per year has been 1980. Forest area burned per forest fire has been 4.17 ha/fire for the last six years. During this period, the

Table 4. Forest fires in Turkey (1937–2006) (Turkish General Directorate of Forestry, 2007).

No.	Years	Forest Fires number	Burnt forest area (ha)	Burnt forest area per forest fire (ha/fire)	No.	Years	Forest Fires number	Burnt forest area (ha)	Burnt forest area per forest fire (ha/fire)
1	1937	544	13564	24.9	37	1973	1208	17002	14.1
2	1938	396	14516	36.7	38	1974	769	14743	19.2
3	1939	510	12304	24.1	39	1975	811	17515	21.6
4	1940	419	18732	44.7	40	1976	702	5171	7.4
5	1941	850	33415	39.3	41	1977	1615	43076	26.7
6	1942	740	73210	98.9	42	1978	1122	13235	11.8
7	1943	779	46723	60	43	1979	1300	34132	26.3
8	1944	536	39315	73.3	44	1980	1092	10248	9.4
9	1945	1169	165307	141.2	45	1981	982	5470	5.6
10	1946	1023	125115	122.3	46	1982	950	4018	4.2
11	1947	868	59999	69.1	47	1983	968	3556	3.7
12	1948	630	32463	51.5	48	1984	1433	7358	5.1
13	1949	738	36502	49.5	49	1985	1793	26006	14.5
14	1950	987	69068	70	50	1986	1526	11037	7.2
15	1951	828	18884	22.8	51	1987	1310	10746	8.2
16	1952	1282	62271	48.6	52	1988	1372	18210	13.3
17	1953	654	17596	26.9	53	1989	1633	13099	8
18	1954	1126	35580	31.6	54	1990	1750	13742	7.9
19	1955	878	27773	31.6	55	1991	1481	8081	5.5
20	1956	1118	38983	34.9	56	1992	2117	12232	5.8
21	1957	779	28634	36.8	57	1993	2545	15393	6
22	1958	725	26862	37.1	58	1994	3239	38128	11.8
23	1959	436	8070	18.5	59	1995	1770	7676	4.3
24	1960	504	8559	17	60	1996	1645	14922	9.1
25	1961	620	9127	14.7	61	1997	1339	6316	4.7
26	1962	717	10059	14	62	1998	1932	6764	3.5
27	1963	455	5178	11.4	63	1999	2075	5804	2.8
28	1964	768	13348	17.4	64	2000	2353	26353	112
29	1965	415	3945	9.5	65	2001	2631	7394	2.81
30	1966	433	6664	15.4	66	2002	1471	8514	5.79
31	1967	473	8441	17.8	67	2003	2177	6644	3.05
32	1968	387	7540	19.5	68	2004	1762	4876	2.76
33	1969	714	16354	22.9	69	2005	1530	2821	1.84
34	1970	790	15019	19	70	2006	2226	7760	3.49
35	1971	651	7532	11.6	**TOTAL**		80011	1571607	19.64
36	1972	440	6913	15.7					

Table 5. Distribution of forest fires by forest management types in Turkey (2006) (Turkish General Directorate of Forestry, 2007).

Fires	Total burnt forest area (ha)	Timberland (ha)	Coppice (ha)	Maqius (ha)	Forestation area (ha)	National park forest (ha)
2226	7760	7067.8	333.1	55.7	301.4	2.3
Proportion		91.08%	4.3%	0.7%	3.9%	0.02%

Table 6. Forest fires causes in Turkey in last 13 years (Turkish General Directorate of Forestry, 2007).

Years	Causes of forest fires								Total
	Purposeful (delibarate)		Lightning		Negligence/carelessness/accident		Unknown reasons		
	Number	%	Number	%	Number	%	Number	%	
1994	289	8.93	135	4.16	887	27.38	1928	59.53	3239
1995	270	15.26	129	7.29	577	32.59	794	44.86	1770
1996	204	12.40	56	3.40	698	42.44	687	41.76	1645
1997	193	14.41	78	5.82	696	51.98	372	27.78	1339
1998	249	12.89	53	2.74	1163	60.19	467	24.18	1932
1999	279	13.44	203	9.78	1151	55.47	442	21.30	2075
2000	410	17.42	132	5.61	1384	58.82	427	18.15	2353
2001	251	9.54	188	7.14	1629	61.91	563	21.39	2631
2002	218	14.81	181	12.30	809	54.99	263	17.88	1471
2003	258	11.85	120	5.52	1317	60.49	482	22.14	2177
2004	242	13.73	128	7.26	1033	58.63	359	20.37	1762
2005	272	17.77	140	9.15	867	56.66	251	16.40	1530
2006	241	10.83	328	14.74	1232	55.35	425	19.08	2226
Total	3376	12.91	1871	7.15	13443	51.41	7460	28.53	26150
Average of 13 years	259.69	12.91	144	7.15	1034	51.41	573.85	28.53	2011.54

Table 7. Causes of forest fires in Turkey (2006) (Turkish General Directorate of Forestry, 2007).

Causes of forest fire	Details	Number	(%)	Area (ha)	(%)
Negligence carelessness	Stubble fire	89	3.99	198.330	2.56
	Rubbish heap	17	0.77	60.700	0.78
	Hunting	18	0.81	10.360	0.13
	Shepherd fire	113	5.07	92.220	1.19
	Cigarette	199	8.95	1075.333	13.86
	Picnic fire	66	2.96	70.726	0.91
	Others	626	28.12	4092.819	52.74
Total		**1128**	**50.67**	**5600.488**	**72.17**
Purposeful (delibarate)	Terror	-	-	-	-
	Arson	65	2.92	72.614	0.94
	Clearance	10	0.45	4.828	0.06
	Others	166	7.46	128.628	1.66
Total		**241**	**10.83**	**206.07**	**2.66**
Accident	Locomotive-railway	5	0.23	2.700	0.03
	Energy transferring line	71	3.19	248.371	3.20
	Traffic	1	0.04	0.050	0.0006
	Others	27	1.21	21.430	0.27
Total		**104**	**4.67**	**272.551**	**3.50**
Unknown reasons		425	19.09	1138.396	14.68
Lightning		328	14.74	542.819	6.99
Total		**2226**	**100.0**	**7760**	**100.0**

Turkish General Directorate of Forestry has used 26 helicopters, 9 fire-fighting planes, 666 sprinklers, 137 bulldozers, 126 graders, 100 trailers, 38 loaders, 144 water tanks, and 366 4x4 vehicles for forest fire fighting. In addition, 10617 forest fire fighters, 1750 technical and administrative personnel, 1000 soldiers, and 7500 forest

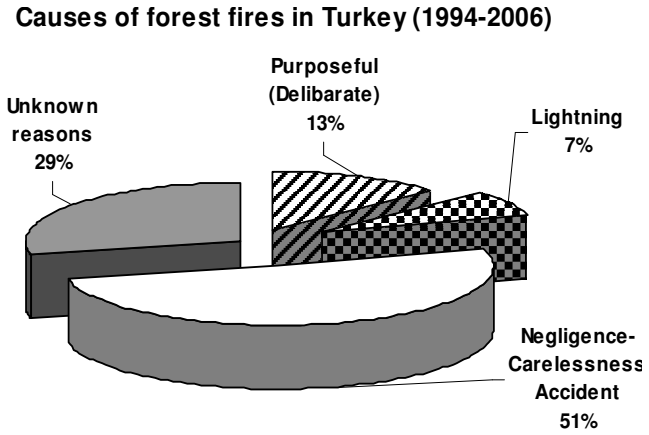

Figure 2. Causes of forest fires in Turkey (1994–2006) (Turkish General Directorate of Forestry, 2007).

villagers have been working in forest fire fighting.

Organizational framework in context of forest fire prevention in Turkey

In recent years, the Turkish government has taken a number of measures to improve its capabilities in forest fire prevention and protection. Forest fire protection rules are published every year by the Republic of Turkey Ministry of Environment and Forestry. These rules clearly define the forest fire safety responsibilities of the different levels of government. In addition, these rules define in detail the forest fire protection responsibilities of the different government units, government-sponsored institutions, forest enterprises, non-governmental organizations, and citizens. All these actions are taken in accordance with the Turkish Constitution (dated 97.11.1980, nr.2709, section 169), Turkish Forest Law (dated 08.09.1956, nr.6831, section 68-76), government regulations (dated 10.09.1976, nr.7/12520), and Forest Directorate Guidelines (01.01.1995, nr.285), and also according to the obligations of the responsible persons in the Turkish General Directorate of Forestry. The Ministry of Environment and Forestry and the Turkish General Directorate of Forestry are responsible for the prevention and suppression of fires in forest lands. Headquarters for forest fire management have been set up both in the central government and in local governments and in both central and local forestry directorates, divided into three management levels: provincial, district, and local. All these headquarters include forest fire prevention groups and have established general forest fire prevention offices with full-time workers. Fire suppression activities are carried out using a wide variety of tools, equipment, and human and mechanical resources, sometimes including aerial support: fire attack crews, fire personnel, bulldozers, tractors, trucks, water trucks, off-road vehicles, UHF and FM communication radios, telescopes, fire-resistant clothing, chemical retardants, airplanes, and helicopters.

Current status and evaluation of forest roads and firebreaks in Turkey

Total identified forest road needs in Turkey are 201810 km, of which 143251 km, or 70.98%, had been constructed by the end of 2006. As shown in Table 8, 70.98% of forest roads, 69.80% of firebreaks, 52.24% of major repairs, 51.67% of paving, 58.28% of bridges, and 64.82% of forest road structures which were planned to be constructed by the end of 2006 had in fact been completed. It is intended that the construction of all planned forest roads and the completion of all associated structures will be achieved within 20 years. As a result, today, a substantial part of the forests of Turkey have been provided with forest roads constructed on the basis of an overall plan, and transportation by truck on such roads has often been the one and only choice. The Turkish General Directorate of Forestry spent $12.7 billion for firebreak construction (5070 km) in 2003.

Forest roads have a very important function in forest fire fighting in Turkey. Although this is well known, forest roads have in fact been planned primarily to satisfy the requirements of forest harvesting and timber transportation. Forest roads have been planned and constructed according to road density (m/ha) and yield/forest area (m^3/ha) criteria to meet the needs of Turkish forestry. However, forest road density should be determined according to all aspects of forestry operations. One of these aspects is in effect forest protection and fire fighting. All the research done in Turkey has stated that forest road density may be 20 m/ha, which presents a high fire risk in forest areas from the viewpoint of fire fighting and forest protection (Mol and Kucukosmanoglu, 1998; Kucukosmanoglu and Hasdemir, 1991).

Conclusions

There is no doubt that much progress has been achieved in forest fire prevention and protection in Turkey. There are different methods for the fuels to eliminate forest fires. Turkish foresters and we strongly believe that all the foresters have agreed that management of fuels means control of the size and difficulty of the entire fire fighting job. The important fuel management activities which are applied in Turkish forests are given below:

i. Cleared and controlled burning road sides, railway and recreation areas.
ii. Firebreaks and fuelbreaks are still the best way to break down the forest fuels.
iii. Area fuel reduction mostly applied under silvicultural

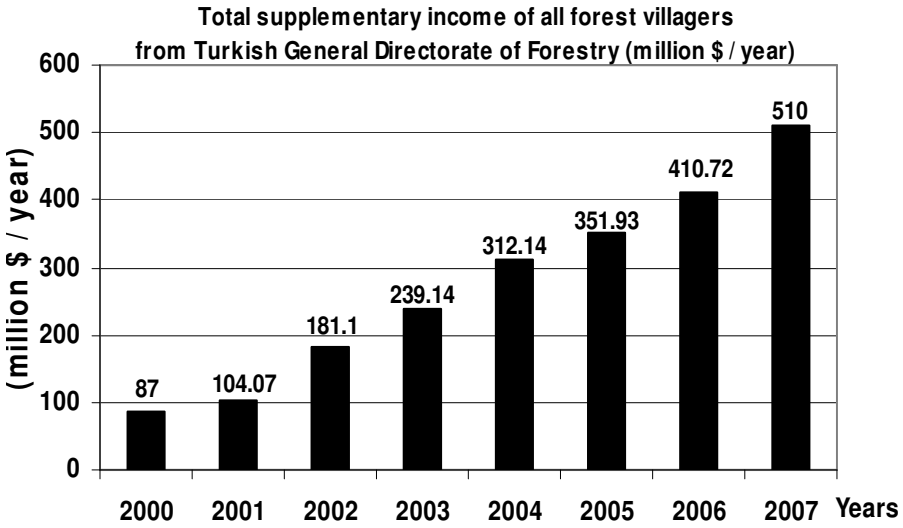

Figure 3. Total supplementary income of all forest villagers from Turkish General Directorate of Forestry (Turkish General Directorate of Forestry, 2007).

Table 8. Current status of forest roads in Turkey (2006) (Turkish General Directorate of Forestry, 2007).

Type		Forest roads needed	End of the Year 2006		Constructed roads (%)
			Constructed	Under construction	
New forest road construction	km	201810	143251	58559	70.98
Fire breaks	km	25544	17832	7732	69.80
Major repairs	km	61100	31923	29177	52.24
Pavement	km	54724	28277	26447	51.67
Bridge	m	23500	13697	9803	58.28
Forest roads structures	km	50000	32412	17588	64.82

methods.
iv. Following the forest disasters, such as wildfire, hurricanes, insect epidemics etc., materials must be taken off from the forest area.

However, with the fast-growing economy in Turkey, the present situation of forest fire protection is becoming severe. The main causes are that technical forest fire protection work has failed to keep up with social development and that regulation and management systems for forest fire protection are falling behind the present state of social development. Therefore, more effective regulations and rules should be set up soon, and a strategy should be developed in Turkey to carry out timely forest fire research work so as to cope with the new challenges of forest fire hazards in the future.

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