Ivan Seletković, Nenad Potočić, Tamara Jakovljević,
Ivana Radojčić Redovniković, Mladen Ognjenović

The use of monitoring data for improving the management of pedunculate oak (*Quercus robur* L.) stands in Spačva basin, Croatia

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INTRODUCTION

- Spačva basin is one of the largest uninterrupted areas of lowland oak forests in Europe (40.000 ha)
- Located in eastern Croatia, on the climatic border to dry steppe conditions, it is unique due to its dependency on groundwater
- Age distribution is skewed with 69% of area covered by oak forests over 100 years of age
- Dieback of trees very prominent: **46% sanitary cut**

INTRODUCTION

- Complex stand/ecological conditions are manifested in dieback, poor stand structure, lack of seed production, changes in soil water table and ground vegetation composition (Matić i dr. 1996).

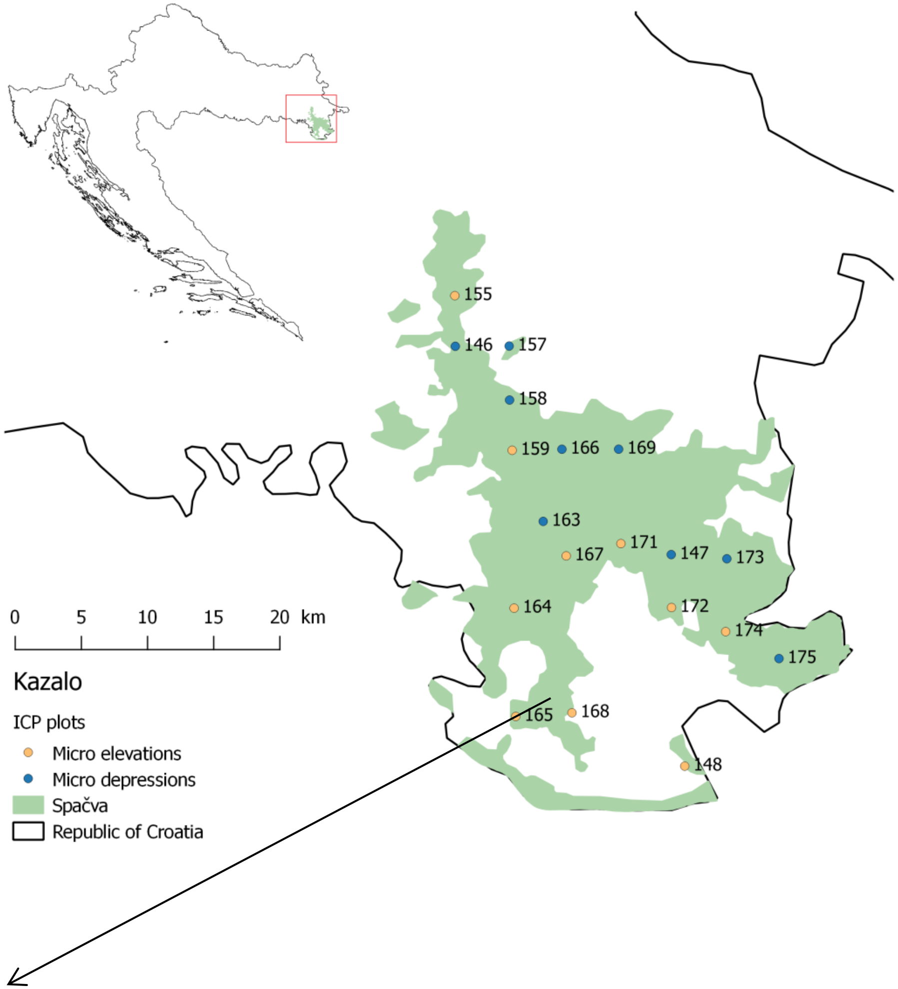
- Various abiotic and biotic factors bring about the physiological weakening of oaks, causing widespread dieback (Prpić 2000).

ICP FORESTS INFRASTRUCTURE IN SPAČVA BASIN

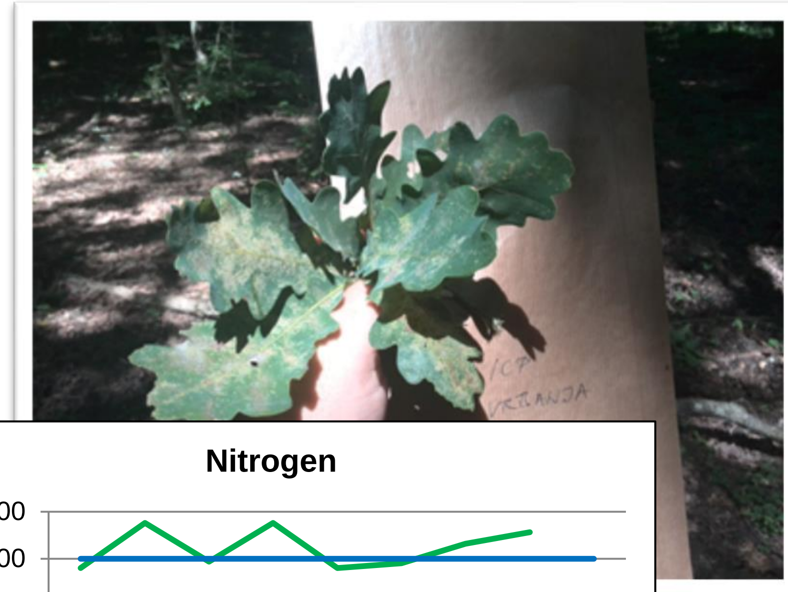
19 16x16 and 4x4 km network plots (low intensity monitoring),

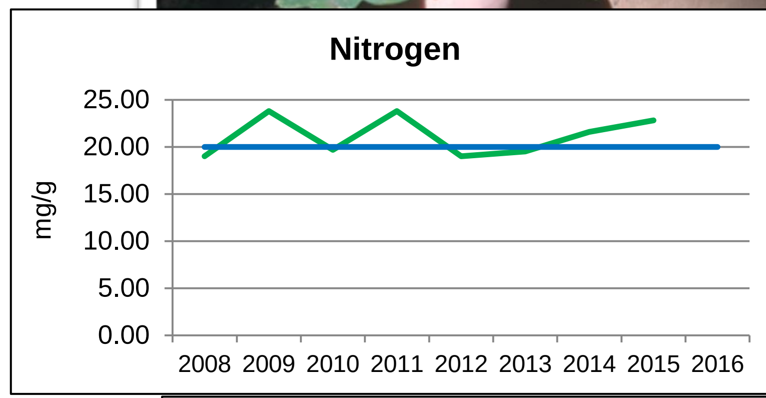
1 Intensive monitoring plot

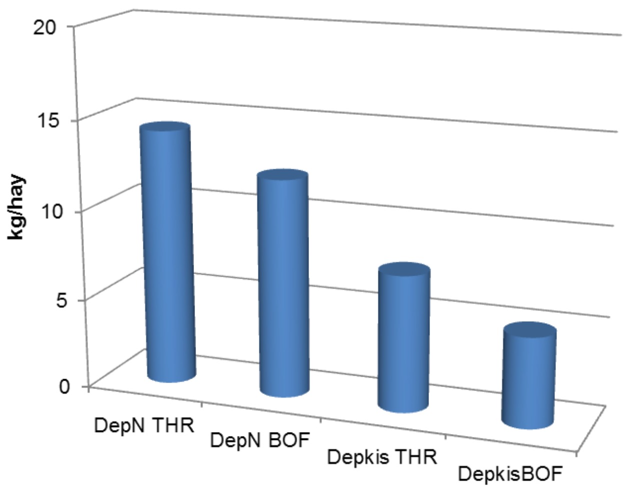
Intensive monitoring plot 109 „Vrbanja”

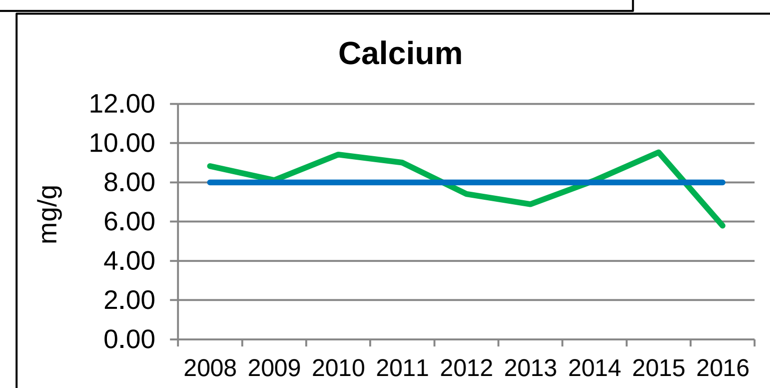


INTENSIVE MONITORING PLOT VRBANJA



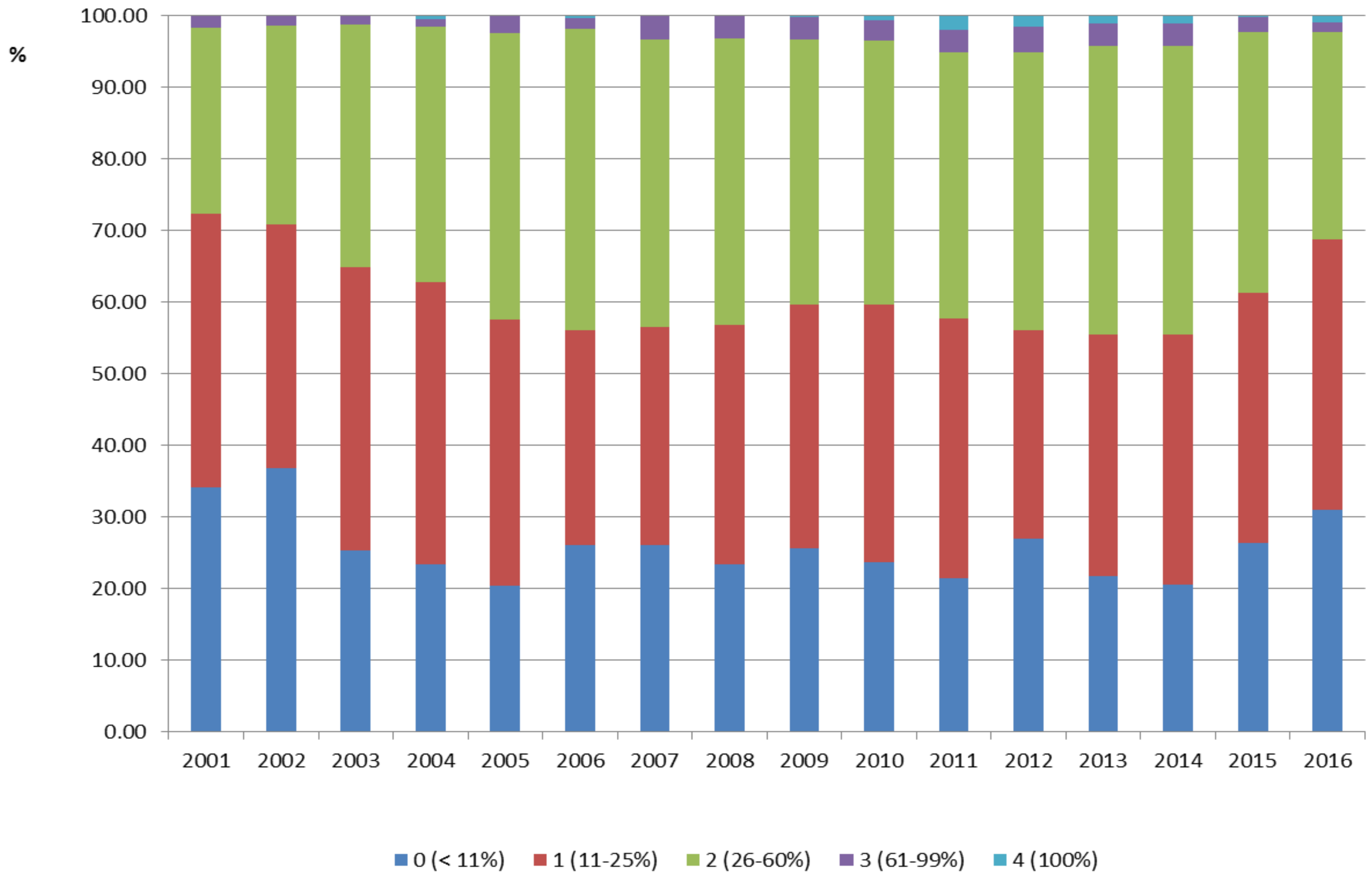




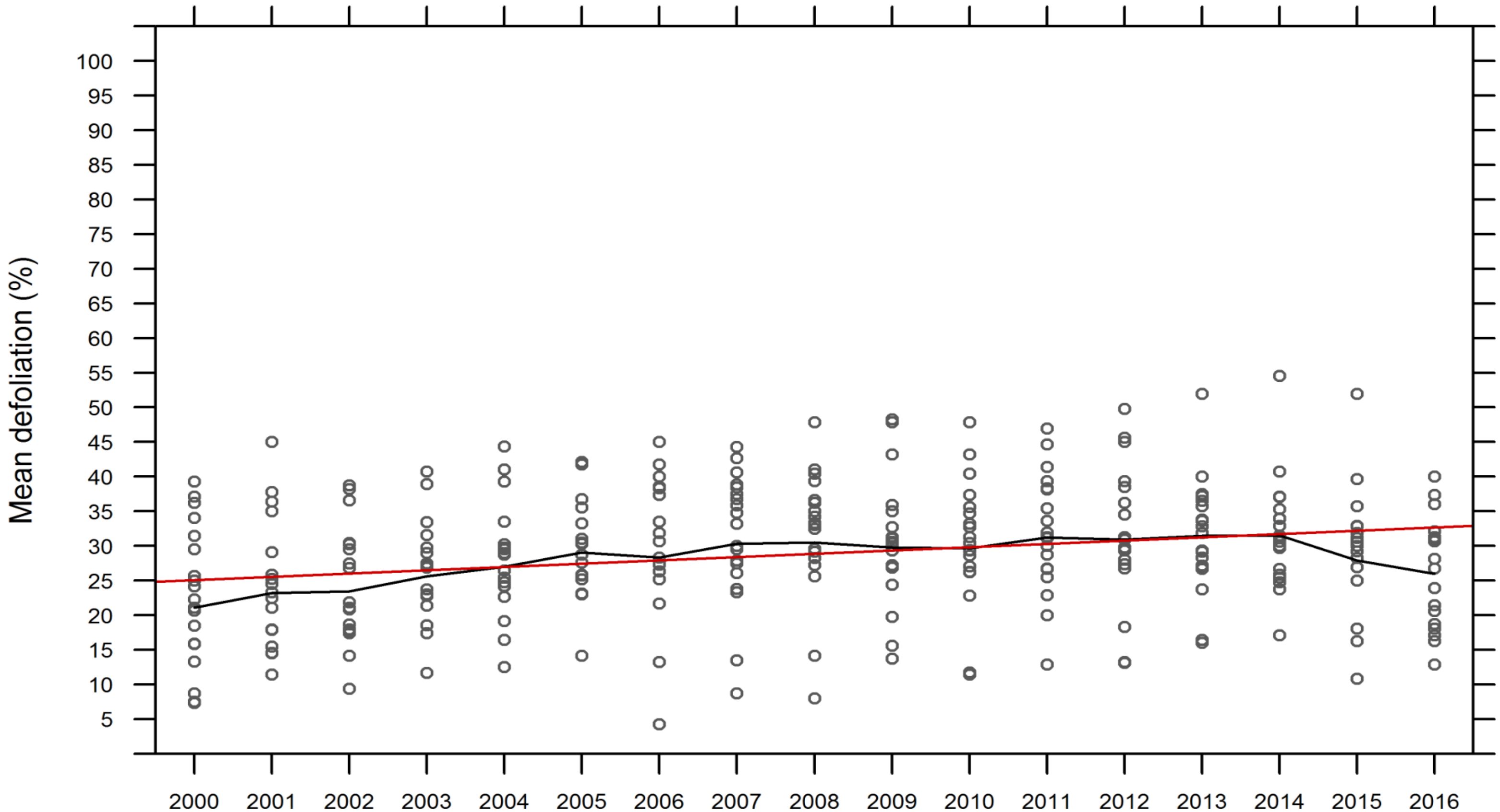


N lower than literature CL for mesotrophic Quercus woodland (15-20 kg $Nha^{-1}year^{-1}$)

DEFOLIATION OF OAKS ON 16X16 AND 4X4 PLOT NETWORK IN SPAČVA

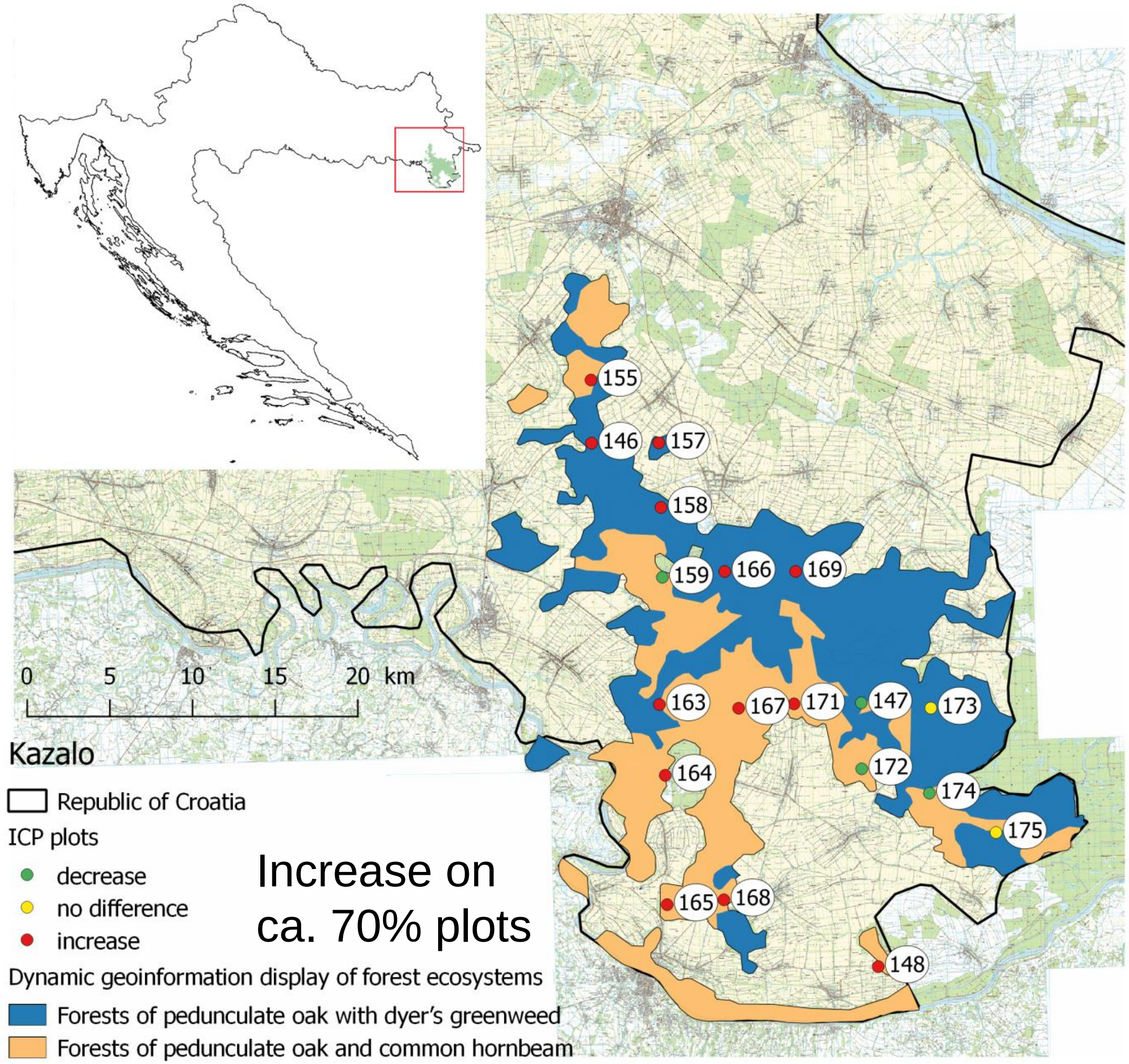


OVERALL DEFOLIATION TREND OF PEDUNCULATE OAK



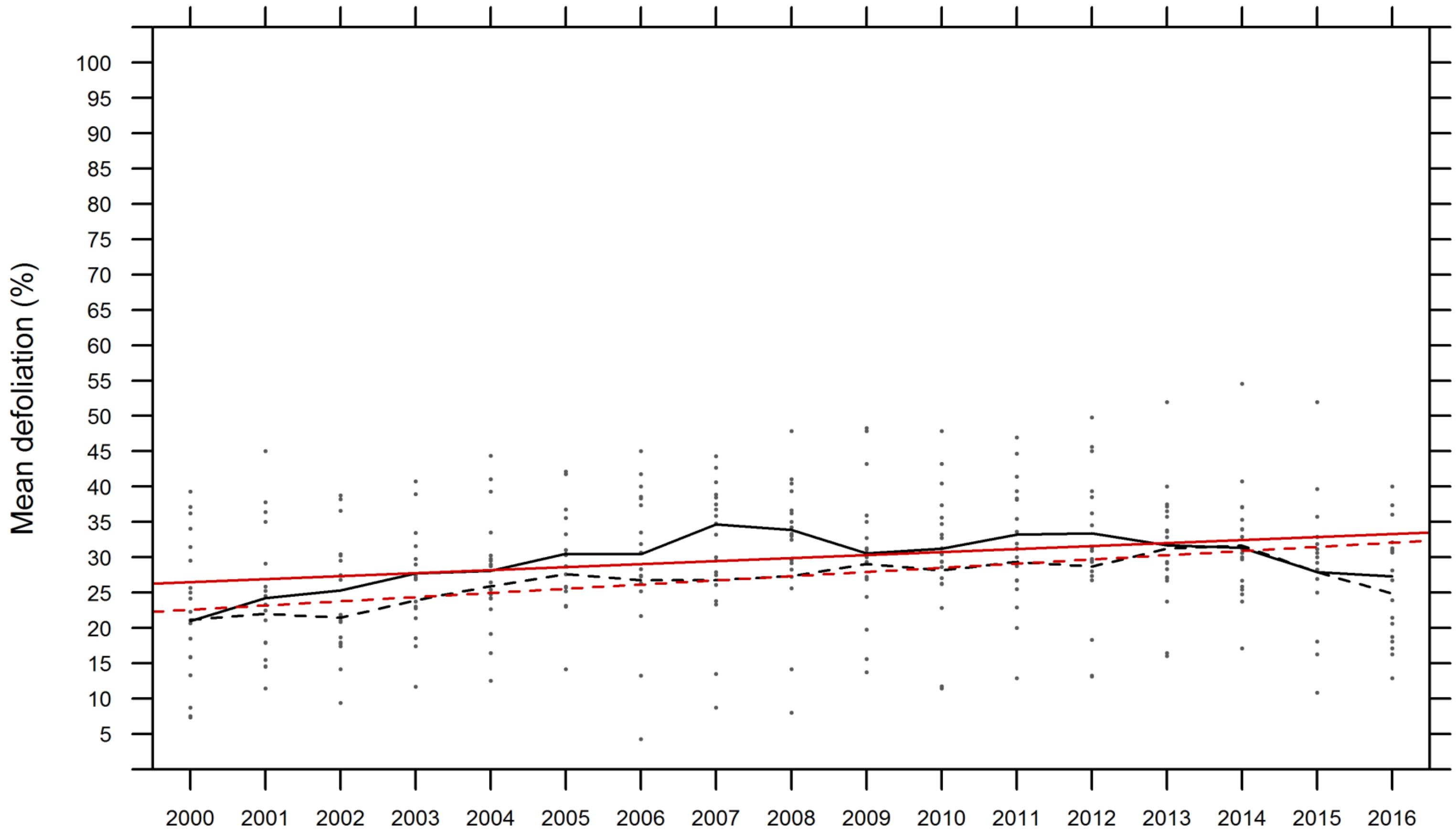
Overall defoliation trend of pedunculate oak (regional Sen's slope = 0.473, p = 0.001, red line) and annual overall mean defoliation (black line); points represent annual plot defoliation means per plot

TEMPORAL AND SPATIAL DEVELOPMENT OF DEFOLIATION



Increase on ca. 70% plots

DEFOLIATION TREND OF OAKS DEPENDING ON THE MICRORELIEF CATEGORIES



(MICRO-DEPRESSION: regional Sen's slope = 0.592, p = 0.0005, dotted red line; MICRO-ELEVATION:regional Sen's slope = 0.429, p = 0.03 red line) and annual overall mean defoliation (black line); points represent annual plot defoliation means per plot.

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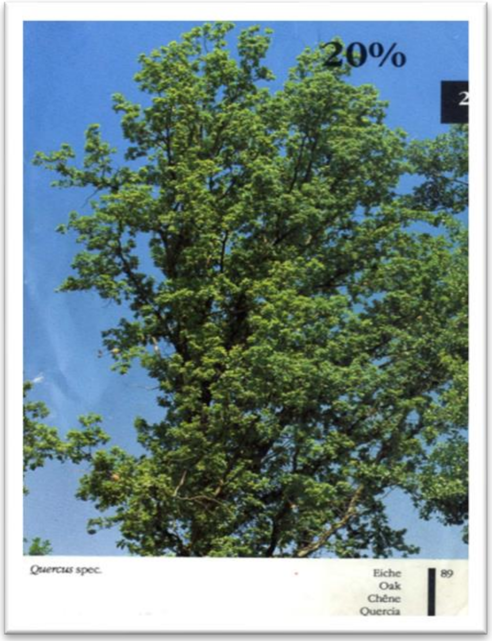
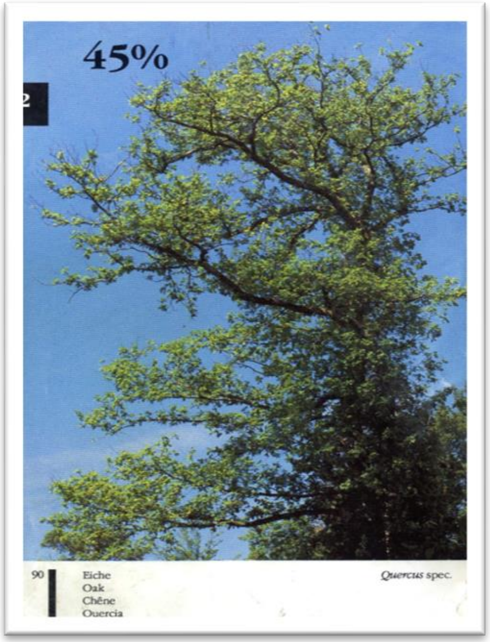
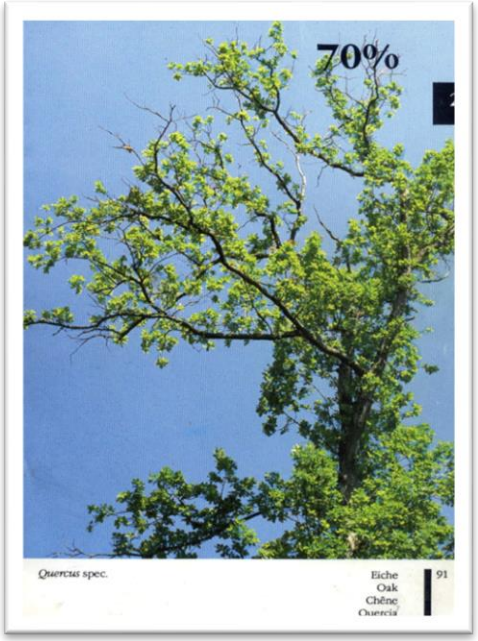
ASSESSMENT OF OAK VITALITY: VISUAL AND BIOCHEMICAL INDICATORS



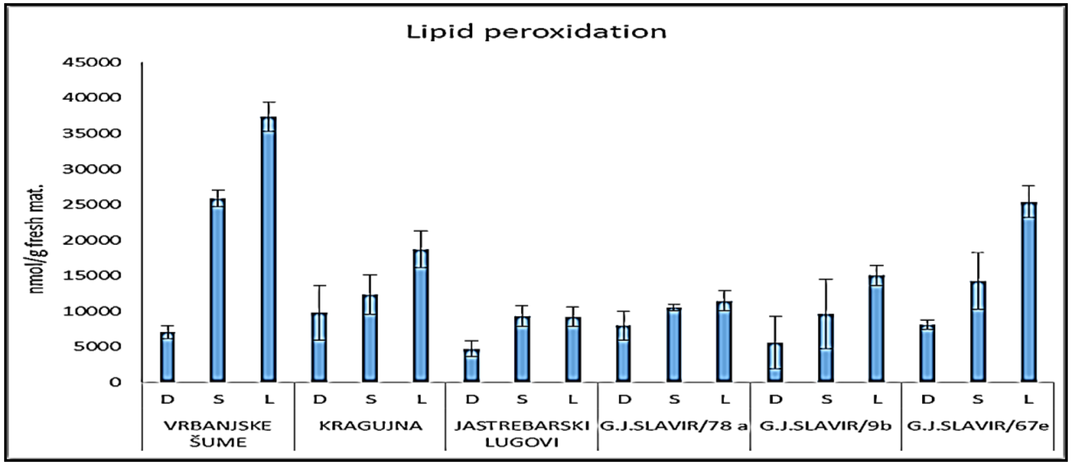




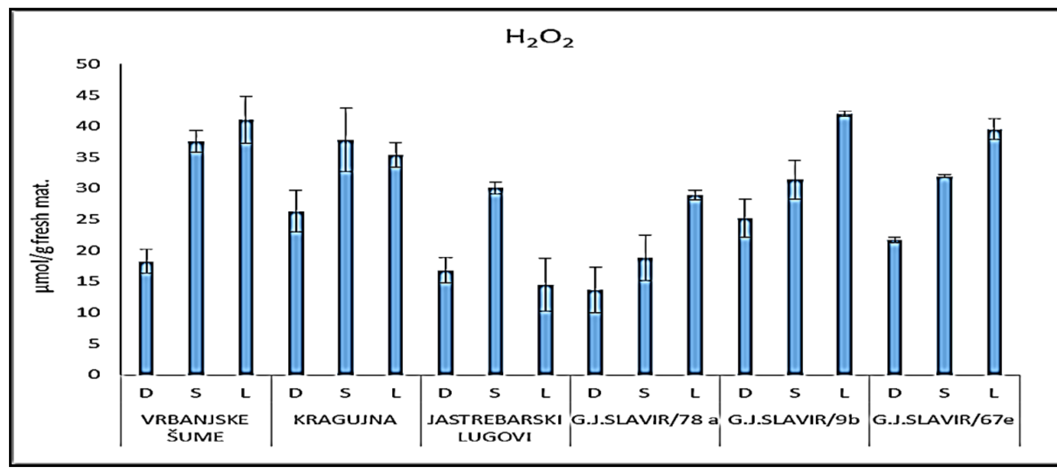
- Objective: to assess and compare the differences in the Ca concentrations (Ca link to water availability), and the extent of oxidative stress (contents of malondialdehyde, MDA and hydrogen peroxide, H_2O_2) in the leaves of *Quercus robur* L. trees of various defoliation degrees.
- Lipid peroxidation, one of the most important causes of cell deterioration during drought stress, generates changes in the composition of fatty acids which affect the structural and functional properties of cell membranes, such as the inactivation of membrane-bound proteins and the increase in membrane permeability (Smirnoff 1993, Asada 1999).

- Water deficit is associated with lipid peroxidation mechanisms: water stress causes elevated concentrations of MDA (Sofo et al. 2003) and H_2O_2 (Cheeseman 2006) in plants.

CONCENTRATIONS OF MDA AND H_2O_2 IN OAK LEAVES



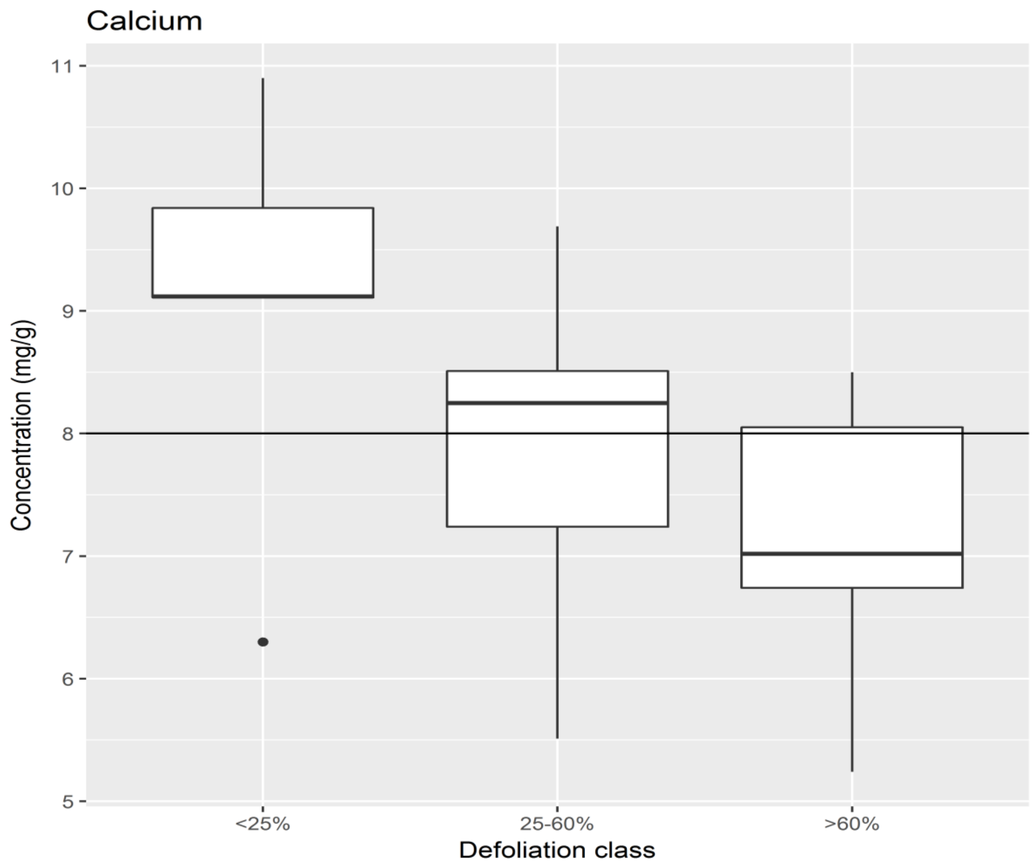
- Lipid peroxidation is a widely used stress indicator of plant membranes (Taulavuori et al. 2001). Essential signaling processes (such as changes in Ca mobilization) are known to be modulated by H_2O_2 (Uzarevic et al. 2011).



The increase in malondialdehyde levels is associated with the oxidation of membrane lipids caused by activated oxygen species and with the damage of photosynthetic apparatus (Sofo et al. 2003).

Ca IN OAK LEAVES OF VARIOUS DEFOLIATION DEGREES

Ca uptake is negatively affected by irregular water supply and, in particular, prolonged dry periods Bergmann (1992). Trees with high defoliation tend to have low foliar Ca concentrations (silver fir, Potočić et al. 2005), especially in dry years.



ASSESSMENT OF OAK VITALITY: VISUAL AND BIOCHEMICAL INDICATORS

2 scenarios possible:

1. lower leaf mass means less transpiration and less Ca due to Ca uptake dependency on transpiration – in this case, **low Ca is the result of high defoliation. In this case, Ca is merely the indicator of oak vitality**.

2. vice versa, the lack of soil water brings about low uptake of Ca, leading to poor control of stomata and excessive transpiration of water stored in plants. Trees shed leaves as a defense mechanism lowering the leaf area and transpiration. This is supported by concentrations lower than CL values, in which case we can suspect **effects of poor nutrition on tree vitality**.

Trees of lower vitality have trouble in regulating water balance due to compromised water uptake and transport, especially in case of lack of available water.

Oak decline is primarily related to water availability and uptake, and the severity of decline is moderated by age and microtopography effects.

BIOMASS REMOVAL

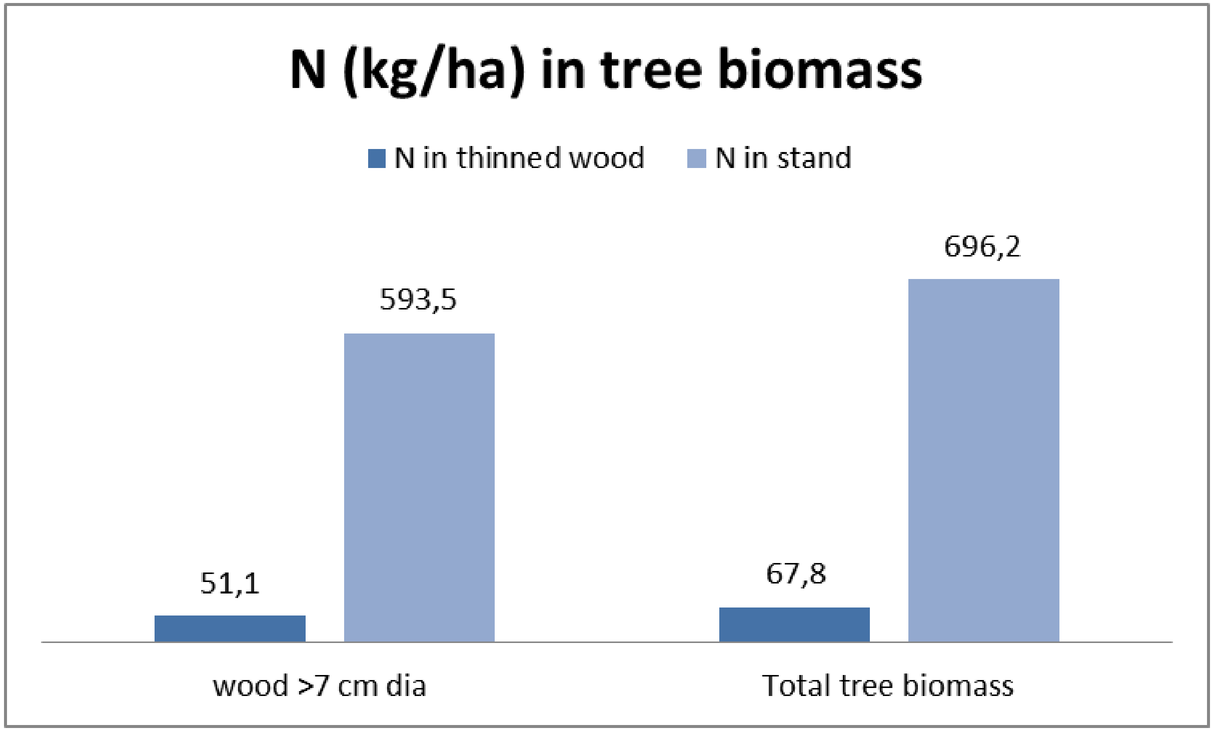
- Stem-only harvesting: logging residues, treetops, branches and foliage left on site.

- Whole-tree harvesting: removal of these residues from site (Röser et al., 2008), increasing the export of nitrogen as these compartments generally contain more N than stemwood (Blanco et al., 2005; Palviainen and Finér, 2012 etc.).

- The depletion of N may result in the degradation of long-term site productivity (Jacobson et al., 2000; Olsson et al., 1996; Helmisaari et al., 2011).

ASSESSMENT OF MINERAL ELEMENT REMOVAL FROM A PEDUNCULATE OAK STAND BY THINNING – A QUICK METHOD

On the experimental plot which was previously measured and trees marked for thinning, three pedunculate oak trees were chosen for sampling, one nearest to mean diameter, and one each from lower and upper diameter class (±5 cm). Trees in these 3 classes represented 90% of all thinned volume. Trees were dissected into stemwood and branches down to 7 cm diameter, branches 3 to 7 cm, branches under 3 cm, and leaves. Components were weighed on the spot to determine fresh biomass, and samples were brought to the laboratory of CFRI for volume measurement, drying, weighing of dry mass, and chemical analyses. N removal was calculated based on the average content in the components of sample trees, multiplied by the number of trees per ha (total and thinned).



Given the average annual deposition of N (12-14 kg/ha according to measurements on the nearby UNECE ICP Forests intensive monitoring plot 108, and removal of nitrogen by stem-only harvesting: approx. 50 kg/ha every 10 years, or on average 5 kg/ha annually, or removal of N by WTH: approx. 68 kg/ha every 10 years, or on average 6,8 kg/ha annually, the difference is 7-9 kg/ha of excess N input annually.

CONCLUSIONS: THE POTENTIAL USE OF FOREST MONITORING FOR FOREST MANAGEMENT

Several different vitality indicators used with good success (Ca, MDA, H_2O_2, defoliation). The relation of MDA and H_2O_2 with Ca concentrations needs further study.

Water availability crucial for oak health, even small differences (1-2 meters) in elevation are very important

Excess N input partly alleviated by biomass removal

Standard ICP Forests monitoring important in providing background information for management planning (vitality development, water management, biomass removal)