Chapter 9
Fire on the Hills: An Environmental History of Fires and Fire Policy in Mediterranean-Type Ecosystems

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Abstract Human impacts on natural landscapes through urbanization and agricultural expansion have left a deep and enduring imprint on almost every dimension of the natural world. Throughout history, fire has almost always been associated with this human expansion, from field clearance and the burning of fossil fuel biomass to human-induced conflagrations. "The arrival of a fire-wielding species," observes Stephen J. Pyne, "was a monumental moment in the natural history of Earth" (Pyne 2010, xvii). These fires, whether anthropogenically sparked or lightning-ignited, have not only shaped where and how humans have settled, but how ecosystems themselves function in fundamental ways. This chapter examines the role of fire in the socio-ecological history of Mediterranean-type ecosystems, with an emphasis on the dynamic interaction between fire and climate, and the efforts of humans to live with and control fire regimes.

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9.1 Introduction

Case studies from the northern Mediterranean basin, China's Shangdong Province, Southern California, and Israel, will be used in this chapter to explore some of the varied historical attempts to master, marginalize, and manipulate fires in Mediterranean and Mediterranean-like ecotones. The chapter begins by exploring the historical-environmental context of fires in the northern Mediterranean basin, including an overview of the spatial distribution and temporal evolution of recent fire history and of the region's fire regimes and fire-weather patterns. Then the focus shifts to the first of three case studies, with an analysis of the fire history in the Chinese Province of Shangdong. In particular, it probes the relationship between climate, historical agricultural and silvicultural management schemes, and recent urban development patterns to characterize the frequency, causes, costs and administrative perceptions related to destructive fires in China's recent environmental history. These issues also form the basis of this chapter's examination of the complicated evolution of recent firefighting policy in Southern California's Mediterranean ecotone; as the 2009 Station Fire demonstrates, the politics of fire in Los Angeles are as controversial and contested as anywhere in the western United States. They are explosive in Israel, too. The charred aftermath of the 1989 and 2010 Carmel fires revealed the complex character of that country's fire science and its policy regimes, as well as some of the flawed responses they subsequently generated.

By setting this cross-cultural analysis of recent fire histories in Mediterranean-like ecotones into the wider context of climate change, shifting land-use patterns, and rapid population growth, this chapter makes the case for a multi-disciplinary approach to the study of fire globally. Doing so will deepen our understanding of the history, science, and policy of firefighting such that we might forge more effective strategies for living sustainably in the fire-prone and dynamic landscapes of Mediterranean ecotones.

9.2 The Recent Fire Environmental History in the Mediterranean

The Mediterranean countries are the most affected by forest fires in Europe (Pereira et al. 2014). In fact, according to the Burned Areas Perimeters (BAP) dataset of the European Forest Fire Information System (EFFIS), Portugal, Spain, France, Italy and Greece accounts for 78 % of total burnt area (hereafter, BA) and 84 % of total number of fires (hereafter, NF) registered in Europe in the 2000–2013 period (Table 9.1). Furthermore, the spatial distribution of fire incidence (number of fires and burnt area) is not uniform between these countries or within each country (Pereira et al. 2011).

The analysis of the EFFIS's European Fire Database (EFD) reveal that, in absolute terms, the most affected countries in the 1980–2013 period are: (i) Portugal

Table 9.1 Fire incidence in European countries. Total and relative number of fires and burned area for the countries contemplated in the European Forest Fire Information System (EFFIS) fire database for the 2000–2013 period

	Burnt area		Number of fires	
Country	ha	%	#	%
Portugal	1,564,400	32	5211	37
Spain	1,052,295	21	3334	24
Greece	593,396	12	653	5
Italy	530,969	11	2382	17
Albania	273,128	6	687	5
Bosnia	181,772	4	286	2
France	118,208	2	377	3
Other	605,197	12	1230	9
Total	4,919,365	100	14,160	100

Adapted from Pereira et al. (2014)

(37 %) and Spain (31 %) in respects to the burnt area; and (ii) Spain (37 %), Italy and Portugal (24 %) in terms of the number of fires. In relative terms, taking into account the size of the countries to overcome the extensive character of these measures of fire incidence, Portugal has seven times more NF and three times more BA than the second most affected country (Italy). Using MODIS dataset to extend the analysis to the southern border of the Mediterranean discloses the high magnitude of the fire activity in North Africa, particularly in Algeria. Recognizing the high fire activity in this region, the EFFIS include, since 2011, fire information from the Middle East and North Africa (MENA) countries in its annual reports (Schmuck et al. 2014).

Land use and population statistics (FAOSTAT 2013) may explain the differences in the fire activity statistics in the Mediterranean countries. In 2001, Portugal, Spain and Greece had the highest percentage of forest cover (37–34 %) and, consequently, the lowest percentage of total area of arable land and permanent crops (17–26 %). The remaining two Southern European countries presents precisely the opposite proportion. In addition, the percentage of rural population is very similar in Portugal, Greece and the MENA countries but much higher than in the other Mediterranean European countries.

Fire activity, however, is not conditioned by national borders. In fact, the most affected regions in Europe are: (i) the NW region of the Iberian Peninsula (IP); (ii) the southern regions of France and Italy, (iii) the islands of Corsica, Sardinia and Sicily; (iv) the Greek regions of Peloponnese (Pereira et al. 2014); and (v) the coast of Algeria. At the global scale, there is a very high correlation between spatial patterns of the pyrogeography and the Köppen climate classification (cp. Krawchuk et al. 2009; Peel et al. 2007). The same similarity is noticeable at a smaller scale in the Mediterranean regions with large NF or BA and hot (Csa) or warm (Csb) summer Mediterranean (temperate) types of climate (Fig. 9.1).

This similarity between the spatial patterns of fire incidence and climate classification can be easily interpreted. The climate determines the existence, type and life

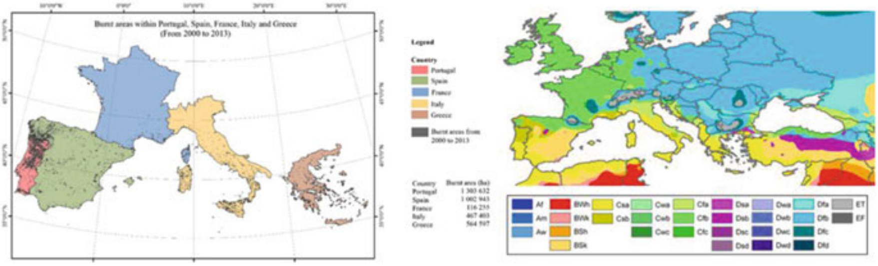

Fig. 9.1 (**a**) Perimeters of burned areas in Southern Europe (Pereira et al. 2014); (**b**) updated world map of the Köppen-Geiger climate classification (Peel et al. 2007)

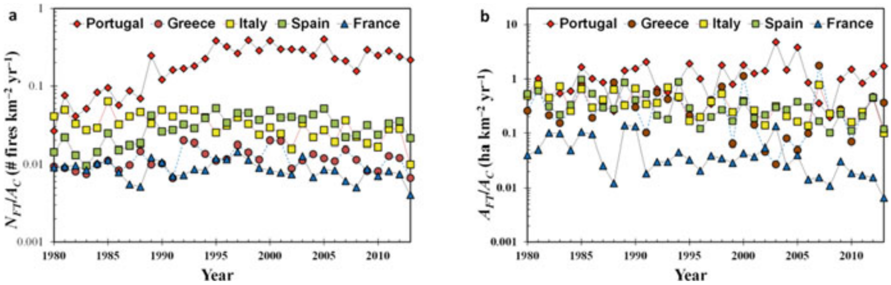

Fig. 9.2 Rural (wildland) fires in Portugal, Spain, France, Italy and Greece, 1980–2013. For each country, the temporal evolution of (**a**) fire occurrences density (number of fires per year NF (#) normalized by country area A_C (km^2)); (**b**) percentage of country land area burnt by rural fires (burnt area BA (ha) per year normalized by country area (km^2)) is given

cycle of the vegetation, whereas the weather conditions determine the state of the vegetation and play a fundamental role in all stages of fire, ignition, behavior and extinction (Benson et al. 2009; Pereira et al. 2013). The temperate climate of the Mediterranean is characterized by mild and rainy winters, favoring the vegetation existence, type and growth, followed by warm and dry summers leading to high vegetation thermal and hydric stress.

Climate and weather conditions also help to explain the temporal distribution of the fire activity. In the Mediterranean, the fire incidence/activity measures present large intra-annual variability with much higher values during the summer season, mainly in the months of July and August (Pereira et al. 2011; Schmuck et al. 2013). However, in some regions a second peak of fire activity is also observed in spring (March). For example, BA in the NW region of IP present a large peak in August and a much smaller one in March while in the N region there are two peaks, one in spring (March) and another in late summer (September), and they are of similar (although small) magnitude (Trigo et al. 2013).

There is also a large inter-annual variability in NF and BA in the Mediterranean countries (Fig. 9.2). This variability is related to the climate variability and to weather conditions that at different spatial and temporal scales may increase the

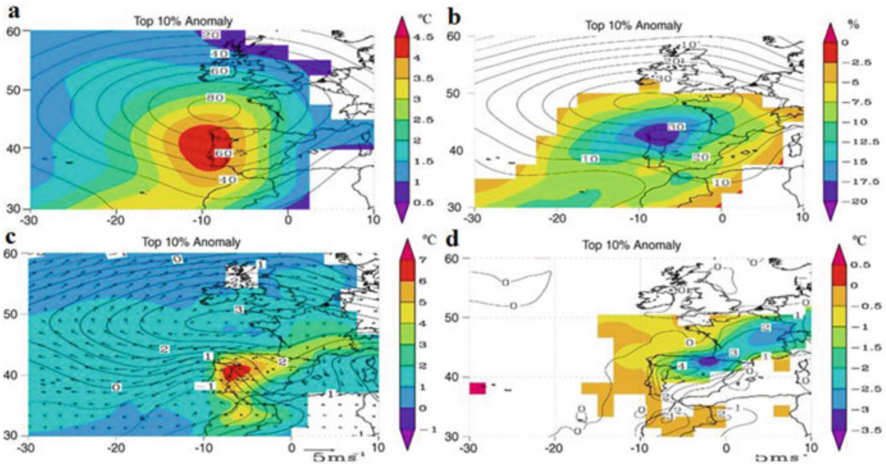

Fig. 9.3 (**a**) Air temperature at 850 hPa and geopotential height (gpm) at 500 hPa; (**b**) relative humidity (%) at 850 hPa and geopotential height (gpm) at 850 hPa; (**c**) maximum air temperature at 2 m height and sea level pressure (mb) and 10 m wind field; (**d**) precipitation rate (mm/day) and temperature range (T_{max}–T_{min}) at 2 m height anomalies for the 10 % summer days of high burnt area (Adapted from Pereira et al. (2005))

fuel's flammability and, therefore the fire danger and risk (Pausas and Paula 2012; Sousa et al. 2015). For example, the occurrence of drought before the fire season (between the end of winter and the beginning of summer) – climate anomaly – and extreme weather conditions (e.g. heat waves) – weather anomaly – have been identified as being associated with large fire activity within the Mediterranean region (Pereira et al. 2005; Trigo et al. 2006; Amraoui et al. 2013; Sousa et al. 2015).

To better understand the relationship between fire, weather and climate some authors studied the meteorological conditions during days of extreme fire activity (burnt area) using, among other techniques, the composite analysis (Pereira et al. 2005; Trigo et al. 2006; Amraoui et al. 2013). Composite analysis consists of computing two arithmetic averages, one using the entire sample or data period (reference, long term or climatological mean) and the other for a subsample (composite), and the anomaly defined as the difference between composite and the reference mean. Thus, positive (negative) anomalies are associated with values above (below) the average. Typically the anomaly is only plotted where it is statistical significant. This approach is motivated and justified by another important feature of the Mediterranean fire regime; like in many other biomes, a small number of large fires is responsible for the major proportion of total burned area (Strauss et al. 1989; Pereira et al. 2011). Pereira et al. (2005) identified and characterized the synoptic patterns associated with large summer forest fires in Portugal by studying the large-scale climatic and dynamical meteorological fields at different levels of the atmosphere for 10 % of summer (June–September) days with the highest values of burnt area (Fig. 9.3).

They found that synoptic patterns of the meteorological fields in days of extreme BA present statistically significant anomalies over western Iberia (Fig. 9.3). Positive anomalies in the (maximum, average and minimum) air temperature and geopotential height fields are observed at surface and at lower (850 hPa) and in the mid (500 hPa) troposphere, associated with negative anomalies of air relative humidity at 850 hPa, precipitation rate, cloud cover and temperature range at surface (Fig. 9.3). These climatic patterns are coupled with anomalous circulation from East (in altitude) and Southeast (at surface) forcing an also anomalous advection of hot and dry air respectively over the continental shelf and from North Africa, which are further heated and dried when crossing the Iberian plateau. These results led to the development of models of the fire incidence based on meteorological parameters. In this case, the best linear model was obtained combining the identified wildfire prone atmospheric patterns (short term heat waves control – weather anomaly) with monthly precipitation (long term precipitation control – climatic anomaly) and was able to simulate about 2/3 of the inter-annual variability of observed summer BA (Pereira et al. 2005).

Similar studies with consistent results were performed on other Mediterranean countries. Amraoui et al. (2013) also used composite analysis to identify and characterize the synoptic patterns associated with large fire activity over the eastern Mediterranean European countries of Italy and Greece. For the Iberian Peninsula, Trigo et al. (2013) used: (i) cluster analysis to identify and characterize four different pyro-regions within IP;(ii) composite analysis to provide an overview of the typical synoptic patterns related with the occurrence of large BA in the IP's pyro-regions; and, (iii) regression analysis to develop the relationship between monthly BA with both long-term climatic pre-conditions (temperature and precipitation from 2 to 7 months in advance to fire peak season) and short-term synoptic forcing (synoptic weather patterns derived from 11 distinct weather types classifications).

These fire-weather relationships can be used to estimate potential impacts of future climate change on Mediterranean fire regimes. For example, Pereira et al. (2013) used regression analysis to develop a Burnt Area Model (BAM) to estimate the decimal logarithm of the monthly burnt areas in July and August using a fire weather index (the Daily Severe Rating, DSR) before and during the fire season. Then the BAM was used to estimate future distribution of BA in summer months based on projections of the DSR for future climate scenarios. Sousa et al. (2015), used different approaches to model future burnt area in the four pyro regions of the Iberian Peninsula identified by Trigo et al. (2013) using outputs from an ensemble of four Regional Climate Model (RCM) and developed models (to simulate the inter-annual variability) which also take into account the extreme meteorological conditions during the fire season and specific meteorological backgrounds (such as prolonged droughts).

Large fire occurrence is dominated by the weather/climate in spite of the current reinforced resources to manage, control, suppress and fight the fires (Sousa et al. 2015). In extreme cases, such as the exceptional fire season of 2003 in Portugal, the associated atmospheric conditions proved to be able to explain not only when but also where large fires occurred (Trigo et al. 2006). Nevertheless many other societal and natural factors contribute to shape the fire regime in the Mediterranean. For example, in this biome fires are essentially human caused by accident, negligence or arson (Pereira et al. 2011) and, consequently, human behavior and socioeconomic activities controls the fire ignition in the Mediterranean region (Costa et al. 2010; Moreno 2014). The morphology of the landscape, land use-land cover can also strongly control some characteristics of the fire activity (Amraoui et al. 2013; Barros and Pereira 2014; Moreira et al. 2011; Pereira et al. 2014).

9.3 Fires and Policy Regimes in Shandong Province China

On May 29, 2014, the city of Weihai on Shandong Province's north coast faced a spectacularly visible fire. With journalists and city residents taking pictures of flames that came perilously close to the urban environment, the Weihai fire created a great deal of media coverage. A small fire in absolute terms, considering the fragmented and small forested areas of eastern China, it was a severe fire for coastal China. It started around 3 pm on Thursday and the main complex was contained by late Friday morning, though small spot fires were not contained until Saturday evening. In the primary complex, a two by seven kilometer swath of a protected area, Xianguding National Park, and parts of peri-urban northwest Weihai City burned in less than 6 h, with numerous stringer fires up canyons and spotting up to three and four kilometers away. Some spectacular long flame-lengths and crown fires were caught on film. Fanned by strong winds, the fires were burning a buildup of dry grasses, leaves, forest litter and trees. The fire burn pattern was caused by strong afternoon coastal and evening foehn-like winds. Visually, the fires were a mix of low intensity surface fires that shifted in and out of crown fires depending on slope and vegetation. In all, some 800+ local people were displaced, most into local shelters. More than 2000 firefighters, soldiers and three helicopters were dispatched to put out the fire. Steep slopes, extremely hot-burning fuel and high winds (at time 60 + km/h) were particularly challenging for fire crews and the helicopters were primarily used to fight the spot fires until crews could later reach and contain them safely. (*Xinhua* 2014; *China Daily* 2014a, b)

This particular fire (and many Shandong fires) acted like Mediterranean-type Climate (MTC) fires. Shandong is not considered an MTC zone, but the fire regime and vegetation system largely act like one. To make some sense of the Weihai fire complex as a Mediterranean zone-like fire regime, unpacking the nature of this region becomes a story of vegetation development, drought and fire activity, and above all, human factors in promoting and managing fires. The vegetation burned in the Weihai fire was dominated by evergreen sclerophyllous leaf development: at higher altitude, *pinus*-dominated conifer forests, broadleaved forests in non-urban and agricultural areas, and a preponderance of multi-stemmed shrubby *phanerophytes*—or in the parlance of some fire-fighters in MTC California, litter-bug shrubs and trees in a patchy network of rural and peri-urban areas. Drought and wind were also important factors, as were local land management systems and contemporary fire policies, a pattern that is reflected in other similarities between Shangdong and traditional MTC fire-prone ecosystems. These include patterns of fuel consumption and fire spread nearly identical to MTC chaparral/shrublands, fire intensity (commonly ground to crown fires), and the influence of high and steady winds.

There are some significant differences between traditional MTC and vegetation zones and this one in Shandong Province. The classic MTC regions are the Mediterranean Basin, California, central Chile, and sections of South Africa and Australia. Evergreen broadleaf shrublands dominate most MTC zones, with some evergreen woodlands of low broadleaf *Quercus* and *Pinus* trees and annual grasslands. The MTC regions also have extreme seasonal wind events (katabatic and foehn winds) that typically last a few days and may occur many times a year. When these winds coincide with droughts and ignitions they are associated with extreme fire events, characterized by high rates of spread, long flame lengths, and long-distance spotting (Keeley et al. 2012).

There are several key elements to fire frequency and severity in Shandong. To begin with, the landscape of Shandong is highly fragmented, dominated by agriculture and fruit tree silviculture, with intermittent grasslands and urban/peri-urban areas. The province is also split by a low mountain range, with a slightly drier and windier north coast and more humid southern half. Deforestation, scrublands, and erosion have been serious issues for much of the province since at least the 200 s CE based on extensive agriculture in lowlands and on marginal hillsides, and especially increasing with the extensive demographic expansion of the region after 1700 CE (*Shandong shengzhi: renkou* 1994). The resulting vegetation and human map of Shandong is one of fragments, a mix of grasslands, rangelands, regrowth timber, upland marginal areas, protected areas, fields, and urban areas—and much of it is fire-prone.

Humans have had a multitude of impacts on fire regimes that include changes in frequency and timing of ignitions and changes in fuel load and landscape patterns of fuel distribution. (Keeley et al. 2009b) In MTC regions where natural ignitions are frequently limited (or limiting), large human populations and population growth have generally been associated with increased fire frequency. But human ignitions are only part of the story—they have also shifted the season(s) of burning to periods of severe fire weather and high winds and high temperatures.

In terms of land use, burning has a clear logic and long history in agricultural Shandong. In effect, historical firing of terrestrial vegetation cleared, defended or recycled plant (nutrient) material. Regular firing could help protect against unpredictable or destructive wildfires, burn off stubble, protect from shrub and tree encroachment, or simply clear new land. The largely protected and peri-urban area that burned in the Weihai fire complex had been at different times crop land, meadow/grass range, covered by heavy forest (regrowth) exploited for timber, shrub wasteland, and it is now moderately forested and shrubland, closed and protected forest reserve and national park. But field burning in particular corresponds with the worst possible time(s) for severe fire weather, high winds and temperatures. In Shandong (as in the Mediterranean Basin and parts of California) repeated burning of shrub lands to expand range and agricultural land has to some degree been

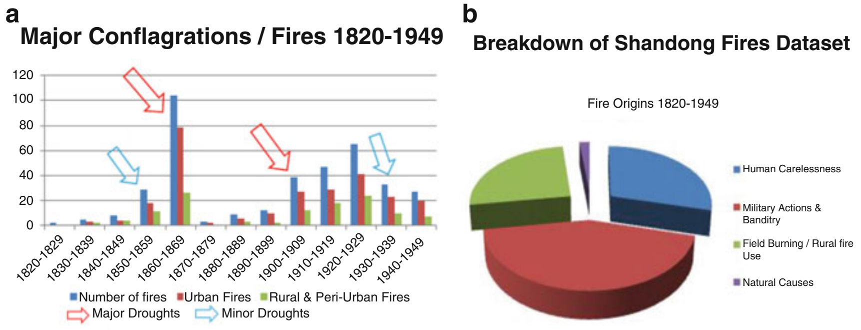

Fig. 9.4 (**a**) Fire and drought cycles; (**b**) fire origins in Shandong Province, 1820–1949

replaced beginning in the late twentieth century by the abandonment of traditional rural lifestyles as well as the outlawing of such burning. Resulting recolonization of previously cleared landscapes by woody species has resulted in increased fuel loads that have contributed to greater frequency of larger and higher intensity fires.

Common commercial and shrubland tree species in Shandong include oak, cedar, elm, pistachio, a variety of pine (especially on hillsides and at higher elevations), as well as bamboo and cypress (especially in the southern half of Shandong). The most fire prone vegetation complexes form a kind of chaparral of largely sclerophyllous vegetation with several key species in common with MTC areas and fire regimes (including and especially *Fagaceae, Rosaceae*, and *Ericaeae* among others), and its patterns of fuel consumption and spread are very close to chaparral shrub, pine, and eucalyptus fire intensity. The shrubland/forest area fuel structure has been altered in diverse ways over the long history of Shandong. When policies of suppressing fires have been successful in excluding fires over broad regions for periods of time (particularly since the late 1980s), fuels have accumulated. This was and is particularly the case in many protected areas of China, including the forest reserves in Shandong (as the example of Weihai demonstrates). Historically, selective and indiscriminate timber harvesting have also had their influence on fuels as some tree species that were once common (*pinus* in particular) have become rare or are missing from plant communities, and others have emerged as common secondary growth (bamboo and cypress in the south in particular) though they do not appear in historical descriptions (*Shandong shengzhi: linye zhi*, 1996).

The vast majority of historical fires in Shandong's MTC-like fire regions were (and remain) human ignitions; those in the pre-1949 period were especially attributable to warfare and human carelessness (Zhong 2005). Although annual summer droughts (climate) contribute to large fire events in all MTC areas, warfare is a rather unique fire factor for Shandong and in this regard, warfare and climate impacts often colluded to facilitate major conflagrations. In the pre-1949 period, severe droughts in Shandong usually coincided with major peasant revolts, including the Taiping and Nian Rebellions of in the 1860s and Boxer Rebellion of 1900–1901 (see Fig. 9.4). Based on available historical data, the fire return interval for

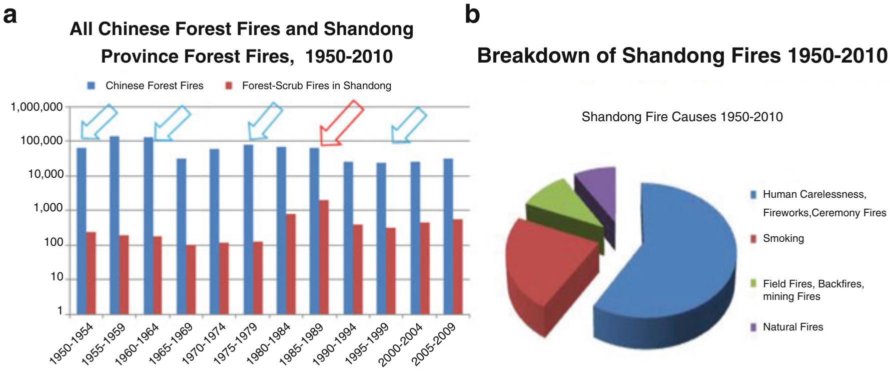

Fig. 9.5 (**a**) Fire and drought cycles; (**b**) fire origins in Shandong Province, 1950–2010

drought-fire-military events was roughly 60 years with minor events between 23 and 27 years (Hayes 2012).

Despite some minor droughts, fire incidence did not rise in Shandong for much of the post-1950 period until the late 1980s when the incident and severity of fires increased significantly. As with other fire prone areas of China's southwest and northeast, Shandong's central mountainous areas and northern chaparral-like shrublands burned in the mid and late 1980s. At the same time, human-related ignition rose, especially from smoking, accidental fires from funeral or other ceremonies, and fireworks, which increased and regularly exceeded earlier fire intervals (see Fig. 9.5).

Part of this trend was driven by the post-1950s expansion of metropolitan population centers into rural and shrub lands. This urban sprawl has placed more and more people and structures at risk and created a very vulnerable wildland-urban (or peri-urban) interface that totals millions of homes and periurban/rural areas while raising the risk of human related fire ignition (Gao 2002). This is a greater problem in the northern half of Shandong, where urban sprawl is increasingly occurring in high-fire-risk vegetation on steeper hillsides. In response to this human growth pattern, fire management in Shandong consists primarily of rapid deployment of fire suppression forces against all unplanned fires. Despite this policy, the total area burned in coastal and foothill landscapes has slowly increased over the past 60 odd years.

Fire management strategies in China, from the late imperial period to the present, focused on minimizing the impacts of fire hazards to human population centers. More recently the Chinese government has ostensibly added to the goal of sustaining natural ecosystems through forest protection to fire management, but sustained attention to this aspect of fire management has been marginal. In post-1949 China, the Forest Protection Office (later Ministry of Forestry) and a suite of forest protection laws have dealt with fire management through rapid deployment of fire suppression forces (almost always elements of the Chinese military) and severe punishments of real or perceived arson or fire accidents. Fire suppression forces until the 1970s usually had little training in actual fire management. However, the basic tools of firefighting were in place and included fighting the fires where they happened (rapid response), creating and maintaining firebreaks, and afforestation (creation of forest fire resistance belts) (Zheng 1991; Du and Wang 2007).

While this "classic" approach helped prevent some fires, and even seems to have helped slowly decrease the overall level of fire incidence prior to the 1980s, droughts and massive and costly fires since the late 1980s have led to new policies and strategies. A salient and important element of the "classical" and contemporary fire-mitigation approach has been the development of generally uniform firefighting policies and strategies across the entirety of China. These policies have been framed around how firefighting has been conducted in China's southwest and northeast with very different kinds of fire regimes (Zheng 1991; Hu 2002). What worked well enough in those regions has proved problematic elsewhere.

National fire issues aside, the 1970s and 1990s in Shandong saw major fuel buildup with related and more severe fires. In the 1970s, forest silviculture and harvesting techniques led to a tremendous amount of slash and forest litter prone to combustion during spring field burning. The 1990s policy reaction, in the wake of the costly Black Dragon Fire (1987), ironically saw a fuel buildup and regular fires because of very rapid response (less fuel load burning off) and incorporation of sections of "forested" (often shrub) lands in regional and national parks. Massive funding was dumped into these fire prevention systems (RMB 56 billion nationally since 1987; RMB 30 million for Shandong c. 2005–2006), and have included since the 1990s an improved forest fire forecast system largely based on Köppen-Gieger vegetation and climate models, synthetic indexes, moisture variants, and US fire danger models. In Shandong there has also been increased concern with wind speed index and patterns, and concern with (but no policy) on fuel moisture and fire behavior standards. These recent policy initiatives have resulted in more monitoring and some prepositioning based on fire danger rating and wind(s) and long standing rapid response reactions to fires when and where they happen.

Shandong's fires are increasing, and especially on the north coast of the province, they usually look and act like Mediterranean type climate fires—and while these fires are usually not BIG fires in relative terms, they are destructive and costly in a highly populated and utilized landscape. Yet fire management and prevention in Shandong continues to be modeled on fires that occur outside of the province. The historical solution to solving Shandong's fire problem focuses on fuels and people who ignite them and the organizational framework persistently frames the urban/peri-urban fire prone interface fire problem in terms of fire suppression and control. Rapid response has helped prevent the spread of many fires, but when severe weather conditions have intervened (as in the 2014 Weihai conflagration), destructive fires have spread rapidly out of control. In the rapidly expanding urban and peri-urban areas of Shandong, especially on the north coast, there is little or no alteration of urban zones to create buffer zones around buildings or other basic fuel treatments along wildland-urban interfaces. Certainly, part of the solution to dealing with the fires is related to land planning decisions—but an equally powerful model might be to look at the nature of major fires in MTC fire zones for additional ways forward.

Buffer zones, strategic land planning decisions, and integration of regional and national fire management teams and forces (the majority of fire management teams are trained for vastly different fire regimes) might help in this process. Even considering avoidance of high fire hazard areas might help in planning decisions—but given historical trends, demographic and economic determinants in Shandong's regional planning, and the province's social and political restraints will likely prevent major shifts in dealing with perennial and dangerous fire situations.

9.4 Los Angeles Is Burning! Los Angeles Is Burning!

The 2009 Station Fire was the largest in the history of Los Angeles County (USA), scorching nearly 65,000 ha in its 2-month run (Fig. 9.6). Late that August, an arsonist ignited the blaze on a steep and inaccessible slope deep in the Angeles National Forest, whose 283,000 ha drape over the San Gabriel Mountains ringing Los Angeles to its north. Because conditions at the site of ignition were so dangerous—very high winds, very low humidity, elevated temperatures, thick brush, and unstable soils—it proved impossible to put firefighters on the ground. In hopes of containing the rapidly growing blaze, the U.S. Forest Service (USFS), which manages the Angeles National Forest, sought to contain the fire through aerial water and flame-retardant drops, even though it knew that such action was most effective only when done in coordination with active management on the line. Moreover, and by policy, it was not allowed to keep its fleet of helicopters and fixed-wing aircraft flying after sunset; as soon as these resources were pulled back at twilight on August 29, the fire blew up (a consequence that ever since has been contested in the U.S. Congress and federal courts). Over the next 60 days, the raging fire forced the evacuation of thousands of residents living in the foothills, canyons, and ridgelines, many of whose homes lacked defensible space. Two county firefighters died while defending structures in the wilderness, a striking decision that was never communicated to the fire's incident commander. Adding to the complexity of the firefighting response, the USFS, The California Department of Forestry and Fire Protection (CalFire), and the Los Angeles County Fire Department joined forces with many local fire departments (GAO 2011). Finally, Los Angeles being *Los Angeles*, the massive conflagration that illuminated the night sky, and whose smoke plume swept as far as Denver, Colorado, more than 800 miles east, was captured by every kind of media, new and old, creating an ongoing, meta-analyses of the fiery event.

As such, the Station Fire offers a unique opportunity to discuss the complicated evolution of firefighting policy in Southern California, a Mediterranean ecotone in which fire is an expected event. Nothing about this evolution—from fitful (and unsuccessful) twentieth-century efforts to establish suppression as the sole response possible to early twenty-first-century strategies that have called for a more varied set of managerial reactions—has been uncontested. These debates, academic and public, have escalated as a result of the Station Fire, as well as from pressures associated with Los Angeles' increased population density, outward sprawl, and the brutal

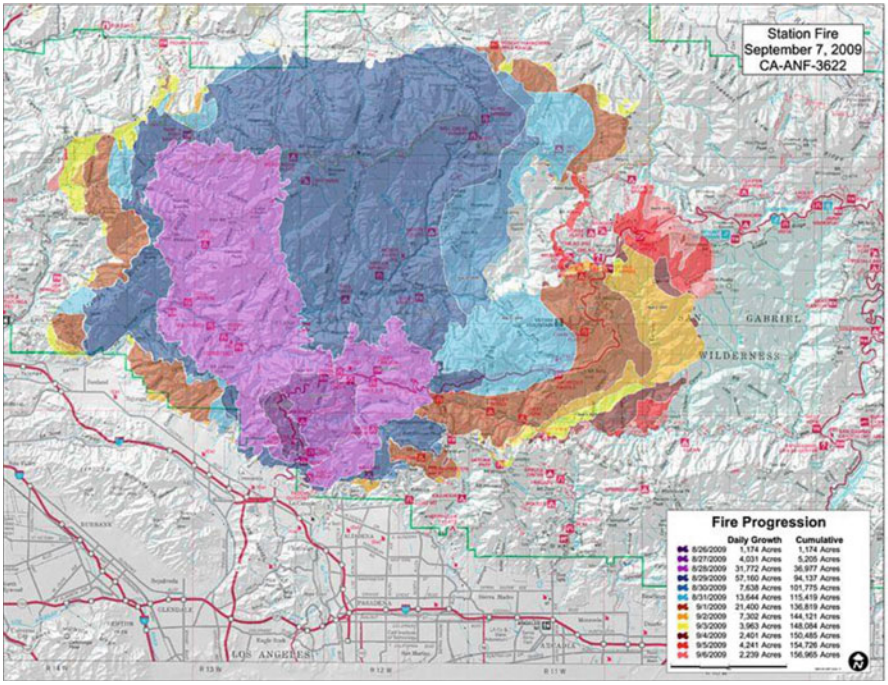

Fig. 9.6 Progression of the Station Fire through September 4, 2009. Note the huge expansion on August 29 (Map courtesy of the USDA Forest Service)

dry spell wracking the region since the mid-2000s (Miller 2013). Because these conditions are not expected to abate any time soon, the politics of fire in Southern California should continue to be as intense as a wind-driven blaze racing through tinder-dry chaparral shrubland.

It was just those sorts of conflagration, and the fears they generated, that led to the creation of the Angeles National Forest in the first place. Forest advocate and real estate developer Abbott Kinney was among the first to urge the protection of these mountainous watersheds. “Native growths of brush and chaparral, scrub oak, greasewood, sagebrush” increasingly were being “removed from the land by clearing and fire,” he wrote in 1880, adding that all the “mesas are bare of verdure.” These environmental alterations left downstream communities and agriculture more vulnerable to winter flooding and summer drought. Kinney concluded in an 1886 report from the State Board of Forestry, on which he served, that “the destruction of the forests in the southern counties means the destruction of the streams, and that means the destruction of the country” (Robinson 1946) (Fig. 9.6).

Six years later, prominent citizens, grassroots organizers, irrigation districts, and chambers of commerce, as well as local congressional representatives, successfully appealed to U.S. Department of the Interior Secretary John W. Noble to address this problem. The Secretary submitted to President Benjamin Harrison a proclamation creating the San Gabriel Timberland Forest Reserve (in 1908, it was renamed the

Angeles National Forest under the management of the USFS in the U.S. Department of Agriculture). It became one of 15 reserves Harrison established using the Forest Reserve Act of 1891 that had granted the chief executive authority to designate “public reservations.”

In so acting, the president was setting the stage for a radical new conception of the purposes of the public domain, those federal lands the government owned in the Western states and territories. Hitherto, Congress’ ambition had been to sell or give away these many millions of acres to homesteaders, farmers, loggers, and miners—not to say railroad corporations—to encourage settlement and development. By the late nineteenth century, this policy had gained an array of detractors. Communities worried about the rapid depletion of local forests and grasslands, for example, found common cause with conservationists and scientists concerned that damaged environments could not be regenerated, with a corresponding loss of a sustainable economy (Miller 2012).

These and other engaged citizens advocated for a more robust nation-state to intercede to protect the public lands and the resources they contained. The government’s protective presence would produce important results, asserted one of the petitions submitted in favor of the San Gabriel Reserve. The reserve’s creation would insure that “the water would be preserved in the mountains, the snow saved from being speedily melted, the waters protected from pollution by large droves of cattle and sheep” (Robinson 1946).

The ideas that managing nature upstream to sustain human interests downstream, and that Washington could and should resolve local disputes over resource allocation and consumption, signaled a broader desire for a more efficient and effective federal government. The call for making public life more orderly, rational, and manageable was a hallmark of Progressive Era reform and activism. Emblematic of this era’s ethos was the establishment of the initial forest reserves, as well the 1905 formation of the Forest Service to manage them.

Emblematic, too, was the 1909 creation of the Los Angeles County Forestry Board, forerunner of the county’s Fire Department. Stuart J. Flintham, the organization’s third head, is credited with developing the department’s mission and launching many of the infrastructural initiatives that since have become essential to fighting forest fires in Southern California. He was its first trained forester, having received his bachelor’s degree in forestry at Cornell University and M.S. in forestry from the Yale School of Forestry, which Gifford Pinchot, the first chief of the U. S. Forest Service had endowed and whose curriculum the legendary conservationist helped devise. After serving as a forest inspector for the Forest Service in California, Flintham moved to Los Angeles and in 1912 took over the county’ fledgling forestry outfit (Miller 2012).

Drawing on his forestry education and subsequent field work for the USFS, and making immediate use of some of the lessons that he and his professional peers learned in the wake of the devastating Big Burn of 1910, which torched nearly 1.2 million hectares in Washington, Idaho, and Montana, Flintham devised a systemic approach to identifying, monitoring, and, where possible, suppressing fires in the San Gabriel foothills.

This included building firebreaks that snaked up foothills and ridgelines, using horses, mules, and vehicles to mount patrols during fire season, and constructing lookout towers to increase surveillance capabilities. First utilizing the telephone to speed up communication between firefighters on the ground, by the early 1920s the county force was making clever use of a mobile radio unit to coordinate its efforts. Even the local U. S. Army air squadron offered its bi-planes to conduct aerial-mapping services and fire overflights. In 1924, Flintham's deft administration earned the praise of one of his Yale classmates, William B. Greeley, then-Chief of the Forest Service. After inspecting the Los Angeles County's forestry program, he reported to *American City Magazine* that it was "exceptionally well organized and eminently progressive" (Miller 2012).

The topography and ecology of the San Gabriel Mountains have conspired against the human desire—however well organized—to exclude fire from this rugged landscape. John Muir, during a 3-day hike in 1875, recorded some of the features that have frustrated firefighters ever since: sheer-walled canyons, treacherously loose soils, and ridges "weathered away to a slender knife-edge," the whole thickly covered in a "bristly mane of chaparral." Its hazards carried a warning, Muir wrote. "The whole range, seen from the plain, with the hot sun beating upon its southern slopes, wears a terribly forbidding aspect. From base to summit all seems gray, barren, silent—dead, bleached bones of mountains" (Muir 1918).

This terrain comes alive when it erupts in flame. At lower elevations, the dominant plant community is California sage shrub and at midlevel elevations, chaparral habitat dominates. These landscapes provide a combustible fuel that if ignited on days of high wind, low humidity, and intense heat can create firestorms of immense and swirling power. Not everyone who has lived within the Los Angeles basin has seen these flames as detrimental to their way of life. The native peoples used fire to manage hillside ecosystems to produce more highly prized plants and animals. The Spanish did the same to promote grasslands for their livestock. These two groups knew enough not to live within the fire zones—the foothills, notched canyons, and upland slopes. Not so for late-nineteenth-century Euro-American outdoor enthusiasts and those seeking domestic solitude from the burgeoning city below. For these newcomers, fire became a problem that had to be solved.

Public concern in the fiery aftermath of major fires from the 1880s to the early 1900s turned political, generating demands for more robust firefighting forces at the local, state, and federal levels. Across the twentieth-century, as major fires continued to erupt, the U.S. Forest Service and the Los Angeles County Fire Department spent much of their budgets each summer and fall trying to stamp out these blazes. That this remains the case indicates that the dream of full-on fire suppression in Southern California has been and remains an unrealized policy aspiration. An aspiration that comes with even greater pressure in the early twenty-first century: more and more people now live in close proximity to the Angeles National Forest, making the protection of their lives and property critical to all firefighting forces in the region. Yet these residents' burgeoning presence—the metropolitan region contains more than 18 million people as of 2014—may be negating the effectiveness of firefighting tools such as bulldozers, chainsaws, and flame retardant-dropping aircraft, of Landsat imagery, drones, and other related high-tech resources (Cermak 2005; Keeley et al 2009a).

Since controlling fire in Southern California remains as partial a solution today as it was a century ago, this in turn raises a direct challenge to the prevailing argument that fire suppression is the source of such mega fires as the 2009 Station Fire. Minnich and others assert that fire suppression has disrupted historic forest-stand structures, allowed an unnatural buildup of fuel, and thus this is why the U.S. West has experienced an increase in fire intensity and size (Minnich 1983, 1995, 2001). Countering this claim is more recent scholarship that probes the ecological record and historical data of fires in the west, and factors in such drivers as drought and climate change. One study of ponderosa and mixed conifer forests concludes that mega fires occurred within these forest types long before the era of suppression emerged in the aftermath of World War II and that subsequent conflagrations were (and are) not therefore "abnormal" (Odion et al. 2014). Another study drawing on historical and ecological data for fires in montane forest of the Colorado Front Range reached the same conclusion (Sherriff et al. 2014). These findings hold true for Southern California's sage brush and chaparral ecosystems: "over the last 130 years there has been no significant change in the incidents of large fires greater than 10,000 ha," note Keeley and Zedkler (2009); "fire suppression activities are not the cause of fire events."

This new evidence of the challenges, past and present, that firefighters have confronted in Southern California is why the future of fire management in the San Gabriel Mountains will remain problematic and continue to evolve. As with China's Shangdong Province, so in this fire-prone landscape: Southern Californians need to learn to live with fire and craft public policy to reflect this new reality. Planning and zoning commissions at the local and county level must stop approving construction of houses in fire zones. Residents living within the San Gabriels' stiff folds must build defensible space around their homes to protect their property and the firefighters who are called upon to defend it. And firefighting agencies at every level of government will need to adopt an array of strategies that includes setting fires and fighting them, "letting them roam and shutting them off, cultivating, if coarsely, the combustibles that sustain them" (Pyne 2004, 191). Learning to tend fire in the Mediterranean ecotones is the essential, first step toward living more sustainably within them.

9.5 The 2010 Carmel Forest Fire – A Historical Policy Snafu

In December 2010 no rains had yet fallen on Israel, even though precipitation in the Mediterranean ecosystem usually begins at least 2 months earlier. Then, over a 4-day period, a wildfire charred approximately 2500 ha of Israel's Carmel forest, including oak scrub and pine forests. While small in absolute terms, the fire's size was much more significant in relative terms: 10 % of the entire Carmel Forest (and 1.5 % of Israel's total forested area) burned. By US standards, this would be the equivalent of a 5 million hectares forest fire (the 2013 Yosemite Rim Fire, by comparison, burned approximately 100,000 ha). Israeli firefighters were caught off-guard and ill-prepared. By the end of the first day of the conflagration, officials interviewed on the radio, when asked "how much of the fire is contained?" answered bleakly "None. It is completely out of control." Four days later, with the help of an international fleet of fire-fighting aircraft, the fire was brought under control.

Had the fire only blackened vegetation, the outcome may have been similar to the many fires that had preceded the 2010 fire. After all, fire is considered an intrinsic and periodically-occurring characteristic of Mediterranean scrublands in general, and in this area of Israel in particular (Naveh and Carmel 2003; Tessler 2012). But, unlike previous fires, the 2010 fire also claimed the lives of 44 people. Most of the victims were prison guards recruited from the south of the country to help evacuate the Damon Prison, located in the midst of the Carmel Forest. A bus carrying the prison guards headed up a steep two-lane road accompanied by a police escort. On a hair-pin turn, the bus and police cars found themselves surrounded by flame on both sides of the road. In a desperate attempt to turn back, the vehicles became trapped and the bus caught fire. Journalists and photographers, who were in the caravan, also documented the tragedy. It was not long before families of victims and scientific researchers alike were suggesting that the fire – and the deaths – may have been preventable had the government followed the recommendations of its own previous inquiries.

Could the tragic results of the 2010 fire been avoided? Did Israeli policy makers and land use managers have the knowledge required? Within the Israeli scientific community the answer is unequivocally, "yes." Pulling no punches, the post-2010 fire scientific report opens with the following statement:

> The committee used documents produced by previous committees (that were set up after the 1989 Carmel fire and the 1995 Shaar Hagai fire) and research conducted after past fires in the Carmel, the Biriya Forest and in the Jerusalem hills. From appraisals of those works, it is clear that the central problem concerning fires is the implementation of the recommendations and the management of forest and maquis shrubland, particularly with regard to fire prevention and not due to the absence of data, professional or scientific. (Perevolotsky et al. 2011), p.4 (*author's translation*)

The Carmel Forest sits on Mount Carmel, a triangular coastal range approximately 30 km long parallel to the Mediterranean coast and 13 km wide (Fig. 9.7). The city of Haifa (pop. 272,000 in 2012) sits on the northern tip of the mountain, straddling the forest to its south. The forest itself is a mosaic of land cover types, including planted pine forests, oak-dominated forests and scrub, fruit orchards, and several settlements, both urban and rural. Likewise, the forest is managed by diverse agencies. The Carmel National Park is managed by the government Nature and Parks Authority (NPA, which was, prior to 1998, two agencies – the Nature Reserves Authority and the National Parks Authority) and areas around the park are managed by Keren Kayemet L'Israel (KKL), which is a private land-owning organization and, since 1960, the country's quasi-governmental forest service (Amir and Rechtman 2006. Within the matrix of natural and forested areas are several human settlements, including two towns and several exurban and rural settlements. The mosaic of land managers is displayed in Fig. 9.7).

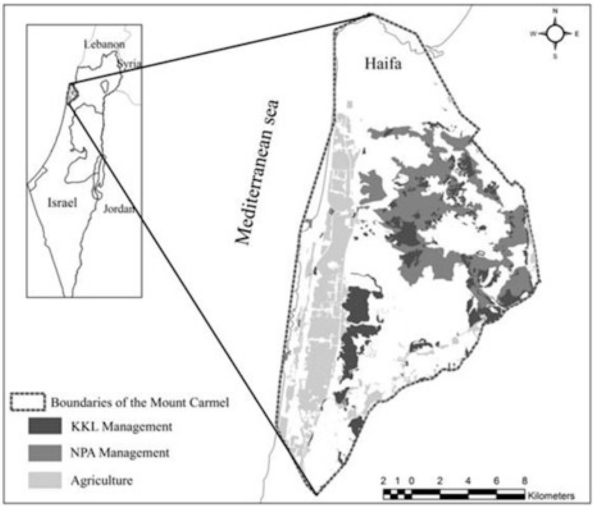

Fig. 9.7 Land management agencies responsible for the Carmel Forest on Mount Carmel and adjacent coastal plain (Map courtesy of Semion Polinov)

As referred to in the quote above, the 1989 Carmel fire was a watershed, Israel's first "national fire," (A. Perevolotsky, pers. interview, 17 June, 2014). The fire had been one of the biggest to date, slightly more than 500 ha (Tessler 2012), and it damaged a popular national park. The KKL turned the event into a trigger for a fundraising telethon that raised an unprecedented amount of money for forest restoration and research. But the fire also catalyzed the creation of a government-appointed scientific committee, which included representatives from the relevant land management organizations, and which was charged with delivering science-based recommendations for Carmel forest restoration. This would be the first of successive investigative panels that would issue similar recommendations following periodic fires all the way through the 2010 fire.

The recommendations, according to participants in the committee, were novel at the time of issue in the early 1990s, and some were even considered controversial, although they have since become routine. The recommendations focused on three spheres of activity: firefighting, fire prevention and restoration. According to Professor Uriel Safriel, ecologist, committee member and chief scientist of the Nature Reserves Authority (NRA) during and after the'89 fire, recommendations to allow more effective firefighting were largely heeded. They included the creation and maintenance of access roads and the establishment of a new fire station. Research on firebreaks was also initiated, but actual firebreaks were not created (pers. interview, 2014). Recommendations concerning restoration focused, controversially at the time, on allowing for natural regeneration and avoiding the replanting of trees (planting of Aleppo pines and other conifers are a historically significant and controversial topic in Israel; see Tal 2013). Following the'89 fire, this recommendation would also be gradually adopted, especially in light of research documenting successful forest regeneration without replanting (Ne'eman 1997; Ne'eman et al. 2004). Equally controversial, according to range scientist and later chief scientist of the NRA, Dr. Avi Perevolotsky, was the introduction and use of domestic animal grazing as a fire-prevention strategy to reduce the fuel load in the forests and to maintain firebreaks. Use of grazing as a fire prevention strategy took much longer to gain acceptance and up until 2010 was not widely practiced or encouraged (A. Perevolotsky, pers. interview, 2014). Safriel (1997) notes an additional management strategy introduced in light of the'89 fire: establishment of a Biosphere Reserve in the Carmel as a mechanism for fire prevention.

Between the 1989 and the 2010 Carmel fire, there were eight large (>100 ha burnt) fires in the Carmel (Tessler 2012) and additional fires in hills west of Jerusalem. Following most of these fires, the State Comptroller and other agencies investigated the factors leading to mismanagement of fire prevention and firefighting. Scientists involved in the various post-fire investigations emphasized that the recommendations were always consistent with former reports, particularly with regard to creation of firebreaks, facilitating natural regeneration, and use of grazing to reduce fuel load. The salient question, then, remains. Why, after so many fires and so many subsequent investigations, did the 2010 fire occur and cause so much damage? Why didn't government and relevant agencies listen to their own scientific committee recommendations?

In the aftermath of the disastrous 2010 fire, national finger pointing was rampant. Various government ministers, ministries, agencies and local governments were blamed. The historical culture of forestry was brought into question, as was the desire of local residents to live near forested areas. Amidst the finger-pointing, the most comprehensive overview of the bureaucratic snafu that characterized the policy landscape of firefighting and prevention was produced by the government Comptroller's Office in the form of an official report entitled "Carmel Fire of December 2010 – Failures and Conclusions" (Comptroller 2012). Weighing in at more than 500 pages, the report spends half of its ink reporting on the specific incident of the bus tragedy in which the prison service personnel and police were killed, a 50-page section on fire ecology in the Carmel, and the rest on the performance and responsibility of various government agencies in fire prevention and fighting.

The Comptroller's report explicitly supports the assessment of scientists that recommendations were never implemented, and it points many fingers via its description of multiple, systemic failures up and down the bureaucratic chain of command. In effect, the report somewhat vindicates the atmosphere of mutual recriminations so prominent in the post-fire discourse. For instance, the report draws attention to no fewer than four government ministries responsible for some aspect of fire prevention. The Ministry of Interior was responsible for the fire service and the roads authority, the Ministry of Environmental Protection was responsible for the oversight of the Nature and Parks Authority, the Ministry of Agriculture and Rural Development was responsible for overseeing the activities of the Forest Administrator (a representative of KKL), and the Ministry of Finance was responsible funding all of these ministries and their agencies. Figure 9.5 summarizes some of the bureaucratic complexity in firefighting and fire prevention policy in Israel. Further, the

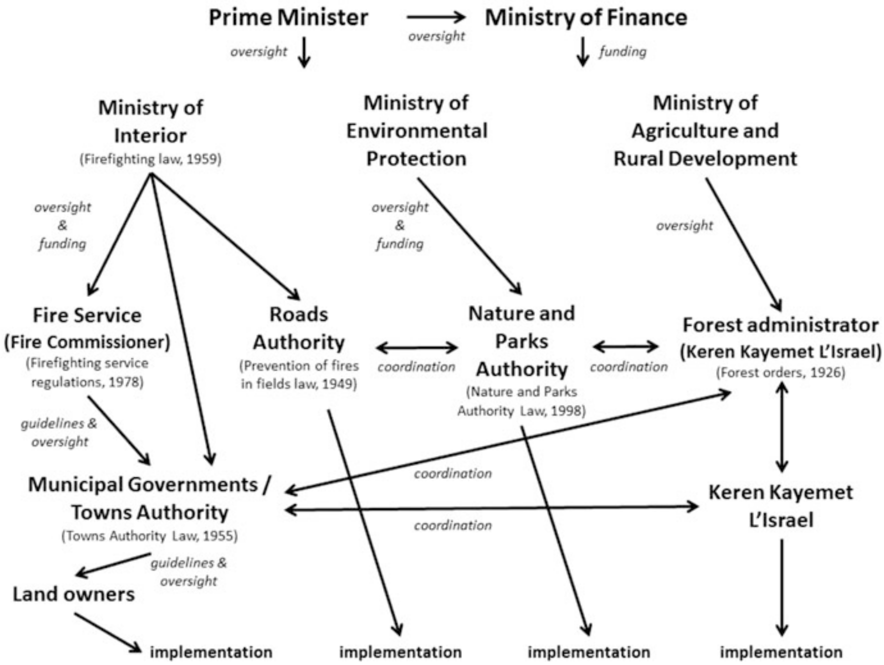

Fig. 9.8 An overview of policy making and implementation including governmental bodies responsible for various aspects of fire policy, the relations between them and the laws and regulations for which they are responsible

Carmel Forest includes areas administered by the NRA (under the aegis of the Ministry of Environmental Protection), the KKL, and several municipalities (Fig. 9.8).

Administrative fragmentation is a known environmental policy challenge (Carter 2007), and more so in Israel, where the peculiarities of its parliamentary democracy lead to coalition governments of parties and ministers that both cooperate and compete to advance their own narrow sectarian interests. Elsewhere in the policy literature, confoundingly complex bureaucratic structures are considered a problem of environmental management that often set up policy for failure (Cohen 2006). The comptroller's report also notes forthright that Israel lacks a comprehensive national-level fire prevention policy.

The comptroller placed his primary emphasis in the report on the chronic budget deficit of the fire service and the finance ministry that refused to address this deficit until the Interior Ministry initiated budget reforms. Further down the bureaucratic ladder, the comptroller points out that various government agencies are responsible for issuing directives to other agencies and then responsible for seeing that those agencies carried out their tasks. For instance, the fire service issues directives to municipal governments for thinning trees and maintaining buffers along roads. Municipal governments pass this responsibility on to individual communities and landowners. In any case, removing trees requires the approval of the forest administrator, who is answers to the Ministry of Agriculture and Rural Development. The comptroller uncovered situations in which directives were given and not followed due to lack of budgets, disagreements or for no particular reason. Considering the length of the bureaucratic chain of command, entangled decision making, and perpetual claims of lack of funding at each link, the lack of preparedness for the fire becomes evident.

The comptroller also concluded that multiple authorities, charged under multiple laws with various aspects of fire prevention, had simply not fulfilled their duties according to the law. These include the fire service, the Towns Authority (representing municipal government), the NPA, and private landowners.

Discussions with participants in the successive scientific committees revealed partial fulfillment of scientific recommendations, but also failures in implementation. For instance, the Nature Reserves Authority (NRA) did not engage in the creation and maintenance of firebreaks following the'89 fire for two reasons. First, there were no budgets available to conduct not only the initial work, but the long-term maintenance of the firebreaks as well. Second, the NRA decided to embark on the establishment of a Biosphere reserve in the Carmel. NRA scientists believed that a properly functioning Biosphere, predicated on active stakholder involvement, would take responsibility for the forests and for fire prevention and even plan and implement firebreaks. While a properly functioning Biosphere reserve may have indeed integrated physical and social tools for fire prevention, the Carmel Biosphere, while recognized by UNESCO, does not function as it should (Gasol 2010) and is accordingly undergoing a major reassessment.

Although funding was invested in the study of grazing as a fire management policy, no action was taken in this regard by any of the relevant management agencies. According to one contributor to the scientific committees' work, grazing "was already in the'89 recommendations, and also in'95, but up to 2010 no one took it seriously. There were all sorts of excuses but primarily no one thought that it was something that had to be done."

Both in 1989 and again in 2010, much of the post-fire budgets for exploring forest restoration and fire prevention went to scientific research. Multiple research projects explore the ecological, lithological, social and hydrological aspects of forest restoration. Much of the research is applied, as in considering how best to manage grazing regimes, how to maximize social value without compromising ecological integrity of the forest, and how to best manage for soil retention. As such, most scientists assert that there is no lack of knowledge regarding what has to be done. The scientist's exasperation is shared in the State Comptroller's report, which notes that all of the conclusions noted in their post-2010 fire report were known for the past two decades and that were reported repeatedly in successive investigation. In short, this is an "ongoing failure that must be stopped" (Comptroller 2012).

The mundane answer to the recurring question regarding why scientific knowledge was not translated into policy implementation is that several key recommendations were lost in the bureaucratic policy snafu, with no one to implement them and with those ready to implement short on the necessary funds to so. This short analysis suggests that current fire prevention policy is spread across too many agencies with too many interlocking and conflicting responsibilities to be effective. In order to determine whether the lessons of the past have been learned and their recommendations fulfilled, the following questions are crucial:

1. Is there a funding mechanism and management plan for the long-term maintenance of firebreaks?
2. Is the Carmel forest being managed using the recommended grazing regimes to reduce fuel load?
3. Are planners working to distance urban and rural development from areas of high fire risk?

Additional exogenous challenges, common to Israel, Shandong and Southern California, will further complicate fire policy: climate change and population growth. According to the IPCC, climate change will likely increase fire frequency and extent, as has already been noted in the Mediterranean Basin (IPCC 2014). Meanwhile, Israel's population continues to grow and more people will live in closer proximity to the forests. Although these two factors suggest that the threat to lives and property by fires in Israel will increase, they are not yet prominent issues on the Israeli policy agenda.

9.6 Conclusions

Climate change is expected to have considerable impact on Mediterranean ecotones; they will be among the most altered biome on the planet (IPCC 2007). Large scale declines are expected in vegetation types endemic to the northern Mediterranean basin, from the Iberian Peninsula east to Italy and Greece. On the north coast of the Chinese province of Shangdong many of those same plant types are beginning to appear (*Shandong senlin* 1986; Yu and Guo 2005). While in Southern California, desert and grasslands are anticipated to expand into mid-elevation shrubland; at higher elevations, mixed deciduous forests will replace conifer stands (IPCC 2007).

These alterations, underway or predicted, when combined with warming temperatures and the potential for extended drought cycles, are setting the stage for shifts in fire regimes across Mediterranean-type ecozones (Arca et al. 2010). Fire seasons are projected to lengthen and the incidence and intensity of fires is expected to increase in the regions this chapter has examined, as well as in Australia, Chile, and South Africa. When setting these transformations within other contexts—land use and land cover changes as well population migration into fire zones—it becomes clear that managing fires will become more complicated and so will the policies and politics that define firefighting in this biome. Making this process even more complex is what historian Stephen J. Pyne calls the "cultural paradigm" of fire: Human "stewardship over fire is the signature of our unique ecological agency. Until we openly acknowledge our firepower, we cannot effectively exercise that stewardship" (Pyne 2010, 86). Nowhere has this stewardship been more complicated, nowhere will it be more tested than in the Mediterranean-type ecosystems.

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