

Assessing Lebanon's Wildfire Potential in Association With Current and Future Climatic Conditions

George H. Mitri and Mireille G. Jazi, Biodiversity Program, Institute of the Environment, University of Balamand, Lebanon; and David McWethy, Department of Earth Sciences, Montana State University, Montana, USA

Abstract—The increasing occurrence and extent of large-scale wildfires in the Mediterranean have been linked to extended periods of warm and dry weather. We set out to assess Lebanon's wildfire potential in association with current and future climatic conditions. The Keetch-Byram Drought Index (KBDI) was the primary climate variable used in our evaluation of climate/fire interactions and conditions. A comparison between the average monthly values (2006-2010) of the Fire Weather Index (FWI) for Eastern Mediterranean and the monthly KBDI average values for Lebanon showed a strong correlation, indicating wildfire potential has increased during the fire season (March through September). The comparison between the relative areas of current and future wildfire potentials showed a significant increase in KBDI values (more than 50) affecting a total area of 1143 km² (441.3 sq mi).

Keywords: Wildfire potential, climate change, downscaled global climate models, Keetch-Byram Drought Index

Introduction

The severe degradation of Lebanon's forest during the past decade has been mainly attributed to an increase in number and extent of relatively large scale and intense wildfires (El Halabi and others 2014). This may be the result of land-use changes, such as rural depopulation, which results in increasing land abandonment and consequently, fuel accumulation and shrub-burning to recover areas for cattle feeding. Another possible driver is climate warming, which is reducing fuel humidity and increasing wildfire risk and wildfire spread (Salloum and Mitri 2014).

As a result of declining rural populations, management of fuels in rural areas via agriculture, construction, and fuelwood collection has decreased, resulting in an increase in the abundance of woody fuels. Fertile lands have been rapidly overgrown by garrigue. Additionally, a buffer zone between natural vegetation and residential developments has declined. There has been a rapid expansion of the vegetation in rural areas accompanied by expansion of development in the Wildland Urban Interface (WUI). This has caused a new form of danger which includes increases in both the forest wildfire danger as well as the urban wildfire danger. In addition, it was hypothesized that a changing climate is worsening the situation: 1) heat waves may increase the likelihood of large scale wildfires, 2) drought periods may lead to forest dieback, and 3) heavy and short rainfall may lead to increased soil erosion, soil water scarcity, and floods.

In this work, we assessed Lebanon's wildfire potential in association with current and future climatic conditions. The specific objectives were to 1) generate a wildfire potential index for current climatic conditions and compare it to an observed estimation of wildfire risk, 2) generate the same wildfire potential index for future climatic conditions, and 3) compare between current and future wildfire potential indices.

In this work, the Keetch-Byram Drought Index (KBDI) was the primary climate variable used in our evaluation of climate/fire interactions and conditions.

Study Area and Dataset Description

The study area comprises the Mediterranean vegetation cover of Lebanon (figure 1). Lebanon has a Mediterranean climate, with warm dry summers, and cool wet winters. Around 90 percent of the total annual precipitation falls between November and March (FAO 2006; Mitri 2009; Mitri and others 2010). Like other Mediterranean countries, fire occurrence in Lebanon is driven by the interrelationship of fuel accumulation, long summer droughts and changing patterns of temperature and precipitation (MOE/UNDP/ECODIT 2011).

The spatial climatic data needed to calculate the Keetch-Byram Drought Index (KBDI) were mostly obtained from observed, interpolated data and simulated Global Climate Models (GCM) for current and projected climatic conditions, respectively. Datasets of current averages (1950 to 2000) and future 30-year running averages (2010 to 2039) included: monthly maximum temperature, monthly precipitation and mean annual rainfall at 1x1 km (30 arcsec) of spatial resolution. The current climatic data were generated through

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Figure 1—Study area: the Mediterranean country of Lebanon.

interpolations of representative observed data from major global climate databases, whereas, the future climatic data were referred to the ‘downscaled GCM data portal’ provided by the Consultative Group on International Agricultural Research (CGIAR) Research Program on Climate Change, Agriculture and Food Security (CCAFS) and prepared for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). The data were generated through the downscaled GCM UKMO-HADGEM1 using the Delta method for the IPCC’s A1B emission scenario.

Methodology

The widely used Keetch-Byram Drought Index (KBDI), which is a part of the National Fire Danger Rating System (NFDRS) in the United States (Liu and others 2010), was selected to investigate wildfire potential in Lebanon. The KBDI is a cumulative estimate of wildfire potential based on meteorological input parameters and an empirical approximation for moisture depletion in the upper soil and surface litter levels (Keetch and Byram 1968). The drought index ranges from 0 to 800, where a drought index of 0 represents saturated soil (no moisture depletion), and an index of 800 represents absolutely dry conditions.

The KBDI was generated using the Model Maker Module in ERDAS IMAGINE software. The KBDI values of current and future conditions were calculated for each day over the average periods of the current and future datasets. Calculations were initialized when the soil was near saturation (January 1 for all Lebanon) and KBDI was assumed to be zero (Janis and others 2002). The calculations consisted of two steps (Liu and others 2010): 1) values were calculated for each day over the 30-year average periods of the current and future datasets, and 2) the same calculation was made starting from January 1 but using the KBDI values for

December 31 as the initial value. The steps were repeated 30 times until the difference between two adjacent years became negligible.

The increase in KBDI values between the resulting current and future fire potentials was computed by subtracting the two spatial images using Model Maker Module in ERDAS IMAGINE software.

Results and Discussion

The monthly wildfire potential for current conditions was generated; in addition, the annual wildfire potentials for current and future climatic conditions were produced. All results were documented in spatially explicit maps.

The quality of the calculated monthly KBDI values was evaluated. A comparison between the average monthly values (2006 to 2010) of the Fire Weather Index (FWI) for Eastern Mediterranean and the monthly KBDI average values for Lebanon showed a similar trend of increasing wildfire potential between March and September (figure 2).

In a subsequent step, the spatial distribution of KBDI classes throughout the year (excluding agricultural and un-vegetated areas) was investigated. This showed that the class ‘Very high’ (700 to 800) occurred in each month of the year with an increasing trend starting the month of March and a decreasing trend starting the month of December. The peak months of ‘Very high’ wildfire potential occurred in the months of September, October, and November, successively (figure 3).

Finally, the comparison between the relative areas of annual current and future wildfire potentials showed a significant increase in KBDI values (more than 50) affecting a total area of 1143 km² (441 sq mi). At the same time, only 442 km² (170.6 sq mi) were affected by a significant decrease in KBDI values (more than -50) (figure 4).

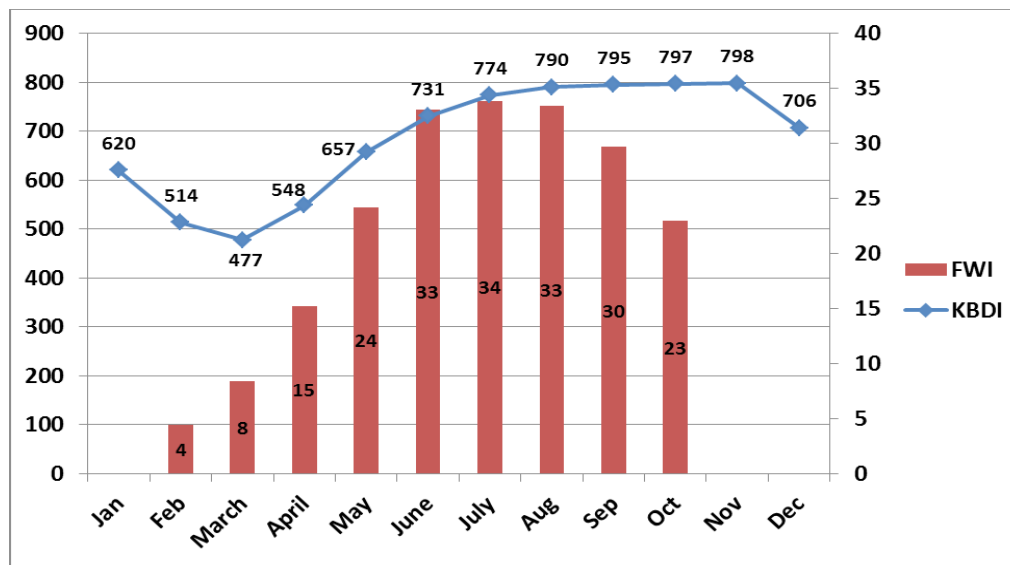


Figure 2—Comparison between monthly KBDI averages for Lebanon and monthly FWI averages for the Eastern Mediterranean

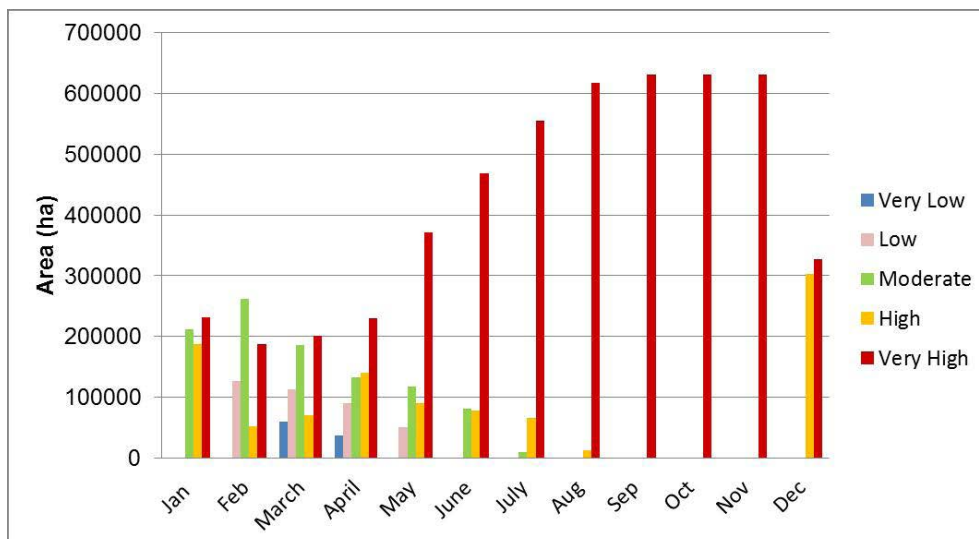


Figure 3—Spatial distribution of KBDI classes throughout the year

Conclusions

Overall, a significant increase in KBDI values (more than 50) affecting a total area of 1143 km² (441.3 sq mi) was predicted between current and future climatic conditions. The KBDI can be viewed here as an early warning tool for fire potential and severity in Lebanon in the absence of any other national climate-based system for drought monitoring and prediction.

Although the scale of the study area is very small compared to that of other countries in the region, this study gives a preliminary indication about the increasing risk of large scale wildfires in the Eastern Mediterranean, and specifically in Lebanon.

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Figure 4—Future increase in wildfire potential

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