

Remote Sensing of Chlorophyll Concentration as Quantitative Index of Forest Condition

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BACKGROUND AND OBJECTIVE

Monitoring forest condition on wide areas and over time is of crucial importance in forest management. Crown **defoliation** and **discoloration** rate are the main indices used in forest condition assessment (UN/ECE 2004).

Remote sensing observations may be used to map **quantitative vegetation variables** that could integrate field surveys in order to assess forest condition. Rossini et al. (2006) showed that **chlorophyll (Chl) concentration** is related to discoloration rate and is the most reliable variable of forest condition in heterogeneous ecosystems.

Objective of this research was to **map Chl** by means of hyperspectral remote observations in order to **assess oak decline** in the Ticino Regional Park.

FIELD DATA

An **intensive field campaign** was conducted in oak stands concurrently with the acquisition of the airborne images.

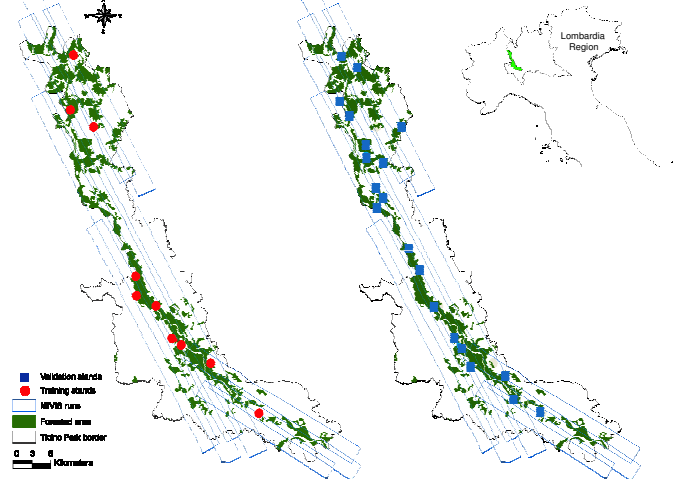
Discoloration was visually estimated in **10 training stands** and **20 validation stands**. Yellowing proportion of leaves of individual crowns were evaluated and categorized in four classes: **class 0**, discoloration < 10%, **class 1**, 11–25%, **class 2**, 26–60% and **class 3**, 61–100%.

For each training stand **leaves were sampled** from three dominant oak trees, located in the stand center. Chl was extracted from five leaves per tree with a total of 150 laboratory extractions (Chl range: 43 - 63 $\mu\text{g cm}^{-2}$).

STUDY AREA AND REMOTELY SENSED DATA

The research was conducted in **oak forests** (*Quercus robur* L.) of the Ticino Regional Park (91 140 ha), Northern Italy.

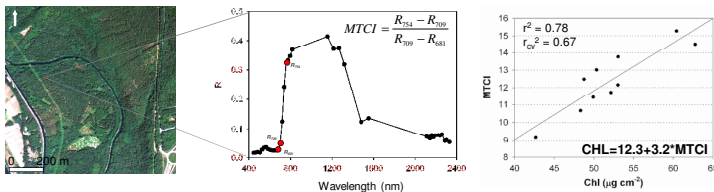
Hyperspectral images were acquired by airborne **MIVIS** (Multispectral Infrared and Visible Imaging Spectrometer) sensor on July the 2nd 2003. The Park forested area (22 000 ha) was covered with 10 runs, at a flying height of 2000 m (spatial resolution of 4 m).



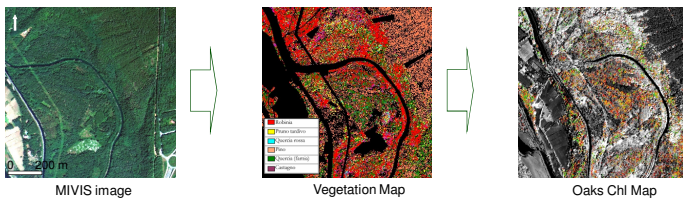
CHL ESTIMATION BY REMOTE SENSING

METHODS

- The **ten training stands** were geo-located on the **MIVIS images** and spectral reflectance was extracted from **3 x 3 pixel areas** (144 m²);
- Optical vegetation indices** were computed from MIVIS reflectance and correlated to Chl concentration by means of a **regression analysis** to develop the semi-empirical model. **MTCI** (MERIS Terrestrial Chlorophyll Index) was the best performer;



- The **semi-empirical model** was applied across the Ticino Park to **oak pixels** identified by means of a map of vegetation species, obtained by MIVIS imagery (Boschetti et al. 2006). The Chl map was validated and finally used to assess oaks decline. Oak forests were delimited and classified in three classes of damage.

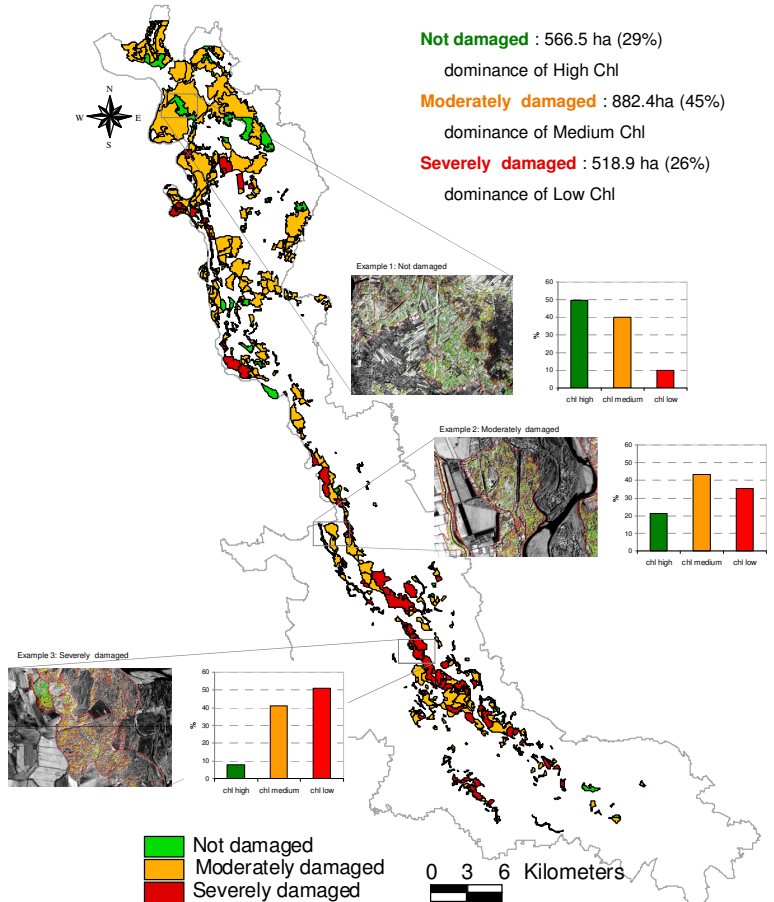


VALIDATION

Chl map was validated in 20 stands. Continuous Chl values were divided in **three Chl classes**: high Chl ($56 \leq Chl \leq 63 \mu\text{g cm}^{-2}$), medium Chl ($49 \leq Chl < 56 \mu\text{g cm}^{-2}$) and low Chl ($43 \leq Chl < 49 \mu\text{g cm}^{-2}$). For each validation stand the most frequent Chl class was calculated and compared with the discoloration class visually assigned.

A good agreement between Chl classes and discoloration classes was observed in 15 of 20 validation stands (**overall accuracy = 75%**).

RESULTS



CONCLUSIONS

The high spectral and spatial resolution of **aerial observations** allow to estimate **Chl concentration over a wide area**. It is confirmed that Chl is a **quantitative index of crown discoloration**. Chl map provide information to assess oaks decline in the Ticino Park. We conclude that hyperspectral **remote sensing may integrate field surveys** in order to assess forest status and to monitor forest decline over time.