Climate influence on silver fir (Abies alba Mill.) defoliation and dieback in Gorski kotar

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Hrvatsko meteorološko društvo

Meteorološki izazovi 6
Znanstveno-stručni skup s međunarodnim sudjelovanjem

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INTRODUCTION

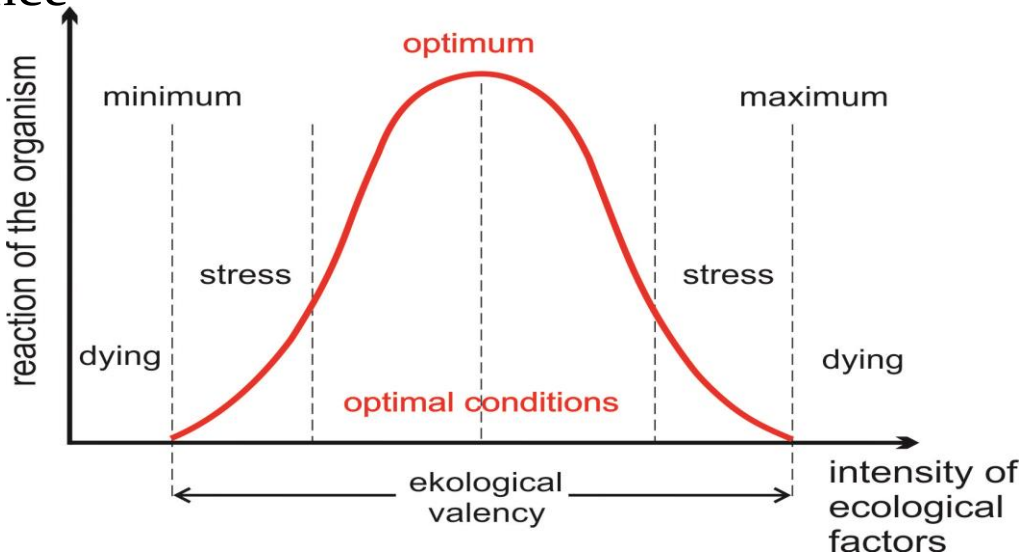
- Forest ecosystems presently are under constant change, caused either by natural variability or human activity.

- Dieback of silver fir at certain areas in Croatia is causing great ecological and economical problems.

- Beside abiotic factors, dieback of silver fir is significantly affected by some biotic factors.

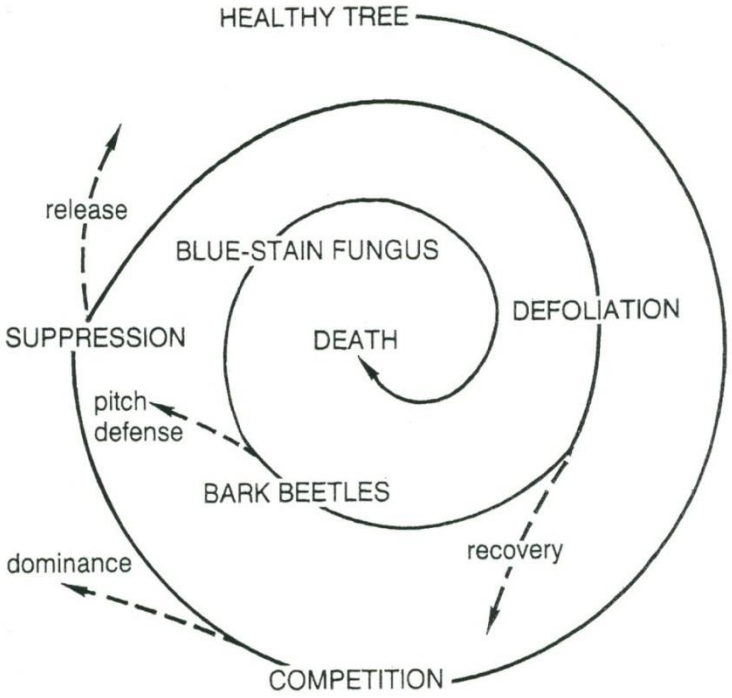
- Considering crown defoliation, according to ICP Forest program for 2016, silver fir is the most endangered conifer tree species in Croatia.

Ecological valence



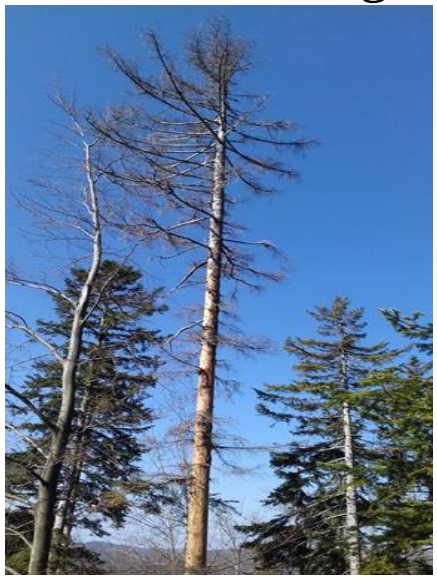
• Ecological valence is tolerance of organism or some species on certain ecological factor i.e. range between ecological minimum and maximum.

Tree dieback – result of abiotic and biotic factors



Mortality spiral illustrates the series of events leading to tree death (Franklin et al. 1987.

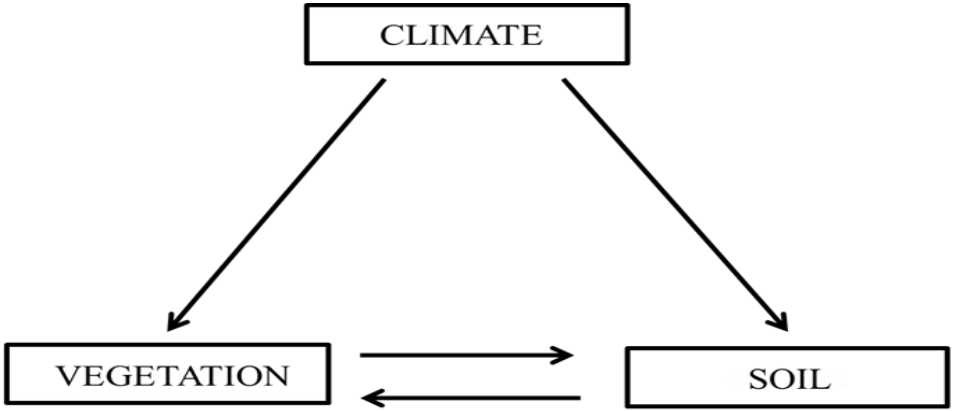
• In state of "stress" are so called "sanitary trees" that are marked for cutting according to rule book.



• State of sanitary trees (crown defoliation and damage, change of leaf colour, symptoms of pathogen infection) is result of limiting values one or more ecological factors (ecological minimum or maximum).

- Air temperature - stenovalent species
- Water - stenovalent species
- Soil – silver fir is eurivalent species

Climate relationship to vegetation and soil



Jenny 1958.

RESEARCH OBJECTIVES

The objective of this study was:

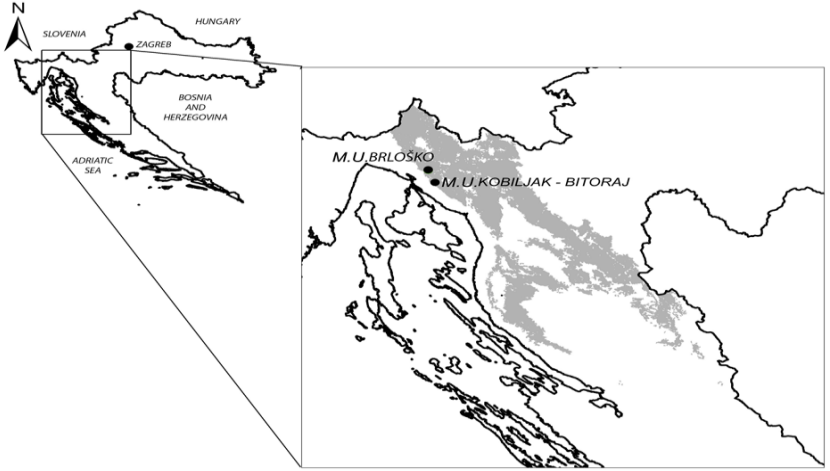
• Determine effect of abiotic factors like climate on defoliation and dieback of silver fir.

• To establish differences between crown defoliation and dieback intensity in two silver fir forest ecosystems as well as differences according to silver fir tree dieback pattern.

Research area - Dinarides

- Mountain Croatia, areal of beech – fir forests
- Beech-fir forests cover ~ 1 Mil. ha in SE Europe
- In Croatia cca 200 000 ha
- Natural structure and species compostion
- No clear cut in the past
- Managed with Selection system
- Emphasised sensitivity of beech – fir forest on the edge of their areal
- Tree dieback and degradation of entire forests stand

Study site



Air temperature = 7.2° C
Precipitation ≈ 2 000 mm

Moderate rain climate

Mountain Croatia, areal of fir and beech-fir forests

Emphasised sensitivity of fir and beech-fir forests on the edge of their areal

Tree decline and degradation of entire forest stands

MATERIAL AND METHODS

Experimentals plots	*Area (m^2)*	*Forest associations*	*Soil type*	*Parent substrate*
Bitoraj, N = 4	10 000	The Dinaric beech-fir forest	Calcocambisol	Limestone
Brloško, N = 4	10 000	Fir forest with hard fern	Dystric cambisol	Silicate rocks

Permanent experimental plots:

- 50 x 50 m
- Bitoraj, N = 194 trees
- Brloško, N = 81 trees

• Each silver fir tree of breast height diameter of over 10 cm was assessed for crown defoliation.

• Visual assessment of crown defoliation was done in July and August of each year during the period from 1994 until 2013 with accuracy of 5 % and categorized into defoliation degrees (ICP Forest).

• For analysis of climatic factors that influence crown condition of silver fir we used data from Vrelo Ličanke weather station.

• Using the KlimaSoft 2.0 program, we established drought years, drought duration in days, water balance and potential evapotranspiration (PET) in mm according to the Thornthwaite method.

• Dieback intensity was shown as percentage of number of dead trees (N %), tree basal area (%) and volume (%) of dead trees against living trees. Dieback causes were divided in two groups: dieback due to crown defoliation and dieback due to wind throw.

• Correlation analysis established the connection between crown defoliation and climatic factors, as well as between crown defoliation and tree dieback.

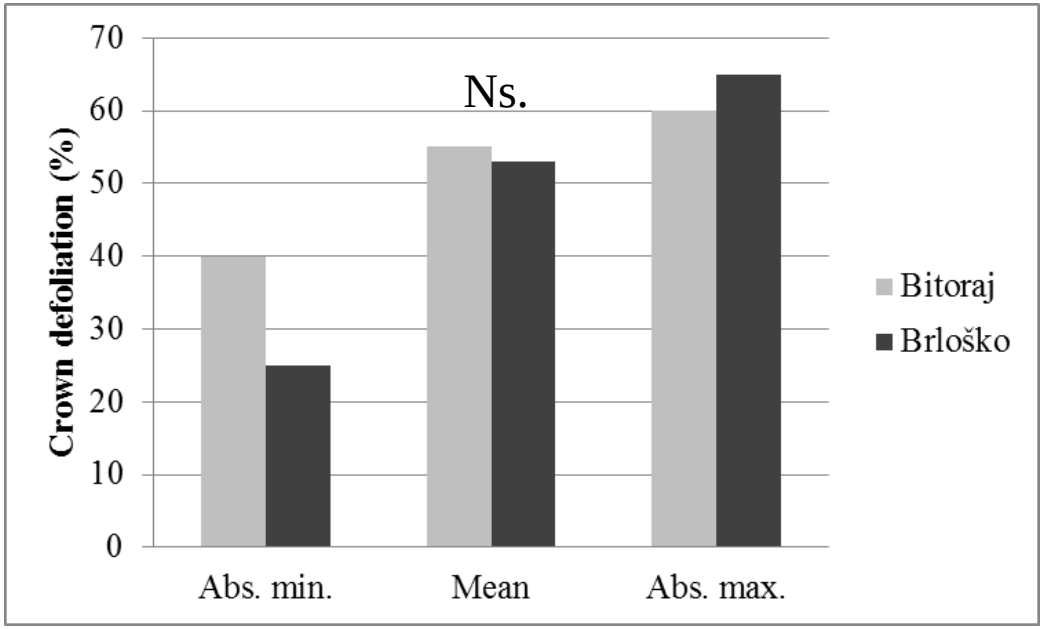
• Student t-test and u-test were used to compare crown defoliation and time of dieback between experimental plots as well as dieback causes.

• All climatic data was processed using the KlimaSoft 2.0 program, while statistical data processing (descriptive statistics, correlation, U-test) was conducted in Statistica 7.1. program (StatSoft, Inc. 2003).

RESULTS

Table 1. Descriptive statistics of climatic factors in research area

Climate elements	Mean	Min − Max
Precipitation (mm)	953,66	585,60 − 1525,10
Ait temperature (°C)	13,12	12,07 – 14,40
Water balance (mm)	480,01	71,50 – 1018,40
PET (mm)	494,13	468,50 – 529,10
Drought (days)	17,00	0,00 – 90,00



Average rate of change

$$\bar{S} = 100 \cdot \left(\sqrt[n-1]{\frac{yn}{y1}} - 1 \right)$$

Bitoraj 2.3 % annual

Brloško 4.3 % annual

Figure 1. Descriptive statistics of crown defoliation (%)

Ns = not significant, $p > 0.05$

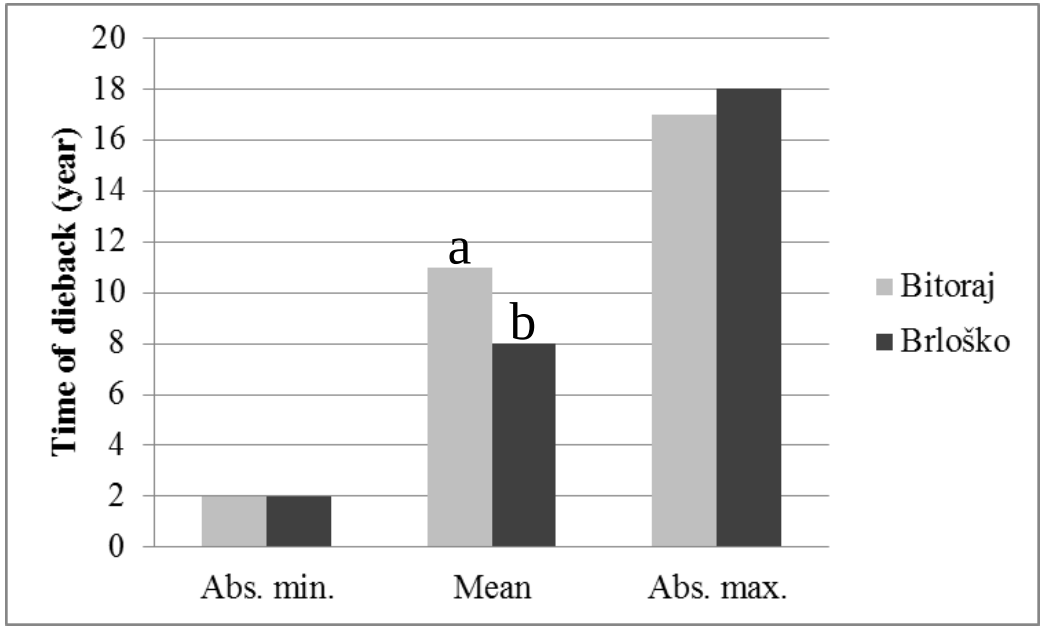


Figure 2. Descriptive statistics of time of dieback (year)

[a,b] Values within column marked with different letter, differ significantly ($p < 0.05$)

Table 2. Correlation between silver fir tree crown defoliation and climatic factors

Variable	Crown defoliation	Monitor. years	Veg. precip.	Veg. temp.	Water balance	Veg. PET	Drought year	Drought days
Crown defoliation	1.00	-	-	-	-	-	-	-
Monitor. years	**0,76***	1.00	-	-	-	-	-	-
Veg. precip.	0,12	0,01	1.00	-	-	-	-	-
Veg. temp.	**0,30***	**0,30***	-0,07	1.00	-	-	-	-
Water balance	0,19	0,11	**0,87***	-0,07	1.00	-	-	-
Veg. PET	**0,23***	**0,24***	0,02	**0,79***	-0,03	1.00	-	-
Drought year	**0,15***	0,19	**-0,34***	**0,41***	**-0,24***	**0,39***	1.00	-
Drought days	0,11	0,21	**-0,28***	**0,37***	-0,18	**0,30***	**0,89***	1.00

** significant at $p < 0.05$*

Table 3. Correlation of silver fir defoliation and tree dieback intensity

Dieback intensity	Site	
	Bitoraj	Brloško
	Crown defoliation (%)	
Number of trees, N (%)	0,61*	0,12*
Basal area, G (%)	0,47*	0,11*
Volume, V (%)	0,43*	0,11*

** significant at $p < 0.05$*

Table 4. Dead silver fir trees (N, %) according to dieback pattern on experimental plot "Bitoraj" in the Dinaric beech-fir forest

Site Bitoraj		Percentage of dieback
Wind thrown/Wind breakage	5 trees	19 %
Crown defoliation	22 trees	81 %
Total number of dead trees	27 trees	
Annual dieback intensity	1,4 tree	

Table 5. Silver fir dead trees (N, %) according to dieback pattern on experimental plot "Brloško" in fir forest with hard fern

Site Brloško		Percentage of dieback
Wind thrown/Wind breakage	6 trees	29 %
Crown defoliation	15 trees	71 %
Total number of dead trees	21 trees	
Annual dieback intensity	1,1 tree	

CONCLUSIONS

- Tree crown defoliation of silver fir has significantly increased over the monitored time period.

- Air temperature, potential evapotranspiration and drought are the most significant climatic elements that crown defoliation depends on.

- Tree crown defoliation of silver fir has significantly increased along with the values of air temperature, potential evapotranspiration and drought in vegetation period.

- Tree crown defoliation has significantly influenced tree dieback process.

• On experimental plots, the dominant cause of dieback was crown defoliation and lesser one was wind throw.

• Average annual dieback intensity according to number of trees was higher on experimental plot „Brloško“ (fir forest with hard fern) in comparison to experimental plot „Bitoraj“ (Dinaric beech-fir forest).


THANK YOU FOR YOUR
ATTENTION!