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Climate Change: Wildfire Impact

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1. Introduction

The European forests harbour biological wealth of international importance (circa 6,000 species are of conservation importance according to IUCN). Changes to come in climate are challenging science, governments, and local communities in order to sustain the health of its ecosystems, which will, in turn, also help protect the quality of life.

European climate system are supported by various factors such as soils, topography, available plant species. Some of these factors are contributing to both natural ecosystems and their fire regimes. Long-term patterns of temperature and precipitation determine the moisture available to grow the vegetation that fuels wildfires (Stephenson, 1998). Climatic inconsistency on inter-annual and shorter scales governs the flammability of these fuels (Westerling, 2003; Heyerdahl et al., 2001). Flammability and fire frequency in turn affect the amount and continuity of available fuels. Therefore, long-term trends in climate can have profound implications for the location, frequency, extent, and severity of wildfires and for the character of the ecosystems that support them (Westerling, 2006a). Human determined climatic change may, over a relatively short time period (< 100 years), give rise to climates outside anything experienced in Europe, since the establishment of an industrial civilization, currently sustaining a population that has increased approximately 270% since 1850. Changes in wildfire regimes driven by climate change are likely to impact ecosystem services that European citizens rely on, including carbon sequestration; water quality and quantity; air quality; wildlife habitat; and recreational facilities. In addition to climate change, the continued growth of continent's population and the spatial pattern of development that accompanies that growth are consequently affecting wildfire regimes through their impact on the availability and continuity of fuels and the availability of ignitions.

South East Europe ecosystems are a vast mosaic of different habitat types. The biodiversity patterns we encounter today are a result of millions of years of climatic and geologic change.

Over years, populations of their native biota expanded and contracted in range – some at local scales, others at hemispheric scales, some up and others down slopes – to find and adapt to the local conditions that allowed them to persist to this day. During drier periods, for example, some species seek out the refuge of mountaintops that provided the conditions necessary for survival; on contrary during wetter periods, those species may have moved from those refuges to re-sort across the landscape that is now found in Europe.

What this dynamism demonstrates us is that change occurs at various temporal and spatial scales, and that while today's climate may be our baseline, our climate has not been and will not be static. It also highlights how critical connectivity is in our landscape: the extraordinary biological richness is to a great degree a product of species being able to shift in their range and adapt to changing climatic conditions. If that landscape connectivity is lost, or if the climate changes overtakes the ability of species to respond, or if populations are already reduced or stressed by other factors, species may be unable to survive through the climate changes to come.

In the case of many species and ecological processes, the effect of past and future land use change may induce significant stresses, that left unmanaged could see species to extinction. Some of these land use impacts may have a more significant impact than a changing climate. The challenge for South East Europe is to describe out the anticipated effects of past and future land use change from those of climate change – so that we can better plan our strategies to protect ecosystem health and conserve the native biodiversity for future generations.

This chapter endeavours to investigate what impact has the climate change, with specific reference to wildfire, on biodiversity and ecological processes in South East Europe and is presenting some considerations on how species native to the region will have to adapt.

2. Climate change

A changing climate will interact with other drivers in pertaining ways and generate feedback cycles with significant consequences. The effects of habitat fragmentation on native species may be dependent on intra- and inter-annual variation in rainfall (Morrison, 2000); so changes in rainfall and development patterns may deepen impacts. Increasing fires, in combination with increasing nitrogen deposition as a result of ash deposition on soil, may facilitate invasive of non-native weeds that in turn increase fire risk. Decreasing water supplies due to human pressure may have negative effects on native plants and animals, like species found in rivers. Meanwhile, increased irrigation run-off from non-porous soil in an urbanized watershed can fundamentally alter hydrological regimes in other ways (White et al, 2002).

These threats may lead to population pressure for native species, and possibly lead to extinction. The urbanization stress on southern part of South East Europe has increased recently, and most of the direct impacts to resources have occurred in the recent past. This means that the indirect effects have yet to be seen. Once these changes have occurred, it is expect that in some areas of South East Europe (eg Croatia, Bulgaria) it will only accelerate. Compounding the ecological impacts of land use change is perhaps an unprecedentedly rapid change in climate. The "climatic envelopes" species need (the locations where the temperature, moisture and other environmental conditions are suitable for persistence) will shift. For many species, a changing climate is not the problem, per se. The problem is the pace of the change: the envelope may shift faster than species are able to follow. For some species, the envelope may shift to areas already changed to human land use. Human

impacts may have undermined the resilience of some species to adapt to the change (e.g., by lowering their overall population). Human land uses also may have disconnected the ecological connectivity in the landscape that would provide the movement corridor from the current to the future range.
This degree of alteration of ecological processes and jeopardise of native species will complete the transformation of the entire region to a "managed ecosystem"(Ioras, 2009). This reality will require that the local politicians articulate what the wanted future condition is for the area in question. Only with an informed thorough assessment of the current and future challenges confronting native species, and a clear articulation of ecological and socio-economic goals, we will be able to manage South East Europe native species and systems through the transformation ahead.

2.1 Climate and forest wildfire

2.1.1 Moisture, fuel availability, and fuel flammability

Climate increases wildfire risks primarily through its effects on moisture availability. Wet conditions during the growing season promote fuel—especially fine fuel—production via the growth of vegetation, while dry conditions during and prior to the fire season increase the flammability of the live and dead vegetation that fuels wildfires (Swetnam and Betancourt 1990, 1998; Veblen et al. 1999, 2000; Donnegan 2001). Moisture availability is determined by both precipitation and temperature. Warmer temperatures can reduce moisture availability via an increased potential for evapo-transpiration (evaporation from soils and surface water, and from vegetation), a reduced snowpack, and an earlier snowmelt. Snowpack at high altitude is an important mean of making water available as runoff in late spring and early summer (Sheffield et al. 2004), and a reduced snowpack and earlier snowmelt potentially lead to a longer, drier summer fire season in many mountain forests (Westerling, 2006b).
For wildfire risks in most Eastern European forests, inter-annual variability in precipitation and temperature appear to be determinant on forest wildfire through their short-term effects on fuel flammability, as opposed to their longer-term affects on fuel production. One way of illustration this is with the use of average Palmer Drought Severity Index (PDSI). The Palmer Drought Severity Index (PDSI) was developed by Palmer (1965) based on monthly temperature and precipitation data as well as the soil-water holding capacity at that location to represent the severity of dry and wet spells over the U.S. The global PDSI data (Dai et al., 2004) consist of the monthly surface air temperature (Jones and Moberg 2003) and precipitation (Dai et al., 1998; Chen et al., 2002) over global land areas from 1870 to 2006. These date is represented as PDSI values in 2.5˚x 2.5˚ global grids.
The time series of the PDSI variations are determined by the mean values from all grid data from the selected area. The mean values are computed by means of the robust Danish method (Kegel, 1987). This method allows to detect and isolate outliers and to obtain accurate and reliable solution for the mean values. The global PDSI variations for the period 1870-2006 are between +1 in the beginning and -2 in 2002. The Palmer classification of drought conditions is in terms of minus numbers: between 0.49 and -0.49 - near normal conditions; -0.5 to -0.99 -incipient dry spell; -1.0 to -1.99 - mild drought; -2.0 to -2.99 - moderate drought; -3.0 to -3.99 - severe drought; and -4.0 or less - extreme drought. The positive values are similar about the wet conditions.
The PDSI variations over the South-East Europe are determined for area between longitude 10°30' E and latitude 32.5°50' N (Fig.1). This area consists of 44 grids of the global PDSI data.

The maximal errors are below 0.08 and the mean value of the all PDSI points is 0.02 (Fig.2). The PDSI variations over the South-East Europe from Fig.3 show several severe wet and dry events.

Fig. 1. Area of South-East Europe between longitude 10°-30° E and latitude 32°.5-50° N.

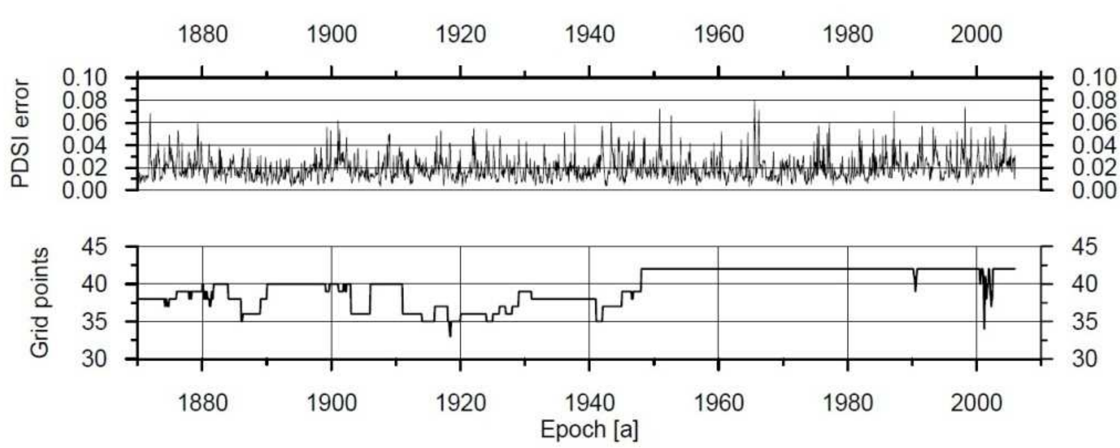


Fig. 2. Number of the grid points and errors of PDSI for South-East Europe (source Chapanov and Gambis, 2010).

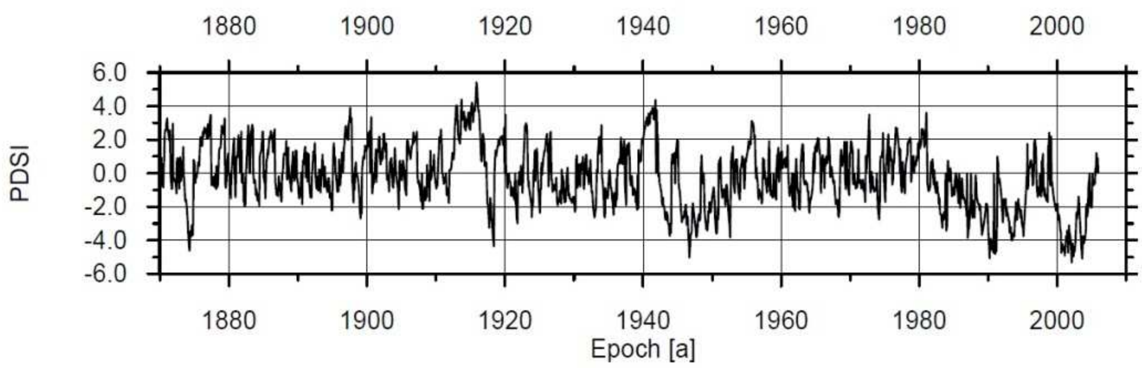


Fig. 3. Variations of the PDSI for South-East Europe (source Chapanov and Gambis, 2010).

Positive values of the index represent wet conditions, and negative values represent dry conditions. This is used here as an indicator of the moisture available for the growth and wetting of fuels.

This analysis included all fires over 400ha -large wildfires threshold (Running, 2006) that have burned since 1970, and account for the majority of large forest wildfires in South East Europe. The fires have been aggregated for each country using the European Forest Institute Database on Forest Disturbances in Europe (Table 1).

Country/Decade	1970-1979	1980-1989	1990-1999
Albania	0	0	9
Austria	1	0	0
Bosnia	0	0	12
Bulgaria	0	2	29
Croatia	10	37	66
Czech	8	4	6
Cyprus	12	10	4
Greece	60	33	46
Hungary	5	5	15
Italy	58	50	102
Macedonia	0	0	25
Moldova	0	0	0
Romania	0	0	6
Slovakia	13	1	3
Slovenia	0	0	13
Yugoslavia	12	17	2

Table 1. Number of forest fire that affected an area over 400ha in South East Europe between 1970-2000.

Note: 0 means no reported data

In the South, the frequency of large wildfires peaks in Italy and Greece, in the East in Bulgaria and Croatia often ignited by lightning strikes before the summer rains wet the fuels (Swetnam and Betancourt, 1998). Since the lightning ignitions are associated with subsequent precipitation, it is possible that the monthly drought index may tend to appear to be somewhat wetter than conditions were at the time of ignition.
In the two northern countries - Slovak and Check Republic-conditions also tended to be drier than normal in the 70s: extended drought increased the risk of large forest wildfires in these wetter northern forests for fires above 1700 meters in elevation, the importance of surplus moisture in the preceding year was greatest for the southern countries. According to Swetnam and Betancourt (1998) moisture availability in predecessor growing seasons was important for fire risks in open conifer forests as fine fuels play an important role in providing a continuous fuel cover for spreading wildfires, but not in mixed conifer forests. Looking at the western part of South East Europe more generally, the moisture necessary to support denser forest cover tends to increase with latitude and elevation. Consequently, the shift in forest fire incidence as one moves from the forests of the SW to those of the NE is broadly consistent with a decreasing importance of fine fuel availability—and an increasing importance of fuel flammability— as limiting factors for wildfire as moisture availability increases on average.

2.1.2 Forest wildfire and the timing of spring

There has been a remarkable increase in the incidence of large forest wildfire in some of the countries in the South East Europe since the early 1980s (Table 2). Understanding the factors behind such increase in forest wildfire activity is key to understanding the recent trends and inter-annual variability in forest wildfire. According to Westerling et al. (2006b) the length of the average season completely free of snow cover is highly sensitive to variability in regional temperature, increasing approximately 30 percent in the latest third of snowmelt years and this has a positive effect on wildfire incidence. In years with an early spring snowmelt, spring and early summer temperatures were higher than average, winter precipitation was below average, the dry soil moistures typical of summer in the region came sooner and were more intense, and vegetation was drier (Westerling et al., 2006b).

Country	Time period	Average number of fires	Average area burned, ha
Albania	1981-2000	667	21456
Bulgaria	1978-1990	95	572
	1991-2000	318	11242
Croatia	1990-1997	259	10000
Cyprus	1991-1999	20	777
Greece	1990-2000	4502	55988
Romania	1990-1997	102	355
Slovenia	1991-1996	89	643

Table 2. Fire statistical data of the SE Europe. Source: GFMC.

The statistics presented here are for only those wildfires greater than 400ha that burned primarily in forests, of which there were 676 in South East Europe since 1970. This region has experienced a number of large wildfires that ignited spread to and burned substantial forested area (Table 2). The consequences of an early spring for the fire season are profound.

Comparing fire seasons for the earliest versus the latest third of years by snowmelt date, the length of the wildfire season (defined here as the time between the first report of a large fire ignition and last report of a large fire controlled) was 45 days (71 percent) longer for the earliest third than for the latest third. Sixty-six percent of large fires in South East Europe occur in early snowmelt years, while only nine percent occur in late snowmelt years. Large wildfires in early snowmelt years, on average, burn 25 days (124 percent) longer than in late snowmelt years. As a consequence, both the incidence of large fires and the costs of suppressing them are highly sensitive to spring and summer temperatures. Both large fire frequency and suppression expenditure appear to increase with spring and summer average temperature in a highly non-linear fashion. In the case of Albania, Bosnia Herzegovina and Romania (Hoxhaj, 2005; Alexandru et al, 2007; Ciobanu and Ioras ed, 2007) suppression expenditure in particular appears to undergo a shift near 15°C during of 2007 (Figure 4 and 5). Year 2007 was used as reference year due to the significant increase of wildfire (Figure 6) and also this year was known to have had a heat wave. Temperatures taken separately above and below that threshold are not significantly correlated with expenditures, but the mean and variance of expenditures increase dramatically above it.

A

B

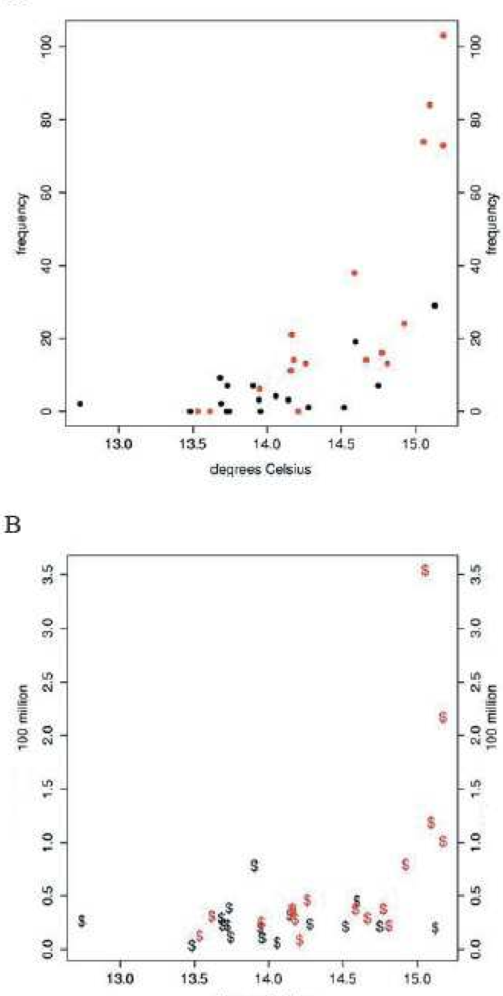


Fig. 4. The annual number of large forest fires in Albania, Bosnia and Romania versus average March – August temperature in 2007.

Fig. 5. The forest fire spread in the South East Europe on 25 July 2007 as seen by the Terra Satellite (Source GFMC).

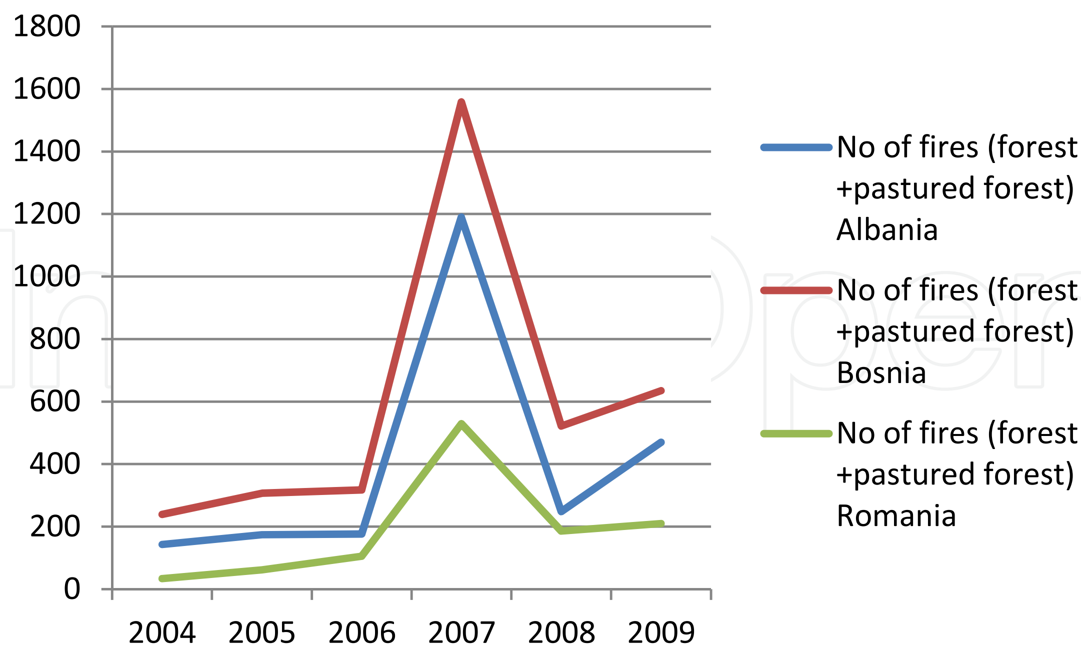


Fig. 6. Forest fire numbers (to include forested pastures) in Albania, Bosnia Herzegovina and Romania between 2004 and 2009.

3. Land use patterns

Looking across South East Europe it is obvious that land uses changes have determined significant, often cascading impacts to biodiversity and ecosystems – and more recently it was witnessed how these have threatened the quality of life for the human residents as well. Ecological impacts of land use have been well documented through pioneering research on habitat fragmentation. Fragmentation can affect communities from the "bottom up". Suarez et al, (1998) research on habitat fragmentation, showed how when non-native species invade, and native ant species disappear other species up the food chain will soon also disappear because they have lost the native species that are their main food resource (Chen et al., 2011). Such "ecosystem decay" leading to loss of biodiversity may take decades to complete following the fragmentation. The cahoots between climate change and habitat fragmentation is the most threatening aspect of climate change for biodiversity, and is a central challenge facing conservation (Ioras, 2006).

3.1 Increasing population

As the human population grows, there will be increased competition for resources (like space and water) with plants and animals. Demand for housing will displace rural land uses like farming that can provide important habitat for some native species. With increased development we will witness more introduction, establishment, and invasion of habitat altering non-native species. More people will demand more opportunity for recreation – yet low intensity recreational uses like hiking when is done is an intensive way can damage fragile environments (Ioras, 1997).

Increased demand for resources, goods, and services will increase demand for transport infrastructure (roads, power lines, pipelines, etc.) which may fragment otherwise intact landscapes and provide an entry point for non-native species such as weeds. More people means increased susceptibility to fire ignitions – and subsequently more restrictions on fire management for ecological outcomes. More people will also increase the potential for human-wildlife conflicts in the remaining wildlands (e.g. interactions with predators like bears, wolfs; biodiversity impacts from efforts to control insect-borne disease vectors). Hence, even distant human land uses can damage natural resources. Pollution, for example – whether it is represented by airborne toxins when wildfires burn, or nitrogen, ozone from urban areas, or wastewater that fouls beaches and other coastal areas – will pose great challenges for the health of the ecosystems.

3.2 Interaction of climate, land use, and wildfire

Fire in the recent years has become a key ecological process in South East Europe. Many plant species display adaptations that are finely tuned to a particular frequency and intensity of fire. Some plants may re-sprout from roots following fire. The seeds of other plants may require heat or chemicals from smoke to germinate. Some animals may be especially suited to invade recently burned areas; others may only succeed in habitats that have not burned for a relatively long time. In some cases species that are highly adapted to – even reliant on – fire can also be put at risk by fire. If fire behaviour is changed by human activities such that it is outside of its natural range of variation, it can have great significant adverse impact on native species. For example Pinus heldreichii H. Christ requires fire to reproduce, but if fires recur too frequently (i.e., before the trees have a chance to mature to reproductive age) fire can kill the young trees and break that finely-tuned life cycle. Its areal covers Albania, Bosnia Herzegovina, Bulgaria, Greece, Macedonia and Serbia (Critchfield et al 1966).

Due to human activities the fire behaviour of the entire region have greatly altered – fires generally occur too frequently in the coastal areas and too infrequently in the higher elevation forests. Fires set during wind conditions can have enormous ecological consequences (see the fire that engulfed Dubrovnik coast during of summer 2007); for some highly restricted species, an individual fire could lead to extinction. Future land use and climate changes will only exacerbate the alteration fire regimes in South East Europe. These have consequences not only on biodiversity conservation but there are also important implications for public safety, the quality of our air and water, and the economy.

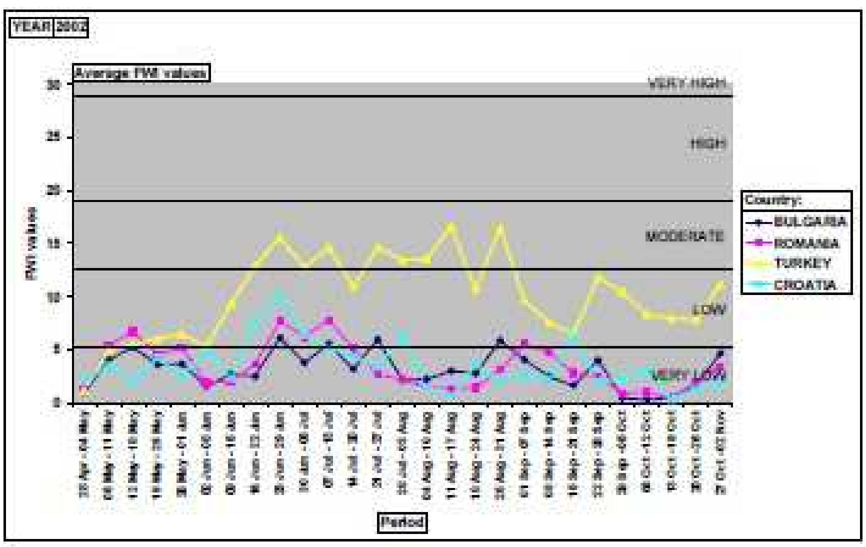
Some parts of Croatia, Bulgaria already have the most severe wildfire conditions in the region, and the situation is only likely to worsen with climate change—meaning dangerous consequences for both humans and biological diversity. South East Europe's coastal area exceptional combination of fire-prone, shrubby vegetation and extreme fire weather means that fires here are not only going to become very frequent, but occasionally huge and extremely intense. The combination of a changing climate and an expanding human population threatens to increase both the number and the average size of wildfires even more. Increasing fire frequency--or ever shortening intervals between repeated fires at any particular location--poses the greatest threat to the region's coastal natural communities (except perhaps in high altitude forests), whereas increasing incidence of the largest, most intense fires poses the greatest threat to human communities.

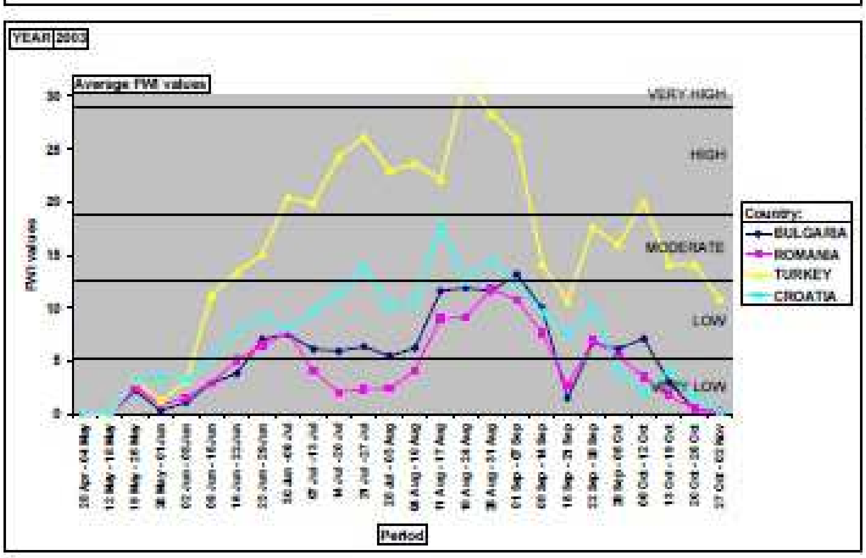
A region's fire regime is defined by the number, timing, size, frequency, and intensity of wildfires, which are in turn largely determined by weather and vegetation. Vegetation on the region's coastal plains and foothills—where humans are most concentrated—is dominated by shrub species that burn hot and fast, and that renew themselves in the aftermath of fire (so long as inter-fire intervals are sufficiently long to allow individual plants to mature and reproduce by resprouting or setting seed between fires). In the

Mediterranean climate, this coastal sage and chaparral vegetation rapidly grows fine new twigs and leaves during the moist winters. This new growth then dries to a highly flammable state during the arid summer-fall season. Consequently, most fires burn during summer when fine, dry fuels become abundant, whereas the greatest total acreage burns in fall, when the largest fires are driven by winds.

Different climate change models yield somewhat different predictions about the frequency, timing, and severity of future region wind conditions, leading to uncertainty about just how fire regimes may change in the future. However, preliminary analyses for the period 2002-2006 suggest that wind conditions may significantly increase earlier in the fire season (especially end of July- start of September) while they may decrease somewhat later in the season (especially towards the end of September). This predicted change to earlier winds occurrences would likely increase the frequency of huge fires as severe fire weather would coincide more closely with the period of most frequent fire ignitions (Fig. 7).

Of course, fires also require an ignition source. Fires started naturally, by lightening strikes, are actually quite rare during the most dangerous autumn fire weather—when the hot, dry sea winds blow. Nowadays, however, the vast majority of ignitions are caused by humans or their inventions; and even without climate change, the number of fires in southern part of





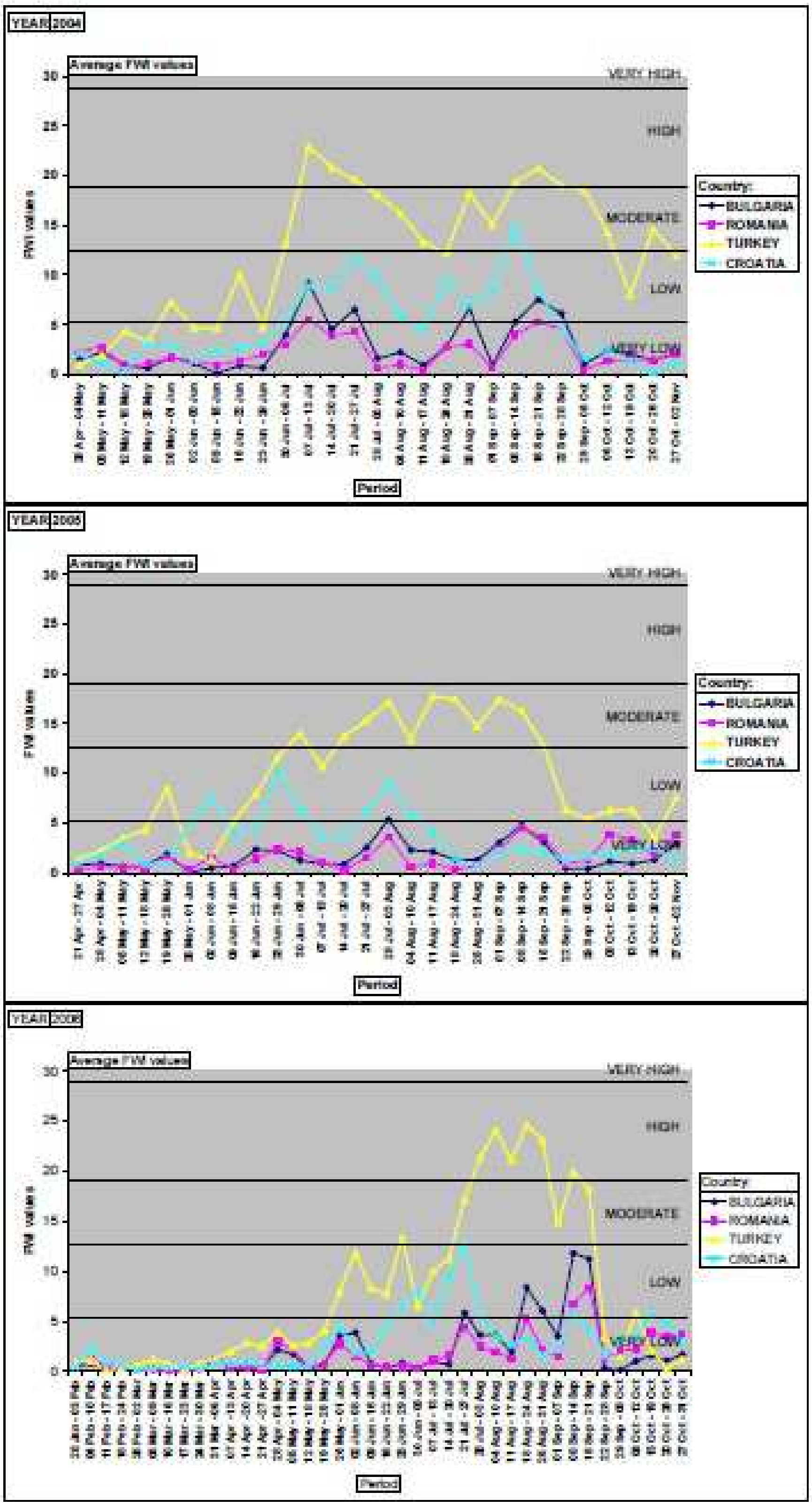


Fig. 7. Fire risk trends (Fire Weather Index -FWI) between 2002 and 2006 in Bulgaria, Croatia, Romania and Turkey. Source EFFIS "Forest Fire in Europe 2006" (http://effis.jrc.ec.europa.eu/reports/fire-reports/doc/2/raw)

the region has been steadily increasing in direct proportion to human population (www.effis.jrc.ec.europa.eu/reports/category/40/fire-reports). This increase in ignitions, especially if coupled with a longer fire-weather season, creates more opportunities for fires to start when conditions are most extreme, however, huge firestorms such as those during 2003 and 2007 are not new phenomena in this region. Studies of charcoal layers deposited on the sea floor near the Cyclades Islands indicate that such major fire events have recurred on average every 20 to 60 years, or roughly two to five times per century over the past 12 to 13 centuries (Bryne et al., 1977). These huge firestorms inevitably occur following very wet years, at the beginning of drought periods (Mensing et al., 1999). How these inter-annual wet-dry cycles may change with changing climate is as yet unclear.

Due to the combined forces of changing climate, increasing fire ignitions, and invasive weedy species, fires are likely to burn ever more frequently in a positive feedback loop. Studies have shown that frequent fires over short time intervals increase invasions by weedy annual plants into native communities. These weedy invaders then set seed, die, and dry out earlier than the natives, thereby starting the fire season even earlier and increasing chances of another fire. These weedy annuals, referred to as “flash fuels” by firefighters, also ignite more readily and burn more rapidly than native perennial plants, thus creating a more favourable environment for themselves at the expense of the natives, which evolved under longer fire-return intervals. The potential for these interactions between climate change, weedy invasions, and changing fire regimes paints a grim picture for South East Europe’s biological diversity and watershed quality, as vast stands of rich biodiverse and soil-holding shrub communities are replaced by biologically sparse, shallow-rooted, fire-perpetuating weeds.

4. Specific challenges of climate change in South and Eastern Europe

The impact of climate change promises to be more visible in southern part of the region because there is such a great diversity of plants and animals. Every species has unique requirements for persistence. This means that species will respond differently to the same climatic change. The range of a species is determined by external conditions like temperature, but also by conditions like interactions with other species.

Thus, native species will face novel environmental conditions – and will have precious little time to adjust. Even if the changes in climate are gradual, it has been recognized that the changes will be steep. Species with limited ability to move will have an especially difficult time keeping pace as Chen et al. (2011) reported that the distributions of species have recently shifted to higher elevations at a median rate of 11.0 meters per decade, and to higher latitudes at a median rate of 16.9 kilometres per decade. Some species may even require assistance moving to new regions.

Of greatest concern for local scientist, however, is that even with a gradual change there may be “tipping points” in the system, whereby ecological complexities interact and there is a dramatic “step change” in the system. These may include massive scale die-back of forests due to abnormal drought conditions, conversion of scrub habitat to non-native grassland with a few too frequent fires, and the scouring of watersheds, excessive erosion, and alteration of geomorphology of region's streams and rivers, with rain after catastrophic fire. Such fundamental conversion of the region’s ecosystems could be abrupt and irreversible. It is not currently known where such thresholds in the system might be.

4.1 Climate change and forest ecosystem

In South East Europe, as in many other places in the world, the distribution of plant and animal populations will not be able to suddenly shift northward or to higher elevations because the potential habitat has been claimed by development, invaded by non-native species, or has unsuitable soils or other physical limitations (Parmesan, 2006).

Extended drought can stress individual trees, increase their susceptibility to insect attack, and result in widespread forest decline. Plant species respond differently and entire species may die off when drought occurs in an area that already has predictable seasonal droughts. Stressed trees have less resistance to insects, such as bark beetles. More indirectly, warmer winter temperatures as predicted for the region's future can increase insect survival and population levels. Drought and abnormally warm years that began in the 1980s have resulted in unprecedented pest outbreaks and tree dieback in southern part of the region (Logan et al, 2003).

Extended drought can also increase the severity of wildfires when they are ignited. The 2003 and 2007 wildfire events in South East Europe were shaped by extended drought that reduced fuel moisture of trees, the sea borned winds and high temperatures, and the ignition in shrubs – maquis type of vegetation that burned "uphill" into the forests.

Forests may not regenerate to historical species composition, when wildfires burn with higher intensity than tree species are adapted to. For example Franklin et al. (2006) surveyed areas in Cuyamaca Rancho State Park, USA, during the first two post-fire growing seasons following the Cedar Fire, and found that most conifers were killed by the high-intensity fire and that pine seedlings have not re-established. Oaks and ceanothus species now dominate the forest.

Forest-dependent fish and wildlife species may be lost in the indirect effects of climate change, drought, and wildfire. For example the Sweetwater Creek State park native trout and stickleback populations in Atlanta were totally eliminated in the Cedar Fire in 2003, and the last native trout population is threatened in Pauma Creek by sediments filling pools (after wildfires and rainstorms).

To understand the impact of climate change particular focus has to be given to shrubland communities that support a diversity of sensitive plant and animal species in the region. To begin to understand how changing climate conditions might affect these natural communities, a climate sensitivity analyses for coastal sage scrub and maquis vegetation and for plant and animal species found in these shrublands is needed (Preston et al, 2008).

To assess sensitivity of species and vegetation types to climate, the model that uses varied temperature and precipitation compared with current climate conditions could be employed. These values fall within the range of various climate forecasts for the region, although the emerging consensus is that the region will become more arid (IPPC, 2007). In response to increasing temperature and reduced precipitation, each vegetation type moves to higher elevations where current conditions are cooler and there is greater precipitation compared with locations where these shrublands / maquis vegetation occur.

In Europe some work was done on modelling habitat shifts due to climate change, however, the most conclusive one took place in the USA. For example analyses was conducted for five different coastal sage scrub shrub species in the USA; California sagebrush (*Artemisia californica*), brittlebush (*Encelia farinos*), flat-topped buckwheat (*Eriogonum fasciculatum*), laurel sumac (*Malosma laurina*), and white sage (*Salvia apiana*). The model developed by The Center for Conservation Biology (CCB) at the University of California, Riverside also modelled two annual host plants, California plantain (*Plantago erecta*) and white snapdragon

(*Antirrhinum coulterianum*) for the endangered butterfly, Quino Checkerspot (*Euphydryas editha quino*). All plant species, except brittlebush, flat-topped buckwheat and white snapdragon showed similar sensitivities as coastal sage scrub and chaparral to altered climate conditions. These three exceptions showed higher levels of potential habitat remaining at elevated temperatures, particularly flat-topped buckwheat.
The CCB also used modelling for the USA-endangered Quino Checkerspot butterfly and threatened California Gnatcatcher (*Polioptila californica*) (Preston et al, 2008). Other models included associations between species and compared predictions under altered climate conditions with models that did not. The CCB found that when vegetation, shrub or host plant species were included in the animal models, potential habitat for the butterfly and songbird was significantly reduced at altered climate conditions. Such models could be used to predict distribution changes with climate change.
Climate change and the pressures associated with human pressure can each lead to large changes in biodiversity. While the ecological effects of each of these stressors are increasingly being documented, the complex effects of climate change, harvesting pressure and urbanization on ecosystems remain inadequately understood. Yet such effects are likely to be extremely important in regions such as southern part of South East Europe.
Exploitation of intertidal and subtidal species as well as runoff and nutrient loading into coastal waters continues to increase as a result of rapid population growth at a time when the species involved are also being subjected to large scale changes in the environment driven by global warming. It is not unreasonable to presume that harvesting can undermine the resiliency of species to climate change. For example, historic data show that body size of molluscs plays an important role in determining which species are likely to shift their geographic distributions in response to climate change (Roy et al, 2001). Yet body sizes of many intertidal species have decreased substantially over the last century as a result of human harvesting of these species. Furthermore such size declines can result in major changes in growth rates, reproductive outputs and life histories of species and can even lead to changes in the compositions of ecological communities (Roy et al, 2003). How such changes in the biology of the species involved affects their resiliency to global warming is still poorly understood but the potential for feedback effects certainly exists.

5. Conclusion

The South Eastern Europe must brace for change. Even without the climate changes to come, native plants and animals, and the ecosystems on which the region rely, will be severely affected in the decades ahead. Climate change will only accelerate – and perhaps dramatically – changes already afoot in natural community composition and distribution. Some species may disappear as their habitat shifts to outside of the region; the range of others may expand to include the region. Species with limited dispersal ability will be most likely tested. Some of region's native species may be wholly reliant on how the region community mobilizes to ease them through the transitions to come.
The most important strategy to increase the likelihood of natural systems to adapt to the new climate regime is to maintain the connectivity between conservation reserve networks of core area representing the diversity of communities in the region for ecological cohesion of the landscape.
A favourable condition for biodiversity and ecosystems in the year to come is continued functionality of ecosystem processes; this would "save the evolutionary stage" and so

perhaps allow the greatest complement of native species to persist. While the current configuration and composition of general vegetation communities will surely be different, it is desirable the communities to be characterized predominantly by species native to the region.

Forest wildfire in the South East Europe is strongly influenced by spring and summer temperatures and by cumulative precipitation. The effect of temperature on wildfire risks is related to the timing of spring, and increases with latitude and elevation. The greatest effects of higher temperatures on forest wildfire in recent decades have been seen in the southern countries - Croatia, Greece, Italy- and a handful of fire seasons account for the majority of large forest wildfires. A seasonal climate forecast for spring and summer temperatures would thus be of value in anticipating the severity and expense of the forest wildfire season in much of the South East Europe, and would be of particular value in Albania, Bosnia, Croatia.

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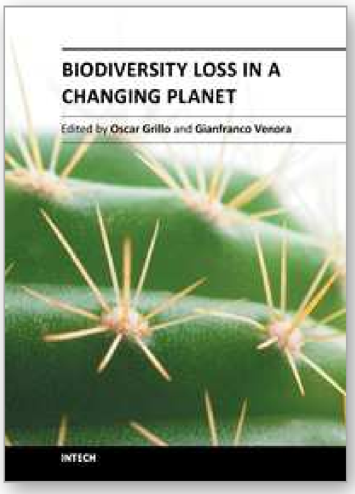

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Every ecosystem is a complex organization of carefully mixed life forms; a dynamic and particularly sensible system. Consequently, their progressive decline may accelerate climate change and vice versa, influencing flora and fauna composition and distribution, resulting in the loss of biodiversity. Climate changes effects are the principal topics of this volume. Written by internationally renowned contributors, Biodiversity loss in a changing planet offers attractive study cases focused on biodiversity evaluations and provisions in several different ecosystems, analysing the current life condition of many life forms, and covering very different biogeographic zones of the planet.

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