POSSIBLE ROLE OF CAROB TREE (*Ceratonia siliqua* L.) IN FIRE PROTECTION OF AGRO-FOREST SYSTEMS OF CROATIAN SOUTH ADRIATIC ISLANDS REGARDING THE SIMILARITIES WITH OTHER MEDITERRANEAN COUNTRIES

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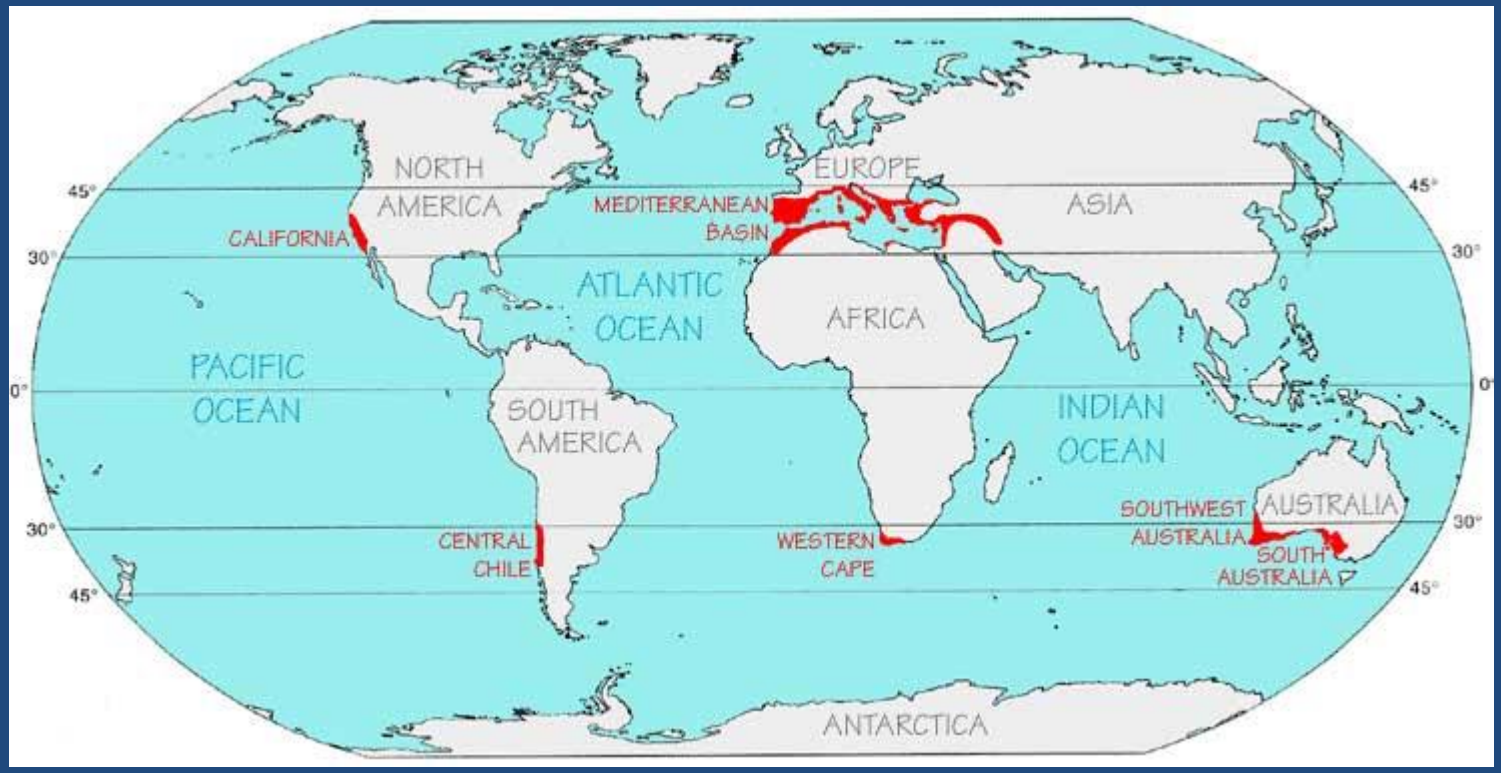
Introduction
Causes of forest fires in Mediterranean area

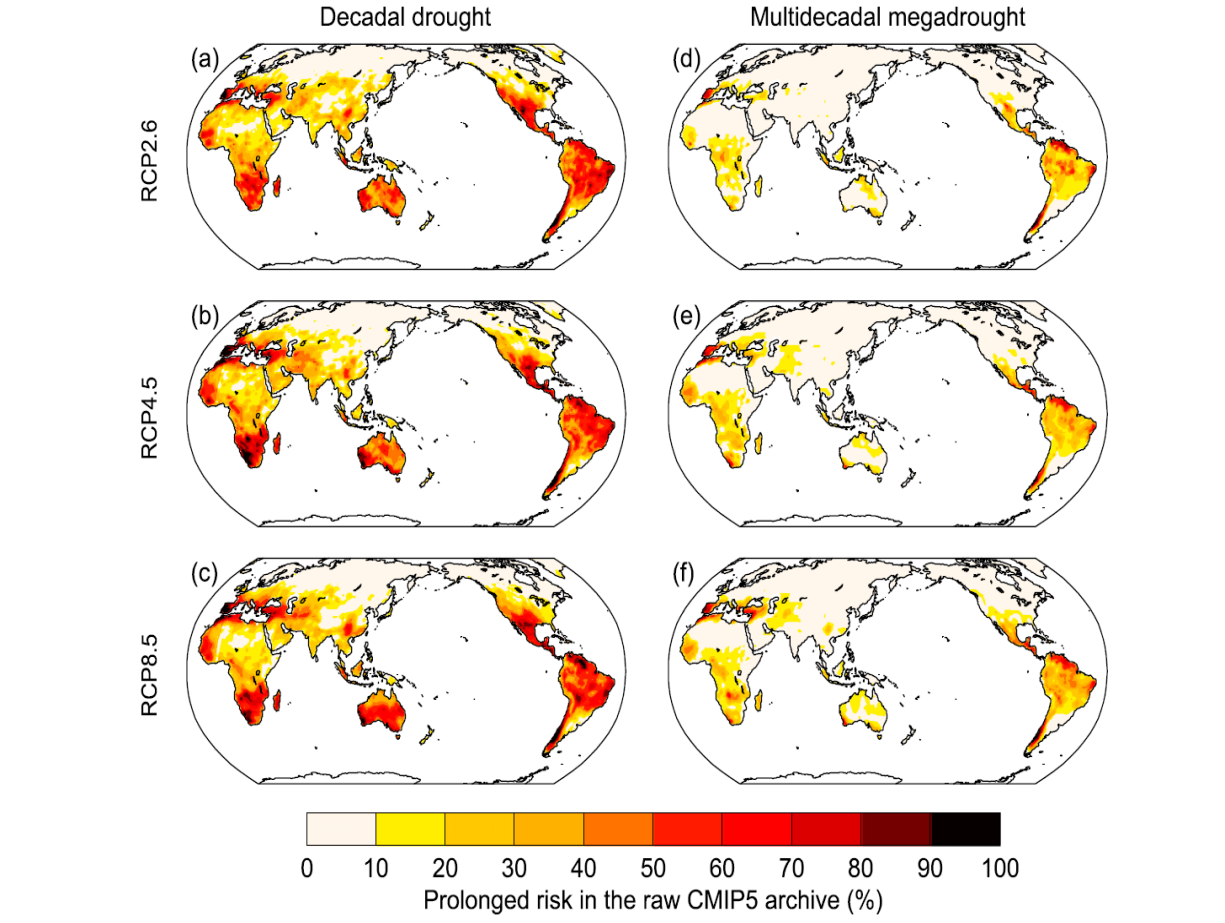
- 95 % of wildfires in Mediterranean Europe were due to human causes, which completely corresponds with official reports of Croatian Ministry of Interior and Croatian Firefighting Association.
- Many forest fires on Croatian Adriatic islands as well as in other Mediterranean countries was and some of them still are deliberately induced by local population in purpose of changing of vegetation of maquis and garrigue, and even because of recovering the vegetation of karst pastures.
- Distribution of Mediterranean climate and vegetation areas strictly correspond with the most frequent and the most catastrophic forest fires.

World Mediterranean areas



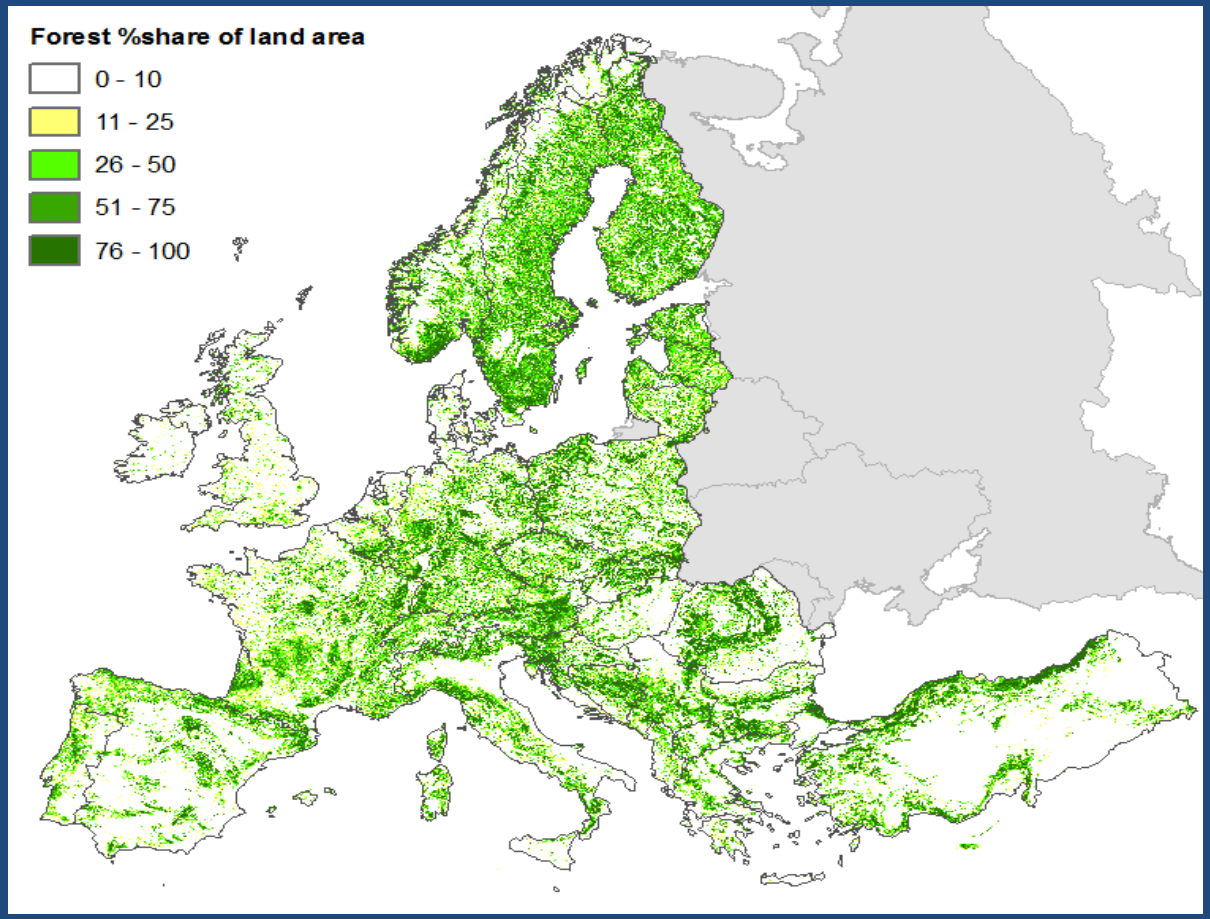
Map is adapted from: Ecosystems of the World, Vol. II, Mediterranean-Type Shrublands (F. DiCastri, D.W. Goodall and R.L. Specht, Eds.), Elsevier, Amsterdam, 1981. (source: http://www.grabovrat.com/cgi-bin/search.cgi?query=mediterranean&start=30)

Causes of forest fires in Mediterranean area



Map is adapted from: Ault, T.R. *et al.* (2014) Assessing the Risk of Persistent Drought Using Climate Model Simulations and Paleoclimate Data. Journal of Climate, 27: 7529-7549.

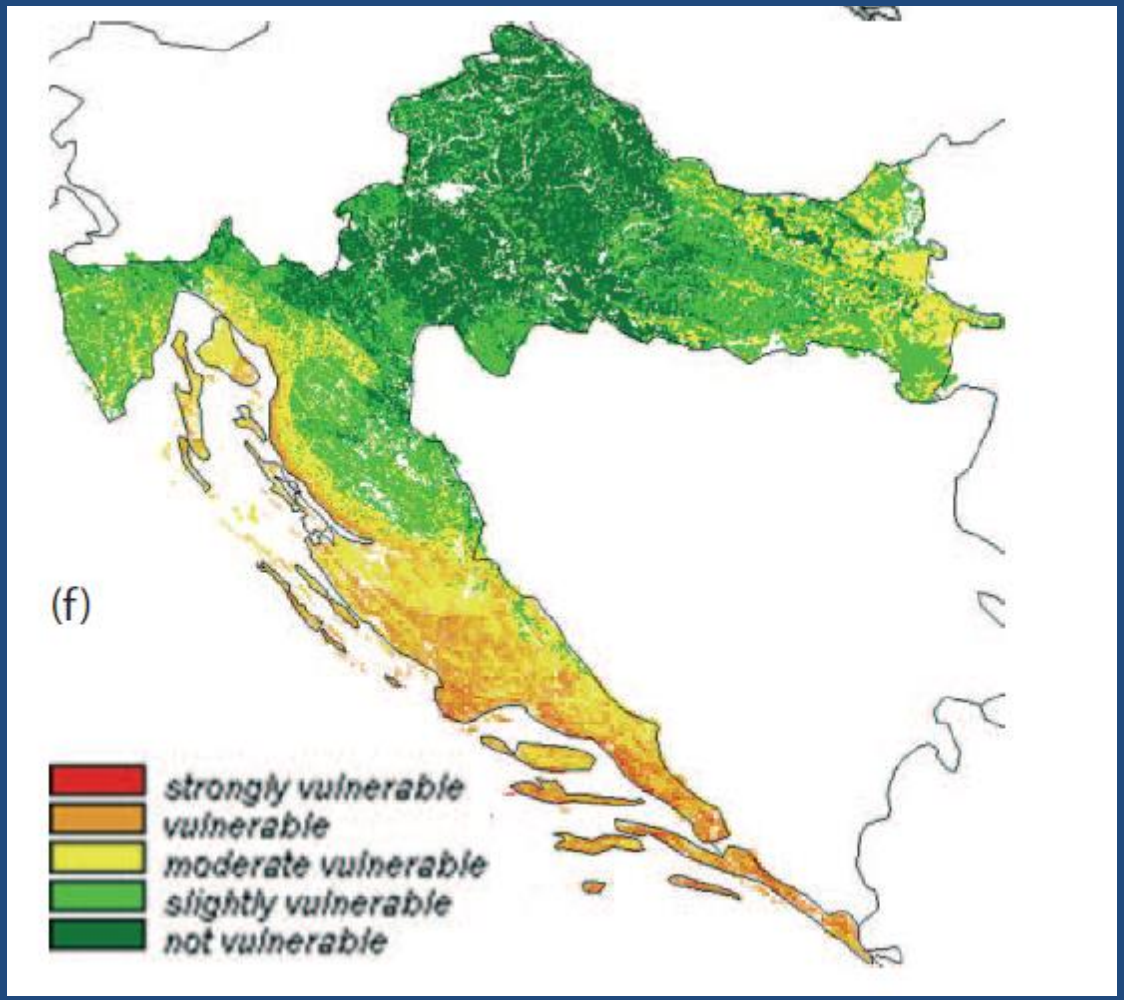
Causes of forest fires in Mediterranean area



Map is adapted from European Forest Institute, http://www.efi.int/portal/virtual_library/information_services/mapping_services/forest_map_of_europe/

Forest cover map of the EC Joint Research Centre (Kempeneers et al. 2011), aggregated to 1km x 1km.

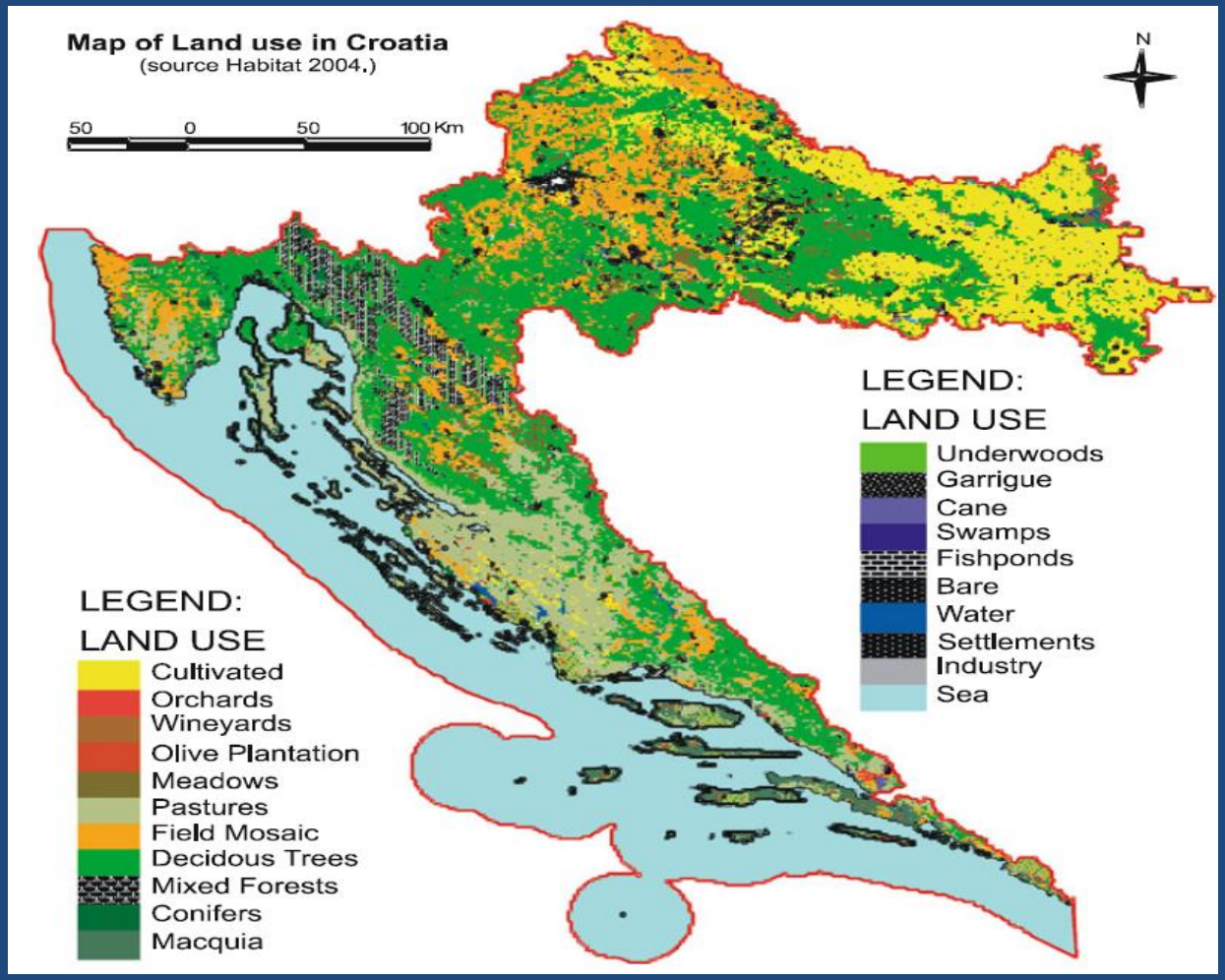
Causes of forest fires in Croatian Mediterranean area: 1. DROUGHT



Drought Vulnerability Map of Croatia

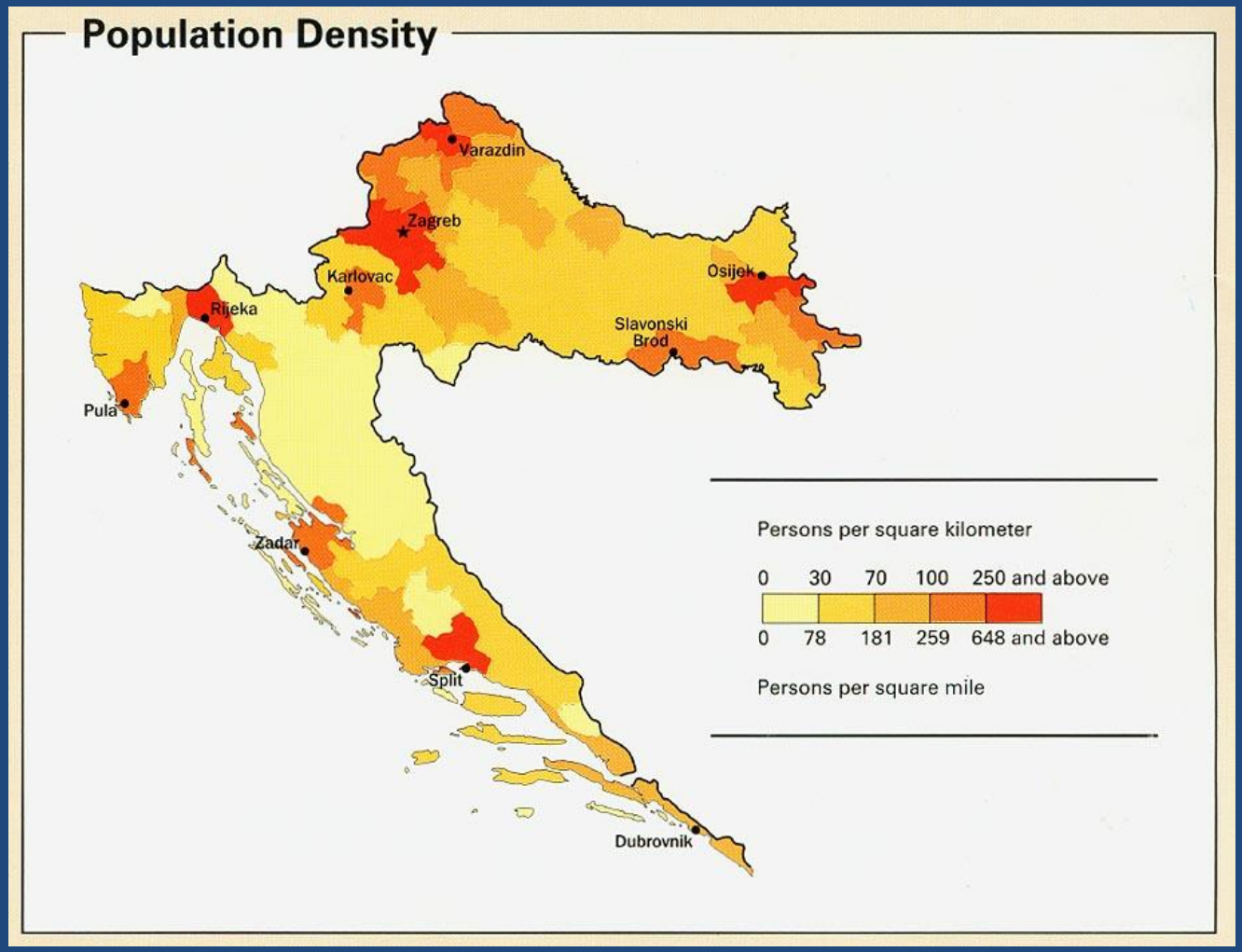
Map is adapted from: Perčec Tadić, M. *et al.* (2014) Drought Vulnerability in Croatia. Agriculturae Conspectus Scientificus, 79(1): 31-38.

Causes of forest fires in Croatian Mediterranean area: 2. VEGETATION



Map is adapted from: Bašić, F. (2013) The Soils of Croatia. Springer, Dordrecht.

Causes of forest fires in Croatian Mediterranean area: 3. SOCIAL FACTORS



Map is adapted from: Free World Population Maps. Source: http://www.mapcruzin.com/free-world-population-maps.htm

Damages caused by fires in Croatian Mediterranean Area = COMPLETE DISASTER in agro-forest ecosystem

(photo by Boris Kačan, 2016)

Damages caused by fires in Croatian Mediterranean Area = COMPLETE DISASTER in agro-forest ecosystem

(photo by Boris Kačan, 2016)

Flammability of most abundant Mediterranean plant species

According to results of flammability tests, provided by ignition apparatus used according to **ISO 5657-1986E** norms, Dimitrakopoulos and Papaioannou (2001) divided the most commune Mediterranean plant species into four groups of flammability;

1. **Less flammable species:** *Calicotome villosa* (villous calicotome), *Sarcopoterium spinosum* (thorny burnet), *Juniperus oxycedrus* (prickly juniper), *Tamarix smyrnensis* (tamarisk), *Nerium oleander* (common oleander), *Castanea sativa* (sweet chestnut), and *Platanus orientalis* (Oriental plane).
2. **Moderately flammable species:** *Quercus coccifera* (kermes oak), *Cistus salvifolius* (sage-leaved rock rose), *Cistus creticus* (gum rock rose), *Phlomis fruticosa* (Jerusalem sage), ***Ceratonia siliqua*** (carob tree) and *Pistacia lentiscus* (lentisco). All these species have hard, leathery leaves with waxy or hairy epidermis which prevents rapid water loss from evapotranspiration.
3. **Flammable species:** *Pinus brutia* (Calabrian pine), *Quercus ilex* (holm oak), *Quercus pubescens* (downy oak), *Cupressus sempervirens* (Mediterranean cypress), *Olea europea* (olive tree), *Pinus halepensis* (Aleppo pine), *Erica arborea* (tree heath), *Arbutus unedo* (strawberry tree) and *Pistacia terebinthus* (terebinth pistache)
4. **Extremely flammable species:** *Laurus nobilis* (bay laurel) and *Eucalyptus camaldulensis* (longbeak eucalyptus)

But(?!)

- Do the laboratory tests of plant flammability completely correspond with the real situation of forest fire?

Why the carob tree is placed in second group of moderately flammable plant species? If.....

source: http://www.ihc2018.org/en/S37.html

Why the carob tree is placed in second group of moderately flammable plant species? If.....

Table 1: List of non-acceptable species

Flammable Indigenous Species

- All pine species i.e. *Pinus halepensis* (Żnuber), *P. brutia* (Żnuber tal-Ivant), *P. pinea* (Żnuber ta' l-ikel);
- Cypress- *Cupressus sempervirens* (Ċipress), and its variants;
- Holm oak- *Quercus ilex* (Ballut);
- Junipers- *Juniperus phoenicea* (Gniepru);
- Lentisk- *Pistacia lentiscus* (Deru)
- Olive- *Olea europaea* (Siġra taż-żebbuġ)
- Common sumach- *Rhus coraria* (Xumakk tal-konz);
- Strawberry tree- *Arbutus unedo* (Imbragla);
- Grasses and other oily shrubs e.g. aromatic herbs.

Flammable Alien Species

- All wattle/ acacia species- *Acacia* sp. (Siġra ta' l-Akaċja)
- Tree-of-heaven- *Ailanthus altissima* (Xumakk);
- All eucalyptus- *Eucalyptus* sp. (Siġra ta' l-Ewkaliptus);
- Castor oil tree- *Ricinus communis* (Siġra tar-Riċnu);
- Tree tobacco- *Nicotania glauca* (Tabakk tas-swar);
- Brazilian pepper- *Schinus terebinthifolius* (Siġra tal-bżar).

Table 2: List of acceptable species

Acceptable Indigenous species

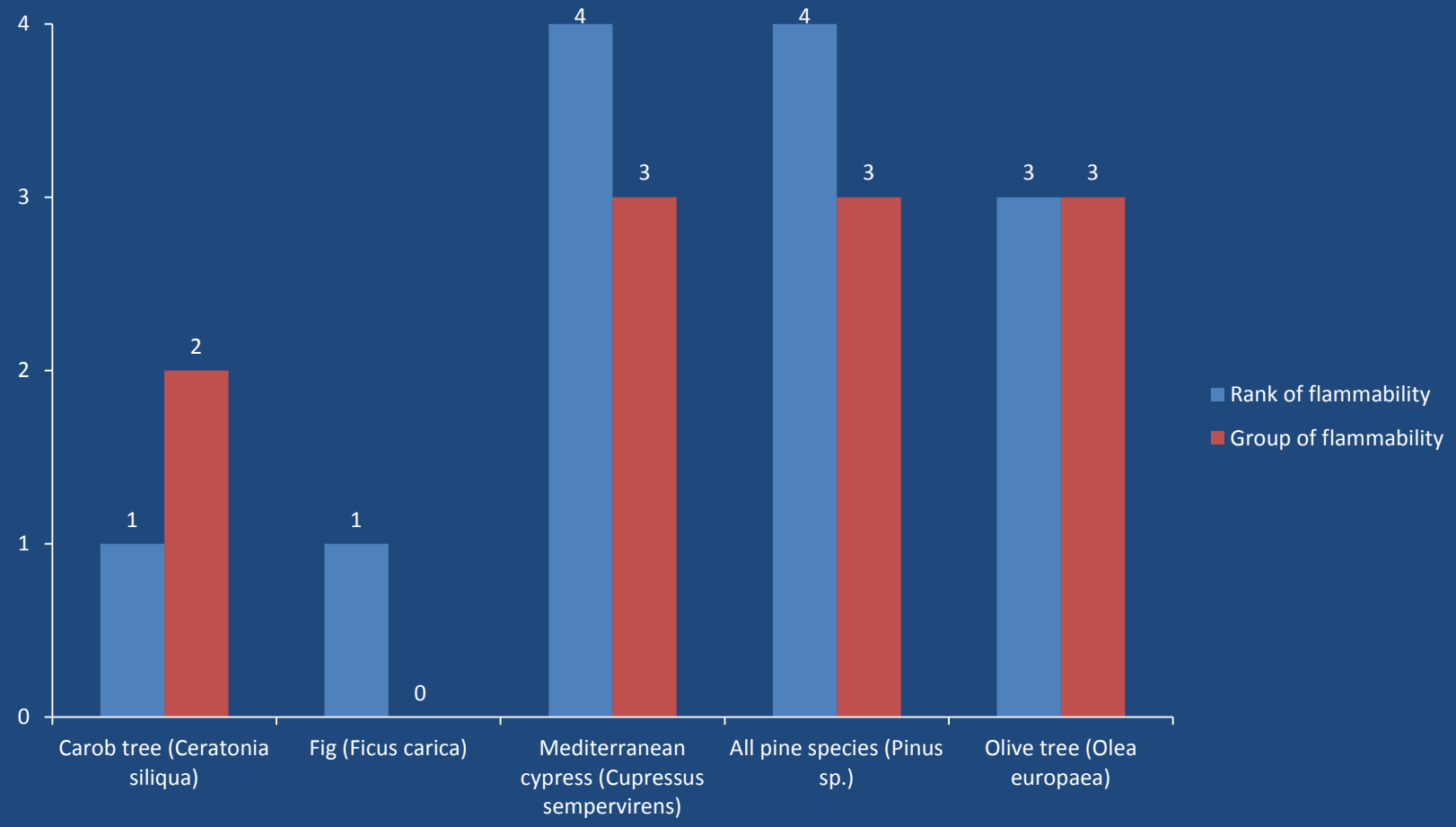
- Carob- *Ceratonia siliqua* (Siġra tal- Ħarrub);
- Judas Tree- *Cercis siliquastrum* (Siġra ta' Ġuda);
- Hawthorn- *Crataegus azarolus/ Crataegus monogyna* (Għanżalor/Żagħrun)
- Quince- *Cydonia oblonga* (Sfarġel)
- Fig- *Ficus carica* (Tin)
- Narrow-leaved ash- *Fraxinus angustifolia* (Fraxnu);
- Bay laurel- *Laurus nobilis* (Rand);
- Medlar- *Mespilus germanica* (Naspli tedeski);
- African tamarisk- *Tamarix africana* (Bruk);
- Elms- *Ulmus canescens, Ulmus minor, Ulmus procera* (Ulmu)
- Ivy- *Hedera helix* (Liedna).

Guidelines on Trees, Shrubs and Plants for Planting and Landscaping in the Maltese Islands (MEPA. 2002)

Methodology

- Ethnobotanical and ethnoecological research according to Martin G.J. (1995) Ethnobotany – A methods manual, World Wide Fund for Nature, UNESCO, Royal Botanic Gardens, Springer, Dordrecht.
- In order to compare the results of provided flammability tests of previous authors, described above, the ethnobotanical field research were carried out during the year of 2016 and 2017, within population of Croatian islands of Drvenik Mali, Šolta, Brač, Hvar and Vis. The research were based on semi-structured interviews on selected local counterparts and also in population of professional and voluntary firemen.
- In order to bridge the gap between qualitative and quantitative approach in semi structured interview, the results of ethnobotanical, i.e. ethnoecological data were compared with the available photoshoots from air of burned area in forest fires from different years and also, the status of vegetation recovery after the forest fires was checked on the ground.

Results


4
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Carob tree (Ceratonia siliqua)
Fig (Ficus carica)
Mediterranean cypress (Cupressus sempervirens)
All pine species (Pinus sp.)
Olive tree (Olea europaea)
Rank of flammability
Group of flammability

Discussion

Defended agricultural zones, soon after the huge forest fire.
In left corner on the bottom of picture are visible survived “nests” of carob trees after the fire (photo by Boris Kačan)

Discussion

Map is adapted from: Srečec, S. *et al.* (2016) Comparison of Morphological Characteristics of Carob Tree (Ceratonia Siliqua L.) Pods And Seeds of Populations Collected From Two Different Habitats, Islands Drvenik Mali and Mali Lošinj. Agriculturae Conspectus Scientificus, 81(1): 61-64.

Discussion

It is of essential need to start also with rehabilitation of burned areas in case of heavy damages of Mediterranean forests in order to prevent the negative consequences of further degradation. In that sense, Turkish experiences are definitely praiseworthy. After the catastrophic fire in Antalya-Serik-Taşağıl forest fire in 2008, Turkey started the project of entitled as “Rehabilitation of Burned Areas and The Establishment of Forest with Fire Resistant Species”, acronym: YARDOP; Yılmaz, F. and Satıl, F. (2017).

Conclusions

1. The results of this studies correspond with the results of previous authors and carob tree has, not just possible, but even important role in designing of fire stopping zones, primarily on southern Adriatic islands of Croatia.
2. Forest fires in all countries of Mediterranean basin became a serious, not just environmental but also a socio-economical issue of sustainability of ago-forest systems and biodiversity of Mediterranean spontaneous phytocenoses.
3. It is obvious that because of global warming, traditional activities of using the fire as a tool in sustainable land use and resource management have to be restricted on minimum.
4. In spite of huge number of research and also, besides of accepted fire management principles and strategic actions, prescribed by Forestry Department of Food and Agriculture Organization of the United Nations, the damages on agro-forest systems caused by forest fires becomes of catastrophic dimensions.
5. Preventive measures are the most important issue in order to ensure agricultural production, protection the biodiversity within Mediterranean ecosystems, and sustainable tourism. One of preventive measures is spatial planning and planting of vegetation fire protection belts by using a low flammable plant species and one of them is definitely a **carob tree** whose growing area corresponds with the heaviest damages caused by forest fires.

ACKNOWLEDGEMENTS

- This paper has been fully supported by **Croatian Science Foundation under the project HRZZ- IP-11-2013-3304-TEUCLIC**.
- The authors of this paper are particularly grateful to **Croatian Firefighting Association**, to Mr. **Milan Lučin** and Mr. **Nebojša Božanić** for very useful information and help in ethnobotanical research. Also, special thanks to Mr. **Boris Kačan** for his permission for using his photographs