Beech nutrition depends on defoliation, soil and climate across Croatia

Ognjenović, M., Seletković, I., Potočić, N., Perčec-Tadić M., Sokol Jurković, R., Marušić, M., Sever, K., Ugarković, D., Timmermann, V., Rautio, P., Jonard, M.

INTRODUCTION

- The cycling of nutrients between the soil and plants is one of the defining aspects of ecosystem functioning. (Lukac et al. 2010)

- A common feature of stress impact is the uneconomical use of nutrients and water, leading to alterations in storage patterns in trees, soils and on the ecosystem level (Augustin and Andreae, 1998)

- At the tree level, this is usually described as decline influencing tree condition or vitality, which can be assessed through the use of tree vitality indicators such as defoliation or foliar nutrition.

- Despite its adaptive diversity, the predicted climate change may significantly affect the vitality of common beech (Simon et al., 2017; Zimmermann et al., 2015).

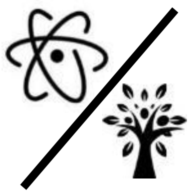
INTRODUCTION

- Extreme climatic events like drought are thought to be important in initiating changes in forest ecosystems (Zierl 2004).

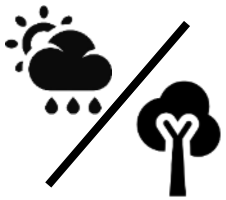
- Global environmental change creates a higher nutrient demand by trees (Lukac et al., 2010), therefore is crucial to account for nutrient limitation when studying the forest response to climate change (Jonard et al. 2015).

- Defoliation seems to be related to the nutritional status of trees:
- Jonard et al. (2010) - better foliar Ca & Mg status lower defoliation levels
- Ferretti et al. (2015) - *F/25%* increases with increasing values of foliar ratios (N/Ca, N/K)
- Thimonier et al. 2010 – No link of N and defoliation
- Gottardini et al. 2016 - Significant differences in photosynthetic efficiency (F_V/F_M)

GOALS



Determine if foliar element concentrations differ according to common beech defoliation



Investigate the influence of climate conditions on foliar mineral nutrition of common beech

METHODS

RESEARCH PLOTS

ICP Forests

16 x 16 km grid

Selection Criteria

N ≥5 Y ≥ 90%
1996 - 2017

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Cross-cluster

24 trees- defoliation assessment

Foliage sampling

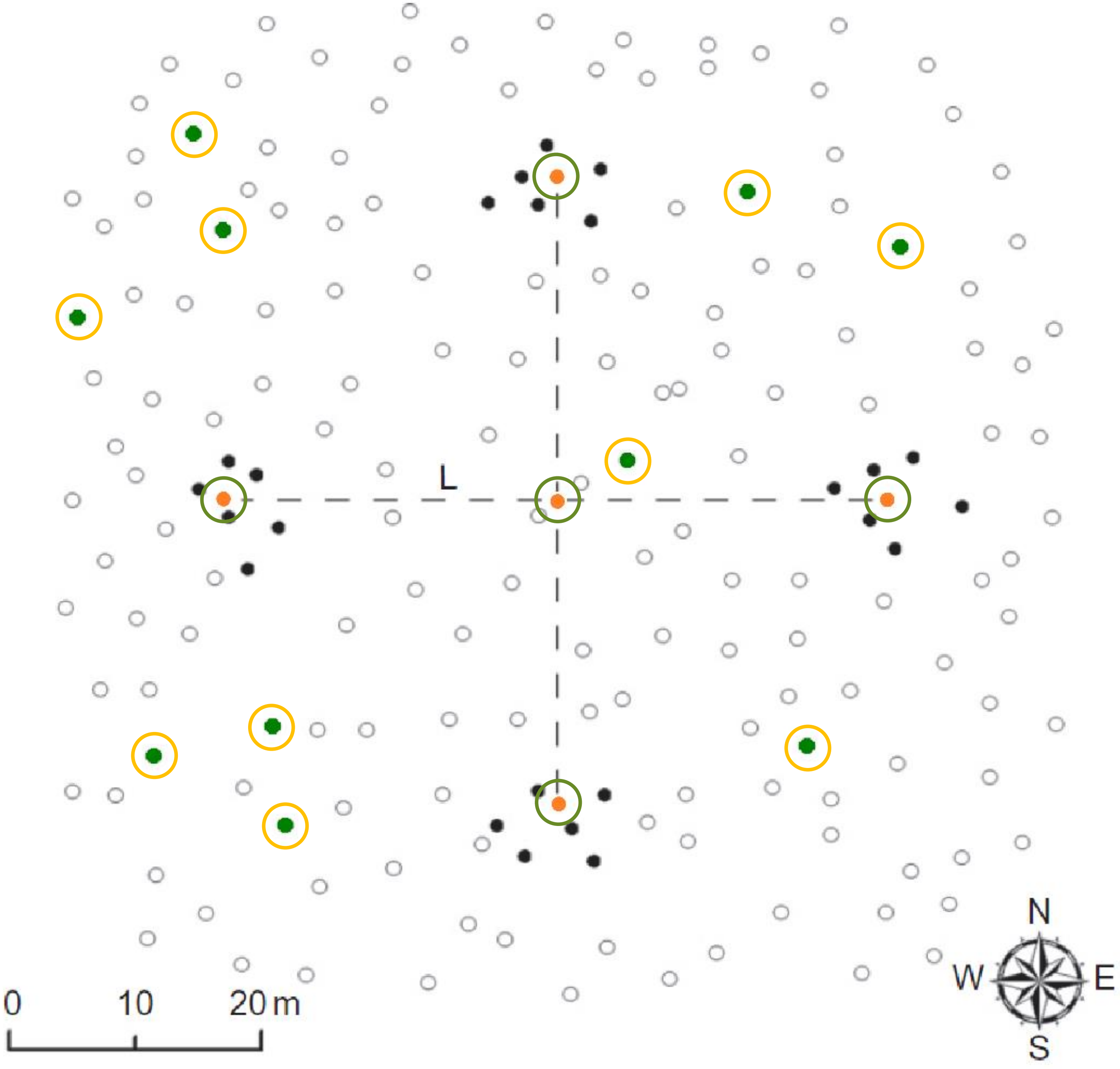
5 trees *≤ 25% defoliation*

5 trees *> 25% defoliation*

Soil sampling

Soil probe

Composite sample



METHODS

FOLIAR ANALYSES

- Element concentrations of N, P, K, Ca and Mg

SOIL ANALYSES

- pH, total N, S and P

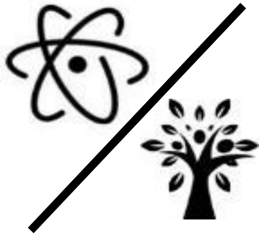
DEFOLIATION ASSESSMENTS

- Eichhorn et al. 2016

CLIMATE DATA

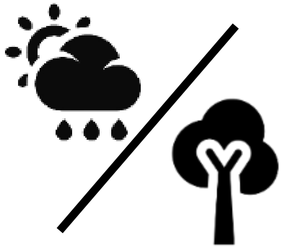
- CroMonthlyGrids (Perčec Tadić 2010)
- Regression kriging framework
- Spatial resolution - 1 km
- Temperature (mean, max, min), precipitation (sum), SPEI, scPDSI
- Yearly, monthly and seasonal values
- Deviation from Climate Normals (1981-2010)
- Lag

METHODS DATA ANALYSIS



Two-Factor Mixed ANOVA

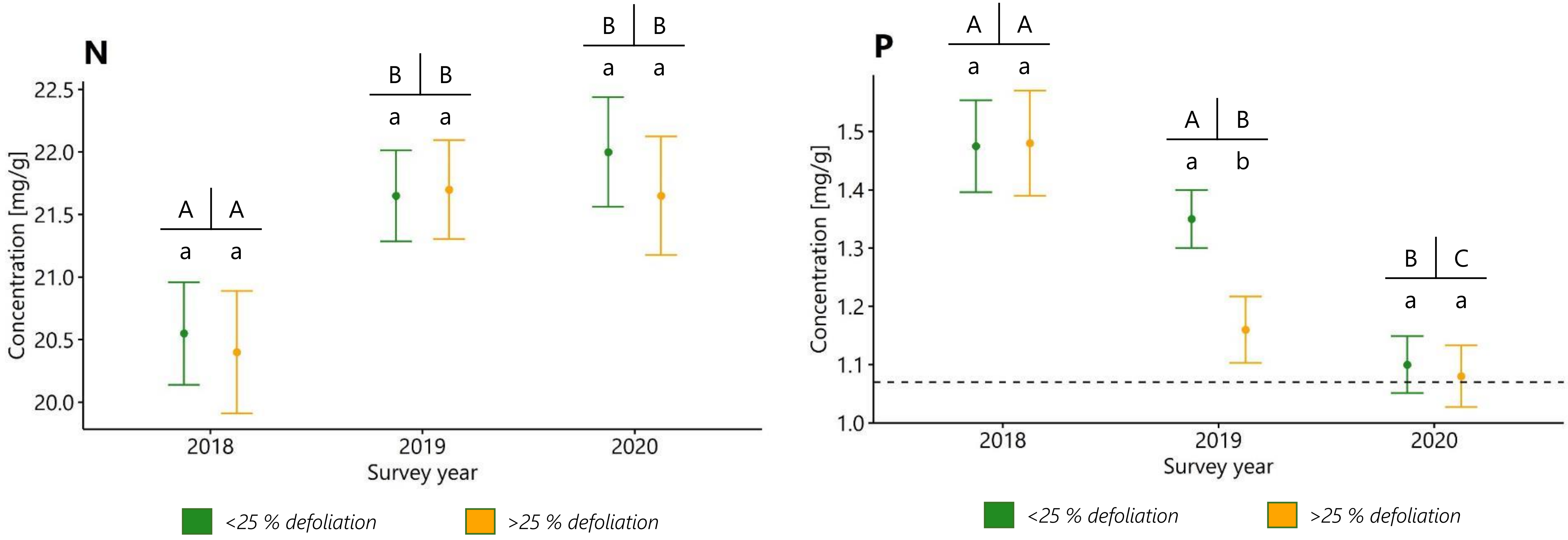
- Data checked for normality and homoscedasticity
- Pairwise comparisons with Bonferroni adjustment



Linear Mixed-Effects Models (LMM)

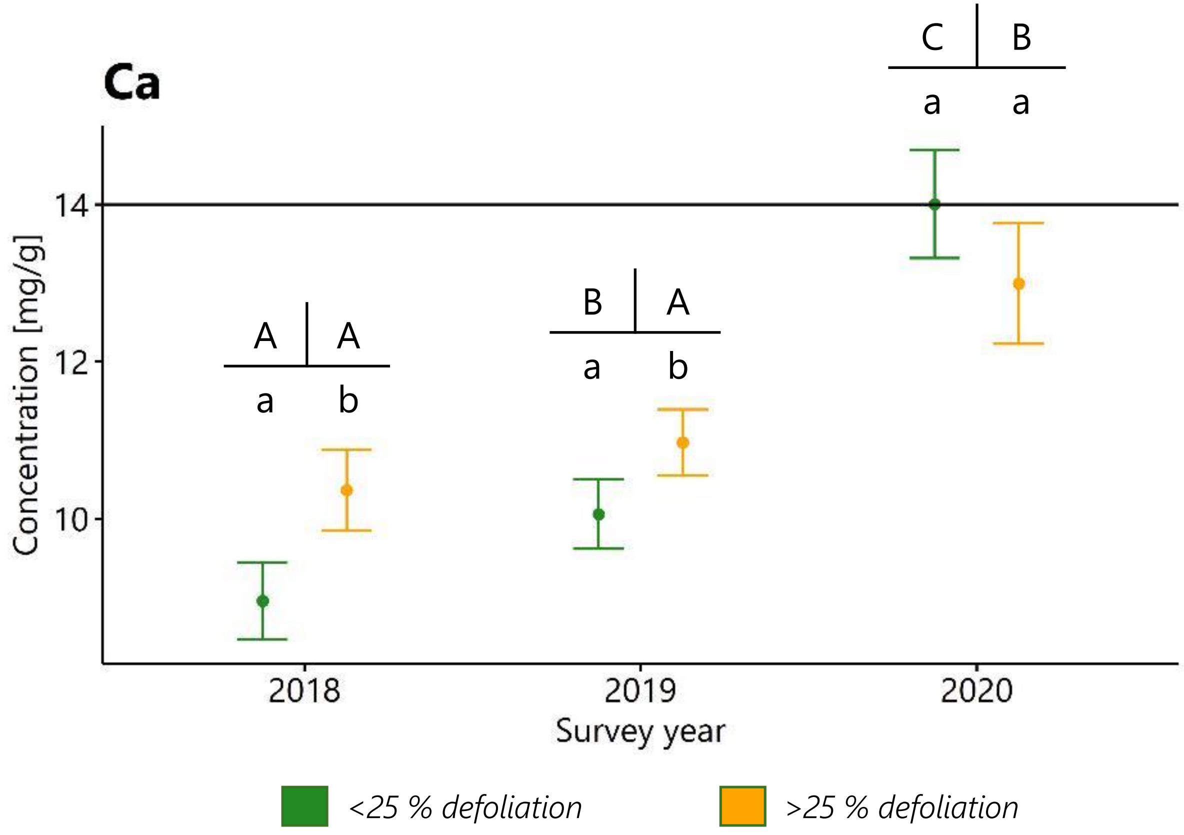
- Random effect “**year**” whose variance reflects the inter-annual variability
- Random effect “**plot**” whose variance reflects the inter-plot variability
- Recursive feature elimination approach (RFE) implemented within the Random forest algorithm
- Mulicollinearity detection by VIF
- Marginal and conditional R^2 for mixed models (Nakagawa et al. 2017), AIC

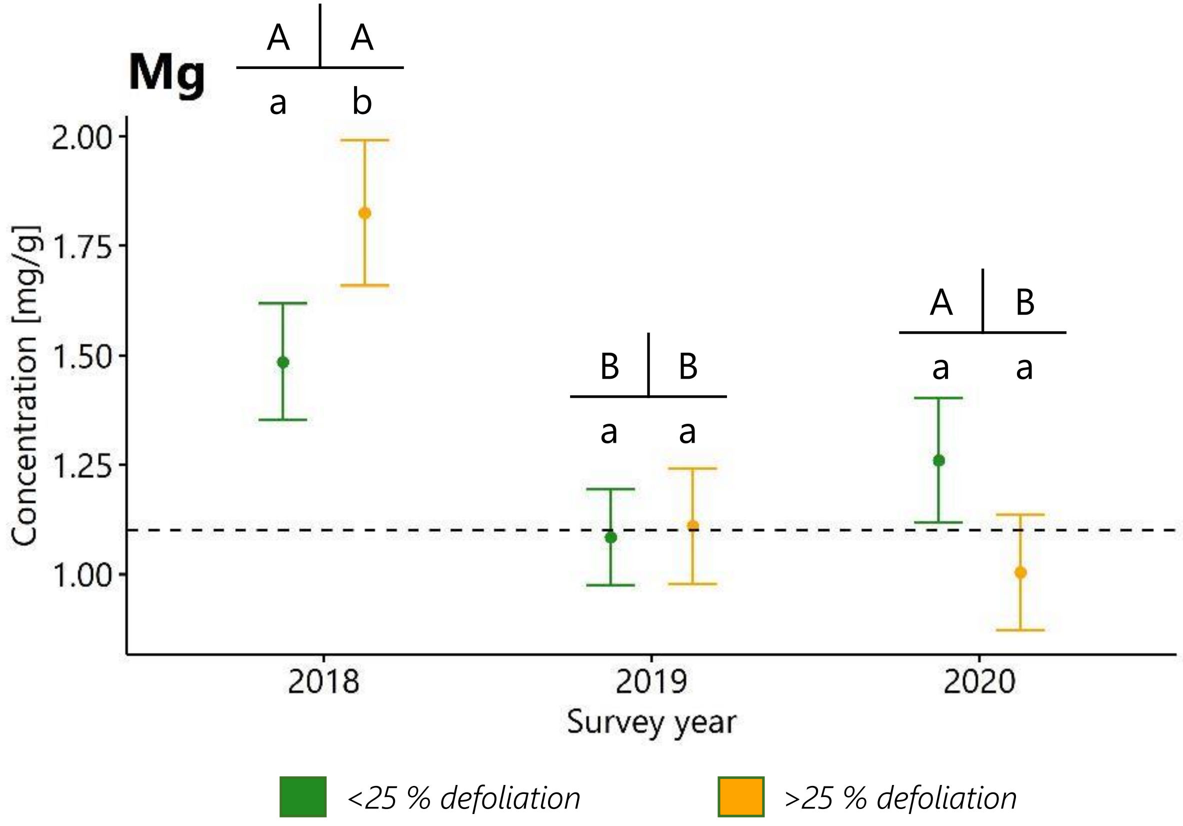
RESULTS AND DISCUSSION



- Amores et al. (2006)

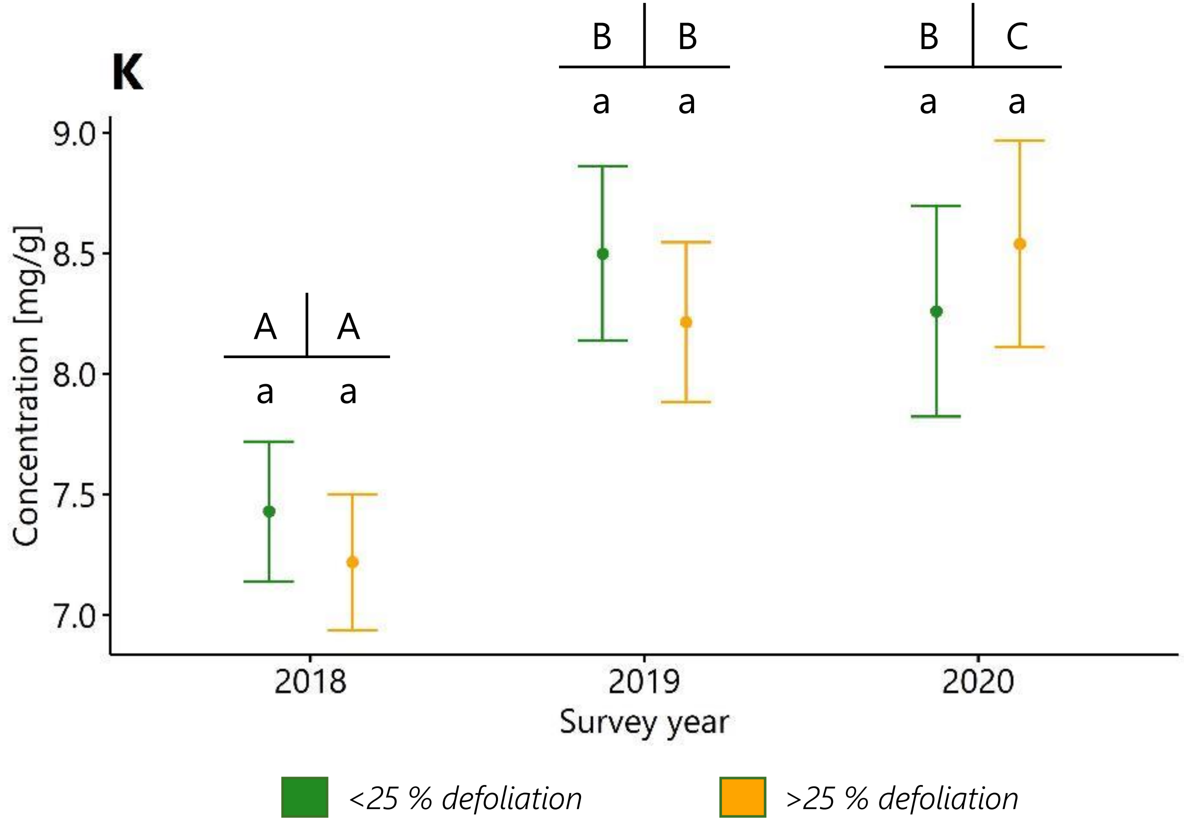
RESULTS AND DISCUSSION





- Amores et al. (2006), Jonard et al. (2010)

RESULTS AND DISCUSSION



- Narrow range of defoliation values; forest growing in near-optimal conditions. (Ognjenović et al. 2020, Thimonier et al. 2010)
- Environmentally heterogeneous forest stands with high variability (Elwad et al. 2005)
- There is a possibility that the pressure of certain environmental factors causes an unbalanced nutrition of trees with higher defoliation.

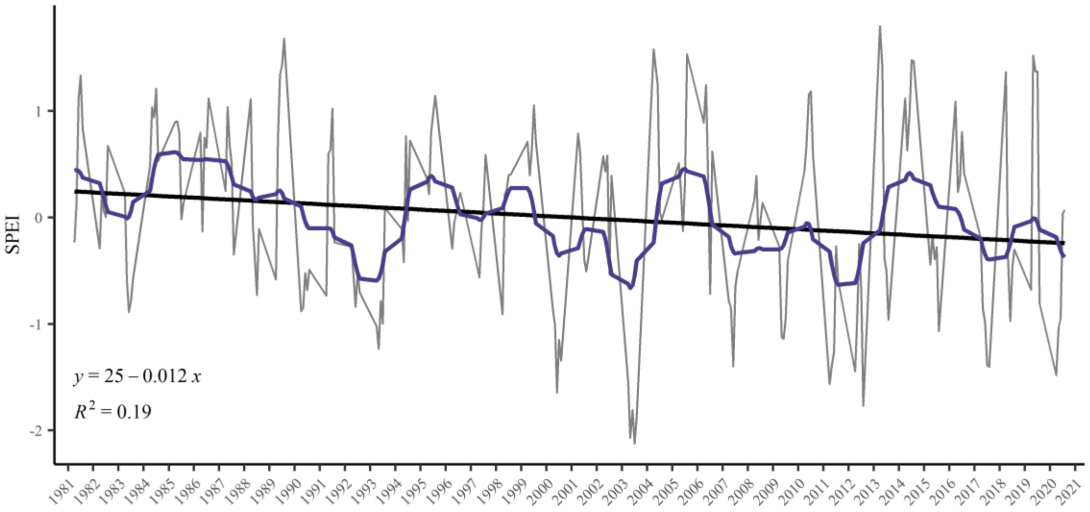
Ouimet & Moore (2015) – higher K concentrations results in lower defoliation of balsam fir

RESULTS AND DISCUSSION

(Braun et al., 2020)

- Different response to SPEI and SPEI_lag

- P influenced by the deviation of climate variables from average

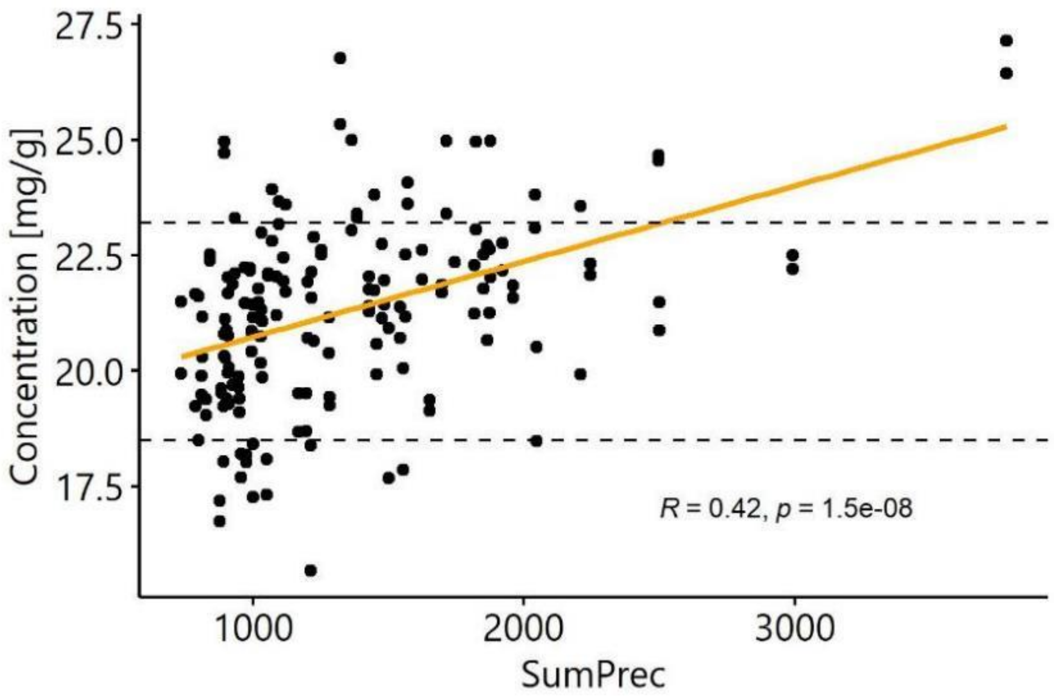


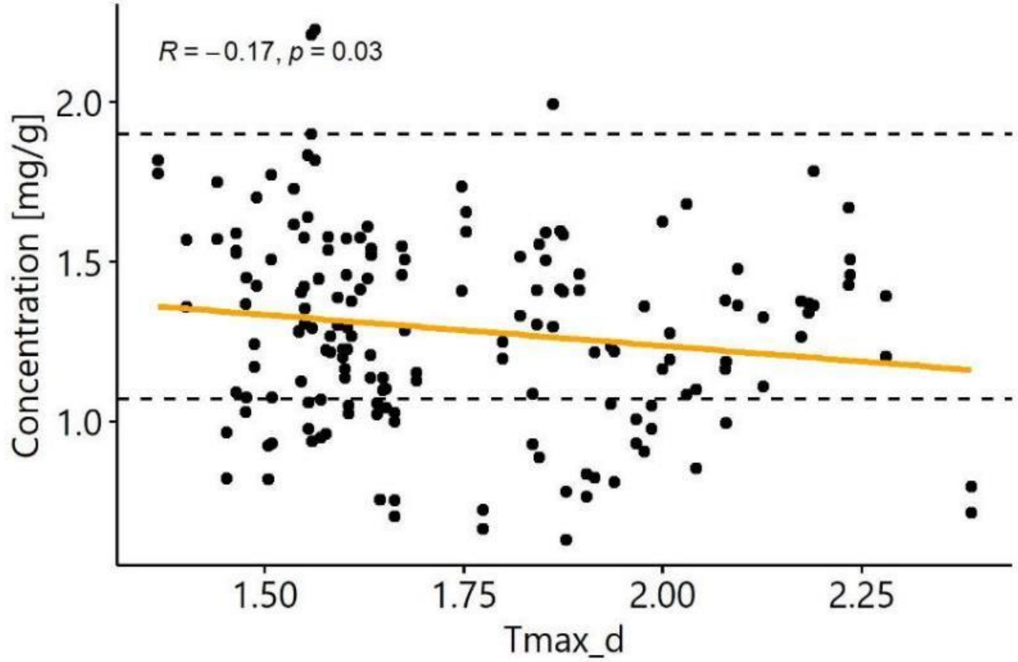
N

AIC	615,68
Con. R^2	0,65
Mar. R^2	0,36
SumPrec	+
tmax	+
PET_tho	-
spei3	-
spei3_lag	+

P

AIC	0,01
Con. R^2	0,61
Mar. R^2	0,35
tmin_d	+
tmax_d	-
spei3_d	-
tm_d_lag	-
spei6_lag	+
nv	+
Region PAN	+





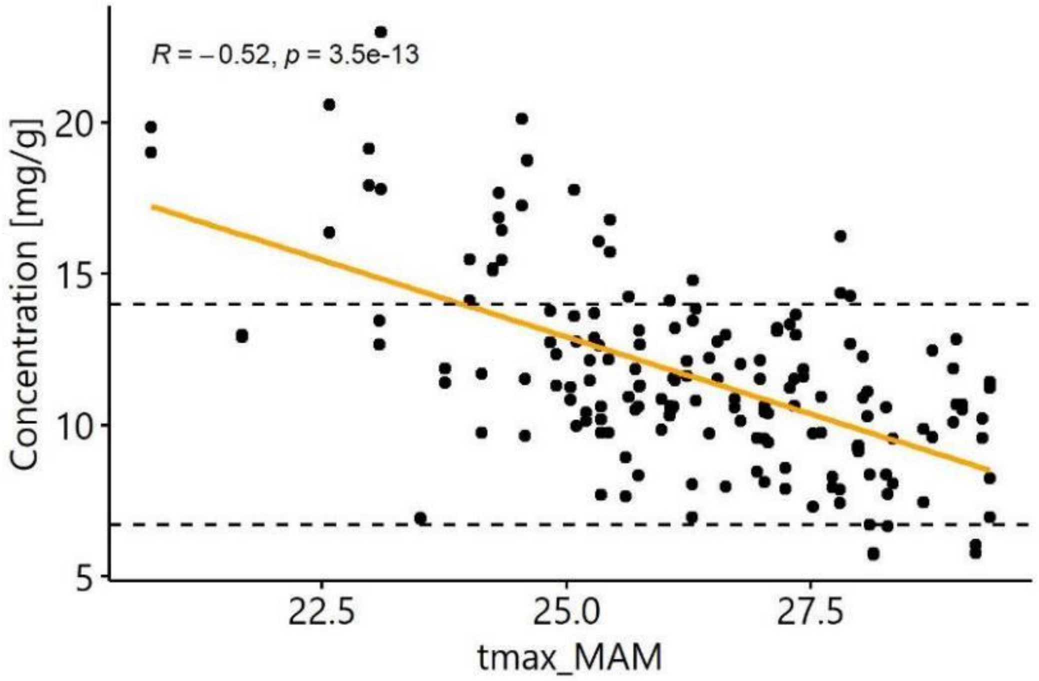
RESULTS AND DISCUSSION

Jonard et al (2009)

- Highest marginal R^2
- Significant difference between defoliation class

Ca

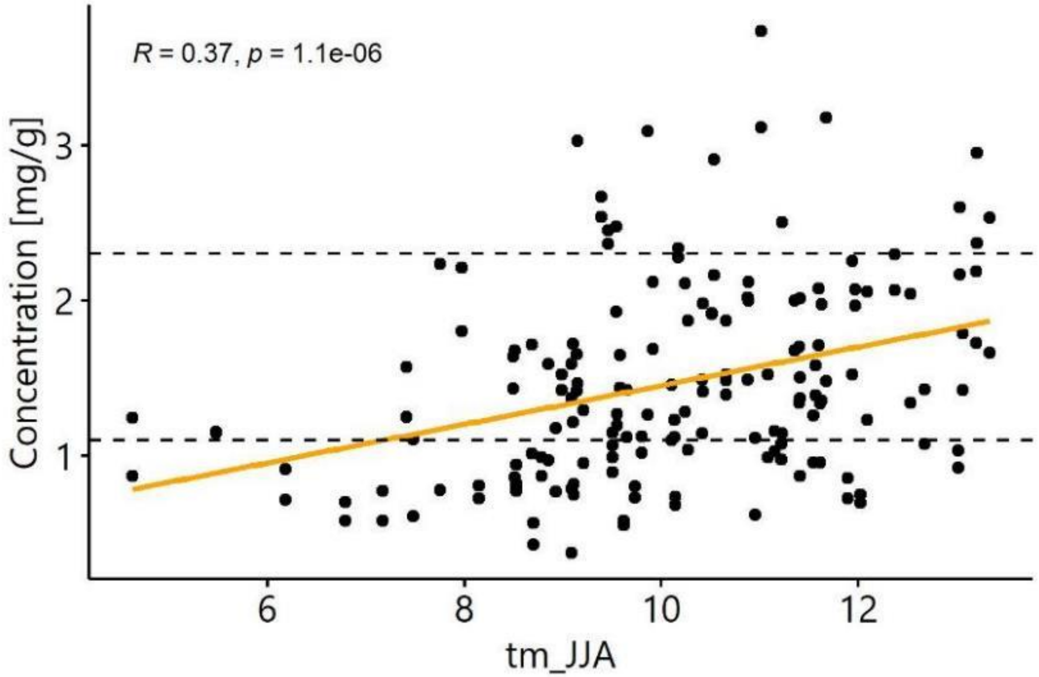
AIC	-84,75
Con. R^2	0,67
Mar. R^2	0,42
spei3_JJA	-
tmax_MAM	-
>25% defoliation	+



- Highest marginal R^2

Mg

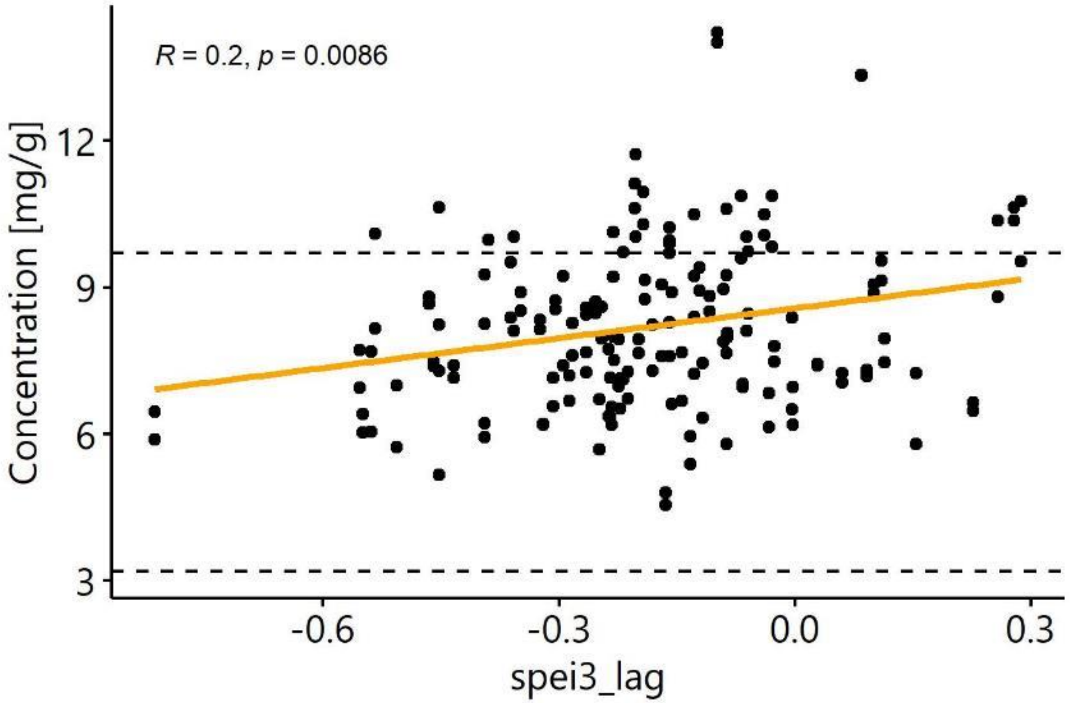
AIC	142,79
Con. R^2	0,61
Mar. R^2	0,32
tm_JJA	+
eks_deg	+
age	+
spei3	+



RESULTS AND DISCUSSION

K

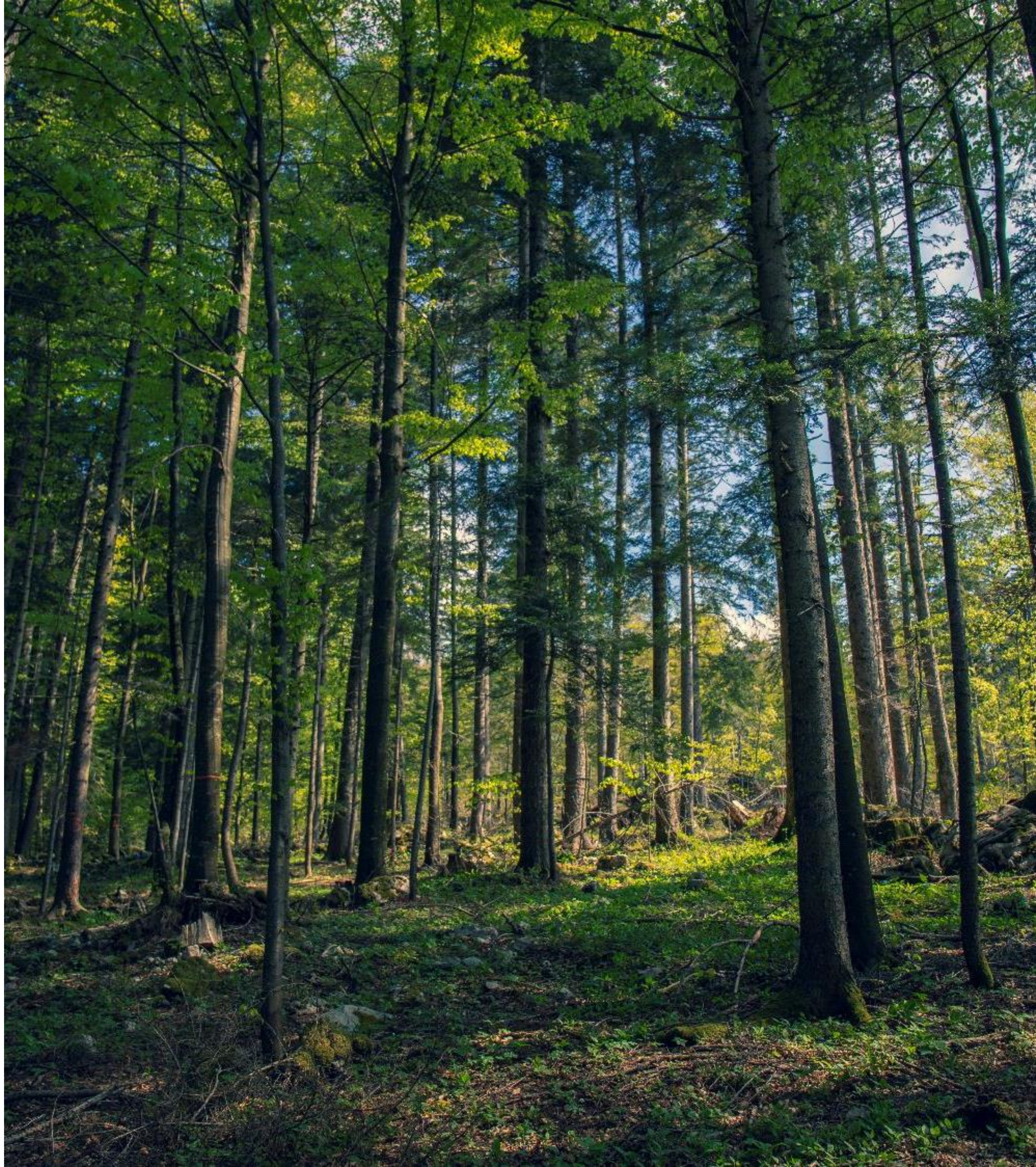
AIC	554,88
Con. R^2	0,57
Mar. R^2	0,57
rr	+
tmin_d	-
spei3_lag	+



- LMM models indicate high influence of inter-annual and inter-plot variability on the variance of element concentrations
- Therefore, the observed influence of climate variables to a lesser extent explains the changes of element concentrations
- Duquesnay et al. (2000)

Outlook

- These results provide the first systematic and multiyear insight into common beech foliar nutrition in Croatia
- Given the expected continuation of ICP Forest monitoring programme, the obtained values will enable comparisons with future surveys
- Preliminary results of a ongoing research project
- Ratios, content



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