Future vulnerability assessment of forest fire sector to climate change impacts in Cyprus


National Observatory of Athens
Institute for Environmental Research and Sustainable Development

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Introduction

- Two are the major classifications of the forest areas in Cyprus: a) forests and b) other wooded land, OWL (incl. maquis and garrique) which are either of state or private ownership.
- These categories account for 41.80% (386,718 ha) of the total land area.
Introduction
Introduction

• Forests of Cyprus are either natural (primary - undisturbed by man) or semi-natural. They are composed of a variety of natural vegetation including forests of conifers and broad-leaved trees such as pines, cedar, cypress and oaks.

• The dominant vegetation, up to 1400 m is Calabrian pine forest (*Pinus brutia*) which occurs in all forested areas of Cyprus. At higher elevation (1400 – 1950 m) the Black pine forest (*Pinus nigra* ssp. *pallasiana*) is dominant up to the highest peak.

• Other important species are the Cyprus cedar (*Cedrus brevifolia*), the juniper tree species of *Juniperus foetidissima*, and *Juniperus phoenicea*, the Mediterranean Cypress (*Cupressus sempervirens*), the Golden oak (*Quercus alnifolia*), the Syrian Maple (*Acer obtusifolium*) etc.
Cyprus forests and Fires

According to the Department of Forests of the Ministry of Agriculture, Natural Resources and Environment of Cyprus (www.moa.gov.cy/), forest fires are considered as the main threat for the forests of Cyprus. Every year, forest fires cause extensive and irreversible damages to forest ecosystems.

Forests of Cyprus are vulnerable to fire, primarily due to the long, hot and dry summers, mild winters, strong winds, intense relief and flammable xerophytic vegetation. These factors, along with human activities, have exacerbated by changing climatic conditions, which favour prolonged periods of drought and extreme weather events.

Number of Fires 2001-2010

Source: Department of Forests
“The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity”

IPCC
3rd Assessment Report
Definitions

- **Exposure** is the degree to which forests will be exposed to future climate changes and their impacts.

- **Sensitivity** is the degree to which forests are or are likely to be affected by or responsive to climate changes.

- **Adaptive Capacity** is the ability of forests to adapt to the changing environmental conditions which is also enhanced by the measures implemented in Cyprus in order to mitigate the adverse impacts of climate change.
Assessment of Exposure

- **Climatic indices:**
  - Number of dry days ($P<0.5$ mm)
  - Max length of dry spell
  - Number of days with $T_{\text{max}}>35$ °C
  - Average summer $T_{\text{max}}$ (°C)

- **Meteorologically based Fire Weather Index (FWI):**
  - Number of days with extreme fire risk ($FWI>30$)
  - Average Summer FWI
**Canadian Fire Weather Index**

Fire weather observations: Temperature, relative humidity, wind, rain

**Fuel moisture codes**
- Fine Fuel Moisture Code (FFMC)
- Duff Moisture Code (DMC)
- Drought Code (DC)

**Wind**
- Temperature, relative humidity, rain

**Fire behavior indices**
- Initial Spread Index (ISI)
- Buildup Index (BUI)
- Fire Weather Index (FWI)

FWI is divided into four fire danger classes:
- Low 0 – 7
- Medium 8 – 16
- High 17 – 31
- Extreme > 32

*(van Wagner, 1987)*
Regional Climate Modeling

- PRECIS (Providing Regional Climates for Impact Studies) - United Kingdom (UK) Meteorological Office Hadley Centre
- Horizontal resolution: 25km
- Control period: 1961 – 1990
  - Near future - NF (2021 – 2050)
- Two future periods:
  - Distant future - DF (2069 – 2098)
- Future projections are based on A1B scenario (IPCC)
## Climatic indices - Results I

### Control Period

<table>
<thead>
<tr>
<th></th>
<th>Western Regions</th>
<th>Southern Regions</th>
<th>Southeastern Regions</th>
<th>Continental Lowland regions</th>
<th>Higher Elevation Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb of dry days (P&lt;0.5mm)</td>
<td>200</td>
<td>250</td>
<td>280</td>
<td>280</td>
<td>265</td>
</tr>
<tr>
<td>Max length of dry spell (days)</td>
<td>15</td>
<td>60</td>
<td>90</td>
<td>85</td>
<td>70</td>
</tr>
</tbody>
</table>

### Future Changes

<table>
<thead>
<tr>
<th></th>
<th>Western Regions</th>
<th>Southern Regions</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Nb of dry days (P&lt;0.5mm)</td>
<td>NF +4</td>
<td>+4</td>
<td>+8</td>
<td>+8</td>
<td>+11</td>
</tr>
<tr>
<td></td>
<td>DF +12</td>
<td>+14</td>
<td>+15</td>
<td>+18</td>
<td>+20</td>
</tr>
<tr>
<td>Max length of dry spell (days)</td>
<td>NF 0</td>
<td>+7</td>
<td>+8</td>
<td>+10</td>
<td>+13</td>
</tr>
<tr>
<td></td>
<td>DF 0</td>
<td>+8</td>
<td>+21</td>
<td>+22</td>
<td>+9-15</td>
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</table>
Climatic indices - Results II

Control Period

<table>
<thead>
<tr>
<th></th>
<th>Western Regions</th>
<th>Southern Regions</th>
<th>Southeastern Regions</th>
<th>Continental Lowland regions</th>
<th>Higher Elevation Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb of days with Tmax&gt;35 °C</td>
<td>4</td>
<td>18</td>
<td>15</td>
<td>41</td>
<td>25</td>
</tr>
<tr>
<td>Average summer Tmax (°C)</td>
<td>27</td>
<td>30</td>
<td>30</td>
<td>34</td>
<td>33</td>
</tr>
</tbody>
</table>

Future Changes

<table>
<thead>
<tr>
<th></th>
<th>Western Regions</th>
<th>Southern Regions</th>
<th>Southeastern Regions</th>
<th>Continental Lowland regions</th>
<th>Higher Elevation Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb of days with Tmax&gt;35 °C</td>
<td>NF +2</td>
<td>+19</td>
<td>+17</td>
<td>+34</td>
<td>+30</td>
</tr>
<tr>
<td></td>
<td>DF 0</td>
<td>+32</td>
<td>+45</td>
<td>+55</td>
<td>+52</td>
</tr>
<tr>
<td>Average summer Tmax (°C)</td>
<td>NF +1.6</td>
<td>+2.0</td>
<td>+1.8</td>
<td>+2.5</td>
<td>+2.6</td>
</tr>
<tr>
<td></td>
<td>DF +3.2</td>
<td>+3.8</td>
<td>+3.4</td>
<td>+4.8</td>
<td>+4.6</td>
</tr>
</tbody>
</table>
Fire Weather Index - Results

Number of days with extreme fire risk (FWI>30)

- Troodos Mountain shows the higher increase 8-10 days in NF and approximately 25 days in the DF.
Fire Weather Index - Results

Average Summer FWI

- Western areas present low fire risk
- The remaining forested regions present extreme fire risk during July
- In near and distant future the fire risk remains in the same high levels
• Taking into account the current exposure of forests to fires as well as the relative future climate changes the exposure of forests to fires for the future period (2021-2050) can be characterized as very high.
Assessment of Sensitivity

- Forests in Cyprus are sensitive to fires because of their composition which is dominated by flammable vegetation and the topography of the forested areas, which is mostly mountainous.

- Moreover, urbanization increases the fire hazard because of the increase of flammable forest vegetation and decrease of human activity in the countryside as well as the availability of human and water resources in case of fires.
### Assessment of Sensitivity

The area, density and distribution of the main forest tree and shrub species that are threatened by forest fires as well as the range of threat within Cyprus

<table>
<thead>
<tr>
<th>Species (scientific names)</th>
<th>Area (ha) of species, natural distribution</th>
<th>Average number of tree per hectare</th>
<th>Distribution in Cyprus</th>
<th>Threat Category*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cedrus brevifolia</em> (tree)</td>
<td>367</td>
<td>75</td>
<td>Local</td>
<td>X</td>
</tr>
<tr>
<td><em>Juniperus excels</em> (tree)</td>
<td>643</td>
<td>32</td>
<td>Local</td>
<td>X</td>
</tr>
<tr>
<td><em>Pinus nigra ssp. pallasiana</em> (tree)</td>
<td>4,970</td>
<td>n.a.</td>
<td>Local</td>
<td>X</td>
</tr>
<tr>
<td><em>Juniperus foetidissima</em> (tree)</td>
<td>72.7</td>
<td>n.a.</td>
<td>Local</td>
<td>X</td>
</tr>
<tr>
<td><em>Quercus infectoria ssp. veneris</em> (tree)</td>
<td>354.7</td>
<td>n.a.</td>
<td>Widespread</td>
<td>X</td>
</tr>
<tr>
<td><em>Cupressus sempervirens</em> (tree)</td>
<td>450</td>
<td>n.a.</td>
<td>Widespread</td>
<td>X</td>
</tr>
<tr>
<td><em>Arbutus unedo</em> (shrub)</td>
<td>1.5</td>
<td>53</td>
<td>Local</td>
<td>X</td>
</tr>
<tr>
<td><em>Phillyrea latifolia</em> (shrub)</td>
<td>596</td>
<td>8.4</td>
<td>Rare</td>
<td>X</td>
</tr>
<tr>
<td><em>Viburnum tinus ssp. tinus</em> (shrub)</td>
<td>17</td>
<td>60</td>
<td>Local</td>
<td>X</td>
</tr>
</tbody>
</table>

* Threat categories: High – threatened throughout species range within Cyprus, Medium – threatened in at least 50% of range within country, Low-threatened in less than 50% of range within country.

Department of Forests, 2011
Assessment of Sensitivity

• The long, hot and dry summers that last from May until October increase the fire risk since they convert the pine as well as shrubs into a dry and highly inflammable fuel mass. During the fire season the temperature fluctuates from 30°C to 44°C increasing the risk of ignition to very high levels.

• Considering the above, the sensitivity of Cyprus’ forests to fires is characterized as very high.
Assessment of Adaptive Capacity

Several measures are taken by the Forestry Department of Cyprus aiming to eliminate forest fires.

• (A) **Fire Prevention measures**: Law enforcement – impose penalties for causing forest fires, Organizing of information campaigns, establishment of Picnic and camping sites, Fire danger mapping.

• (B) **Fire Pre-suppression measures**: Fire breaks, Forest roads, Forest telecommunications, Forest Stations, Silvicultural treatments, Detection and reporting of forest fires etc.

• (C) **Suppression measures**: Fire brigade, Stand-by of forest officers, Fire engines, Aerial means, Water tanks and hydrants etc.
Assessment of Adaptive Capacity

- In the framework of the Rural Development Programme 2007-2013 of Cyprus, economic incentives are provided to individuals through the Measure 2.5 "Protection of forests from fires and reforestation areas".

- The main purpose of the measure is to improve the existing protection system of forests and other forest areas from fire as well as the restoration of burned areas. The measure includes the following two actions: (i) fire prevention, (ii) reforestation of burnt areas.

- This measure enhances the protection of private forests which are not covered by the national forest protection programme.
Assessment of Adaptive Capacity

- Despite the great efforts and the good results of recent years, the problem of fires still exists and will always constitute a permanent threat for the forests of Cyprus.

- The adaptive capacity of Cyprus forests to fires can be characterized as moderate.
### Assessment of overall vulnerability

#### Degree of sensitivity, exposure & adaptive capacity

<table>
<thead>
<tr>
<th>Degree of sensitivity, exposure &amp; adaptive capacity</th>
<th>Degree of vulnerability</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>None ≤ 0</td>
</tr>
<tr>
<td>Limited</td>
<td>1</td>
<td>Limited 0 &lt; V ≤ 1</td>
</tr>
<tr>
<td>Limited to Moderate</td>
<td>2</td>
<td>Limited to Moderate 1 &lt; V ≤ 2</td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
<td>Moderate 2 &lt; V ≤ 3</td>
</tr>
<tr>
<td>Moderate to High</td>
<td>4</td>
<td>Moderate to High 3 &lt; V ≤ 4</td>
</tr>
<tr>
<td>High</td>
<td>5</td>
<td>High 4 &lt; V ≤ 5</td>
</tr>
<tr>
<td>High to Very High</td>
<td>6</td>
<td>High to Very High 5 &lt; V ≤ 6</td>
</tr>
<tr>
<td>Very high</td>
<td>7</td>
<td>Very high 6 &lt; V ≤ 7</td>
</tr>
<tr>
<td>Not evaluated</td>
<td>-</td>
<td>Not evaluated</td>
</tr>
</tbody>
</table>

**Vulnerability = Impacts – Adaptive capacity**

**Impacts = Square root of (Sensitivity x Exposure)**
Overall future vulnerability of forested areas in fire risk

<table>
<thead>
<tr>
<th>Impact</th>
<th>Sensitivity</th>
<th>Exposure</th>
<th>Adaptive Capacity</th>
<th>Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fires</td>
<td>Very high (7)</td>
<td>Very high (7)</td>
<td>Moderate (3)</td>
<td>Moderate to high (4)</td>
</tr>
</tbody>
</table>
Conclusions

• Drought and hot conditions that drastically increase flammability during summer period are expected to increase highly in the near and distant future in the forested areas of Cyprus.

• The investigation of the FWI, revealed that Troodos Mountain and the majority of the forested areas present extreme fire risk both in near and distant future.

• The sensitivity of Cyprus forests to fires is highly increased because of their composition which is dominated by flammable vegetation and the topography of the forested areas, which is mostly mountainous.

• The adaptive capacity of forests are greatly depend on the measures that are taken by the Forestry Department of Cyprus to eliminate forest fires but the problem of forest fire still exists and will always constitute a permanent threat for the forests of Cyprus.
Thank you for your attention!

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