Detecting foliar nutrient status of northern hardwoods from the sky

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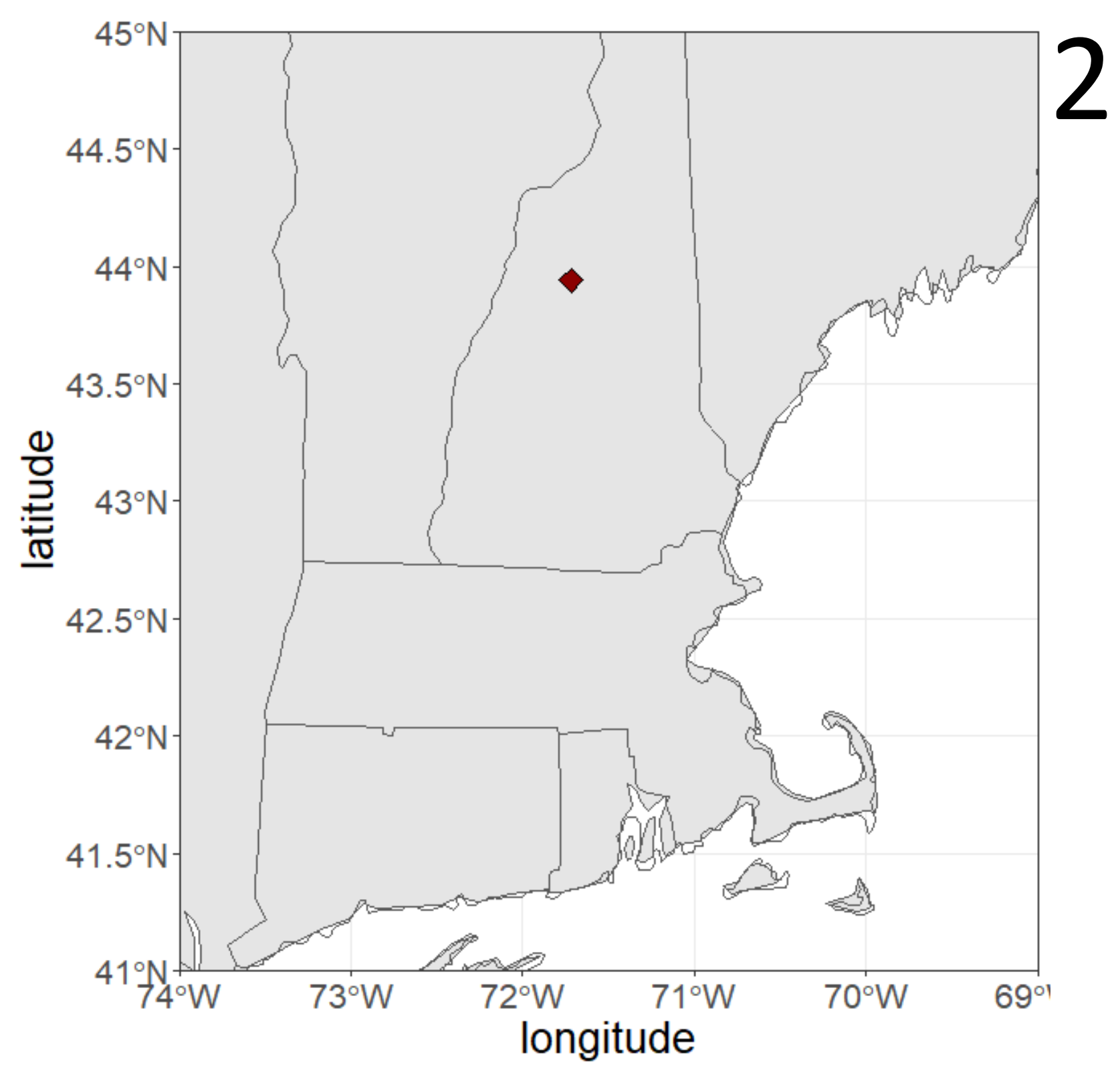
Introduction

Airborne remote sensing of forests would improve efficiency of collecting tree-level information across a landscape, but understanding how this remotely sensed vegetation information relates to nutrient availability in forests is difficult without experimental nutrient manipulation.

Methods and analysis workflow

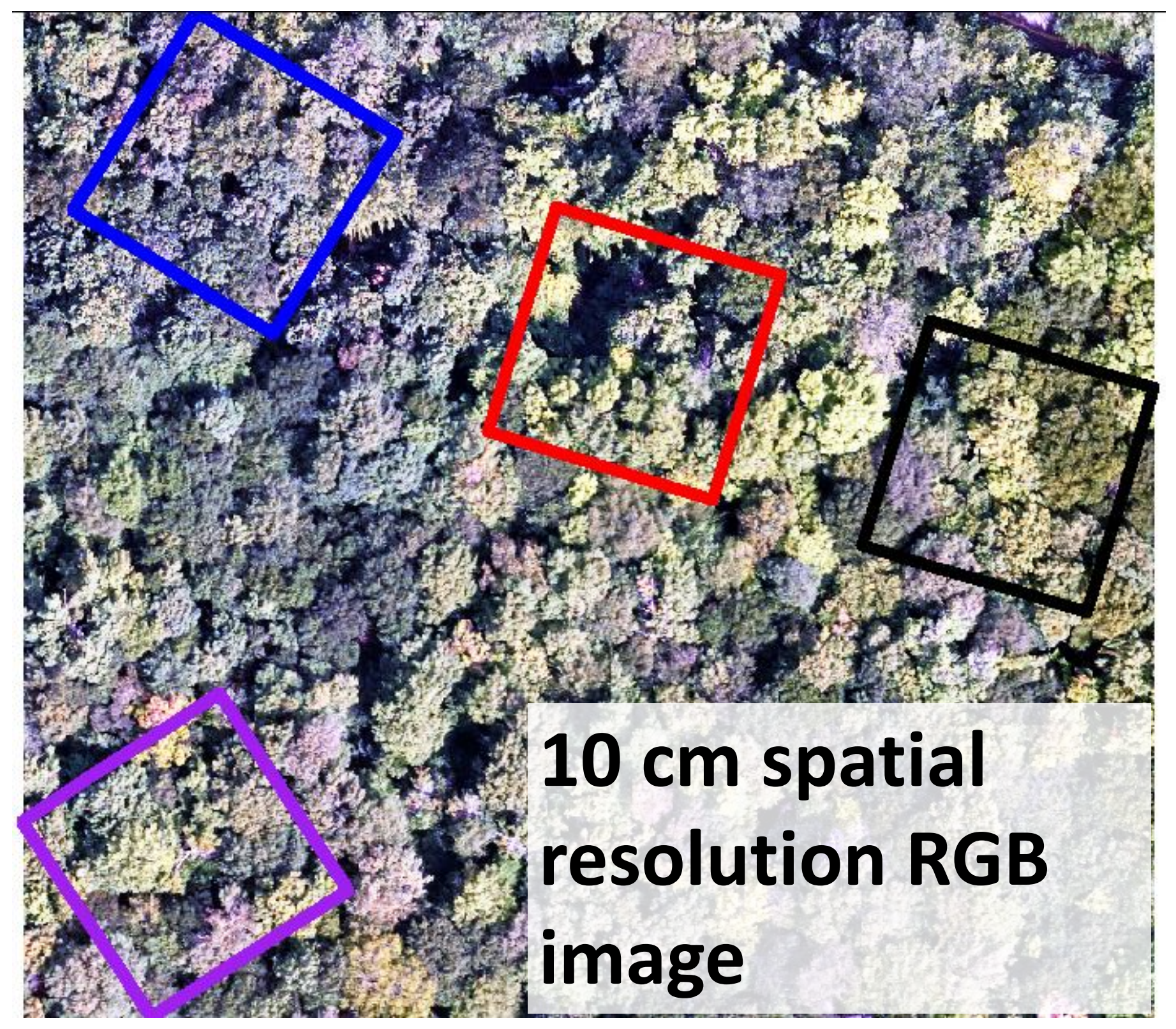
Since 2011, annual additions of N (as NH_4NO_3; 30 kg/ha/yr) and P (as NaH_2PO_4; 10 kg/ha/yr) have been added to 9 forested stands at the Bartlett Experimental Forest to study nutrient limitation. In August 2017 the Airborne Observatory Platform of the National Ecological Observatory Network collected data for all 9 * 4 = 36 nutrient treatment plots. Here we test the ability to distinguish four nutrient treatment classes in an N*P factorial design.

1.



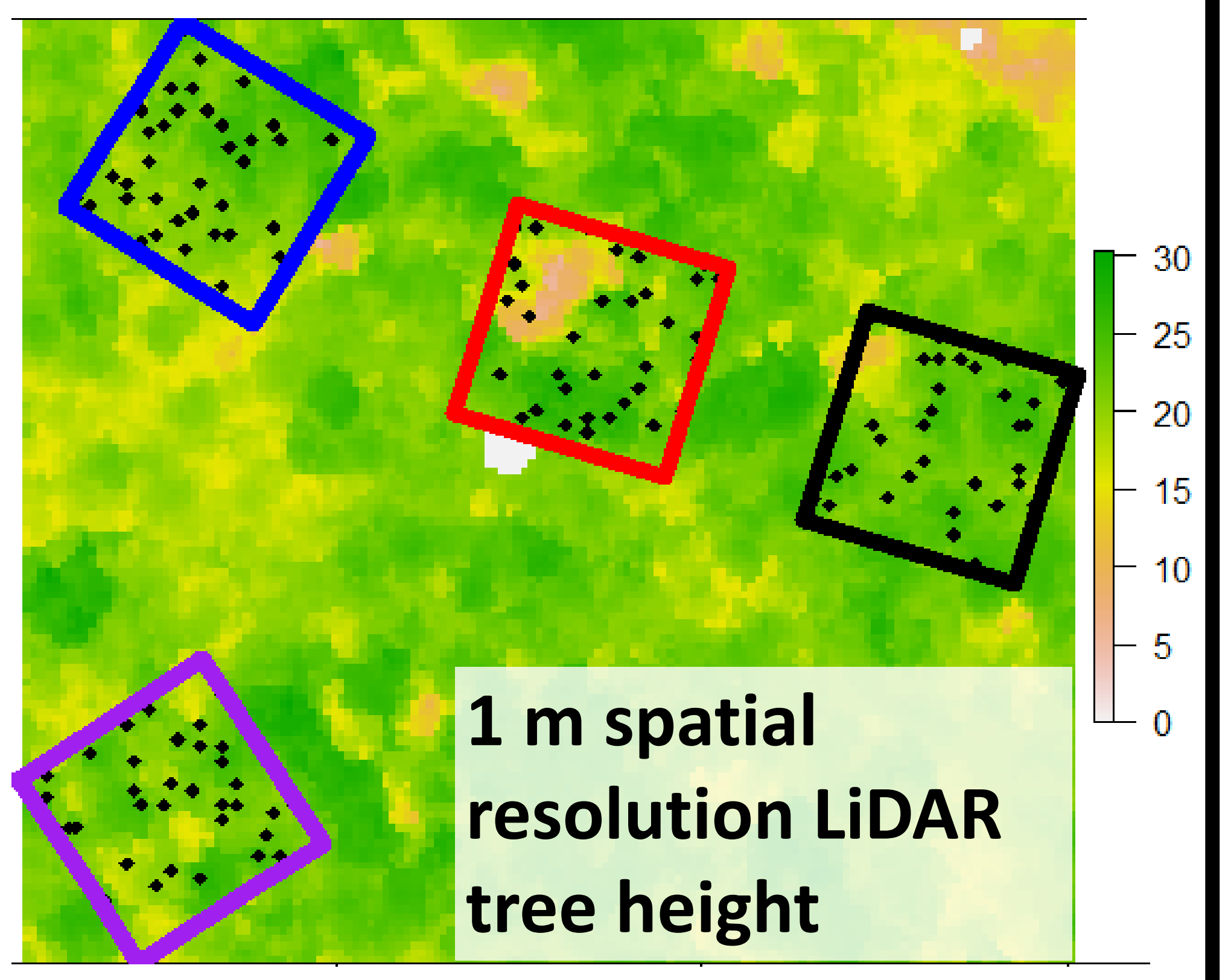
Bartlett Experimental Forest, central New Hampshire, USA.

2.



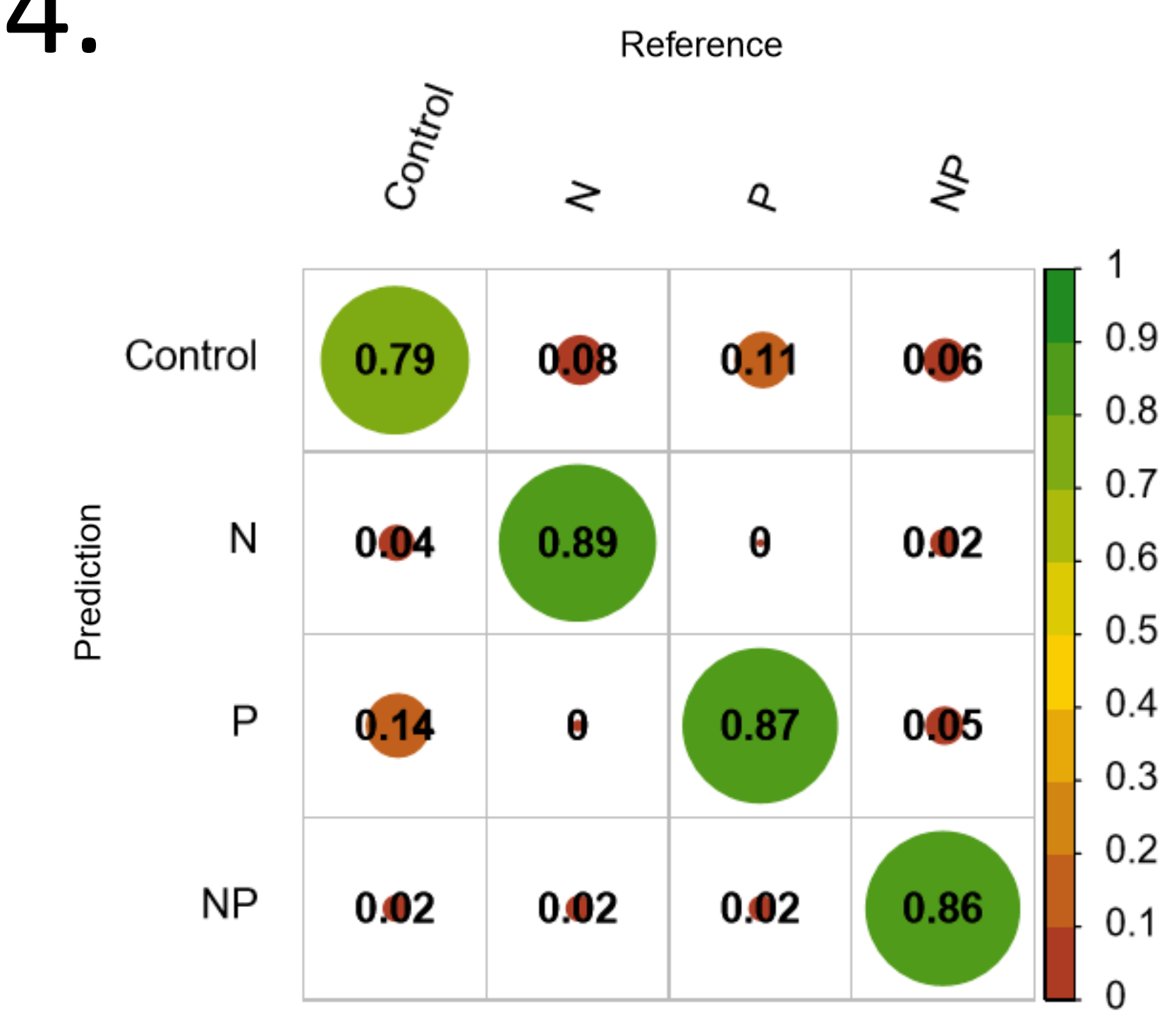
One of nine nutrient addition stands with N*P factorial design.

3.



Only pixels identified as treetops using aerial LiDAR were used.

4.

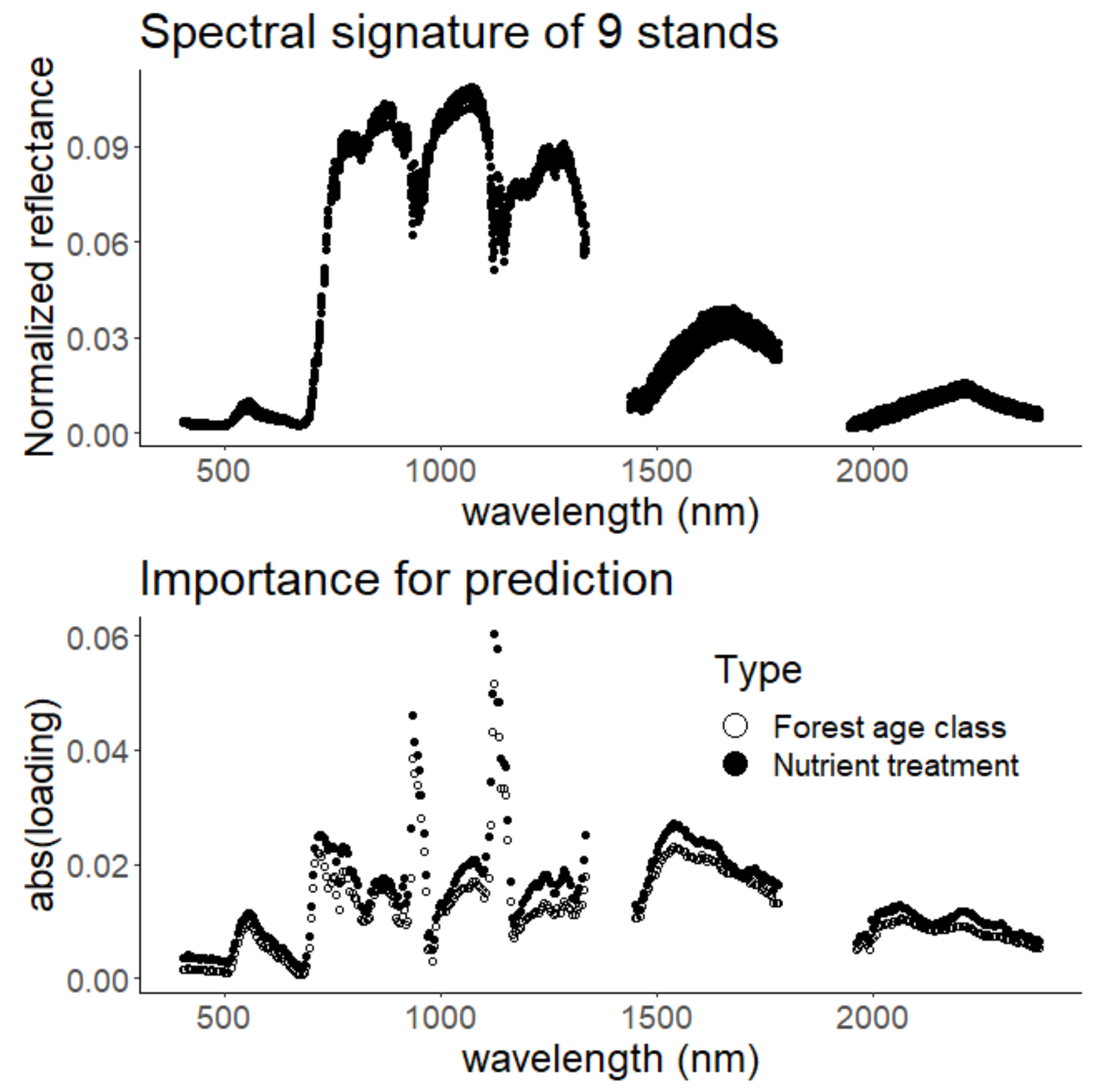


The PLSDA algorithm had 84% accuracy for the prediction of nutrient treatment using plot-averaged spectra. We used 75% of the plots for training and predicted the with-held 25% of the plots.

5.

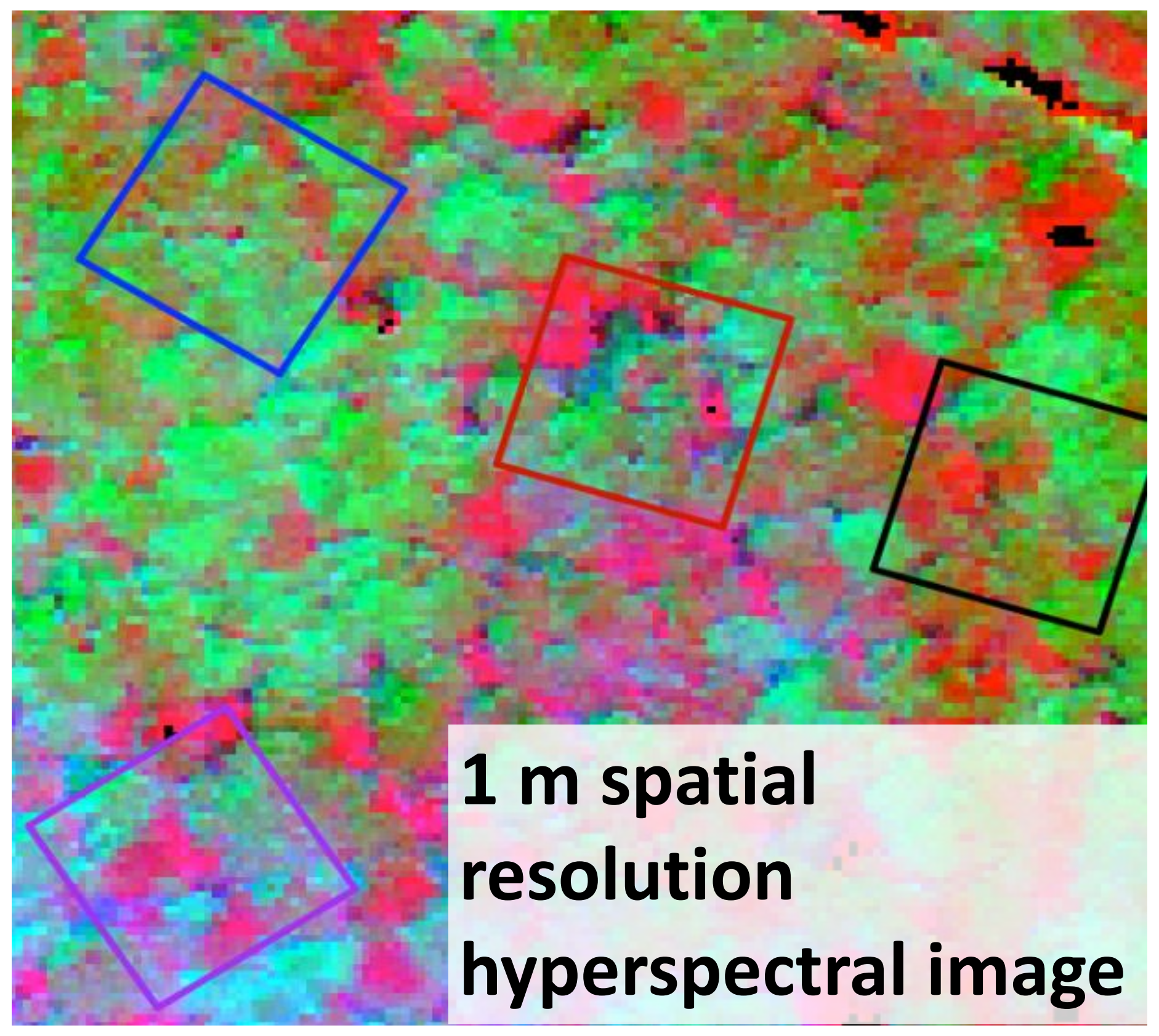
Spectral signature of 9 stands

Importance for prediction



The wavelengths important for the prediction of nutrient treatment were strikingly consistent with those important for predicting forest age.

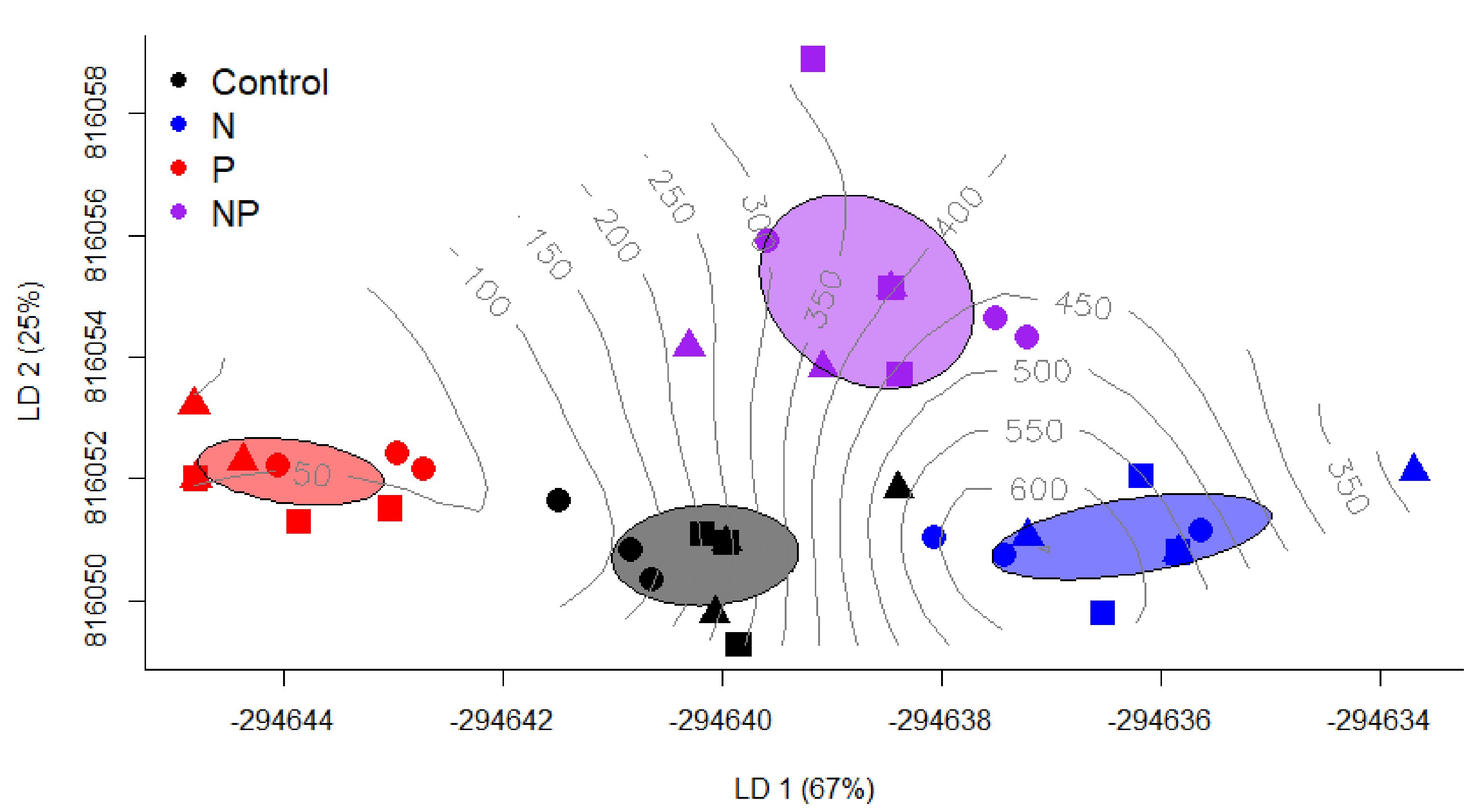
6.



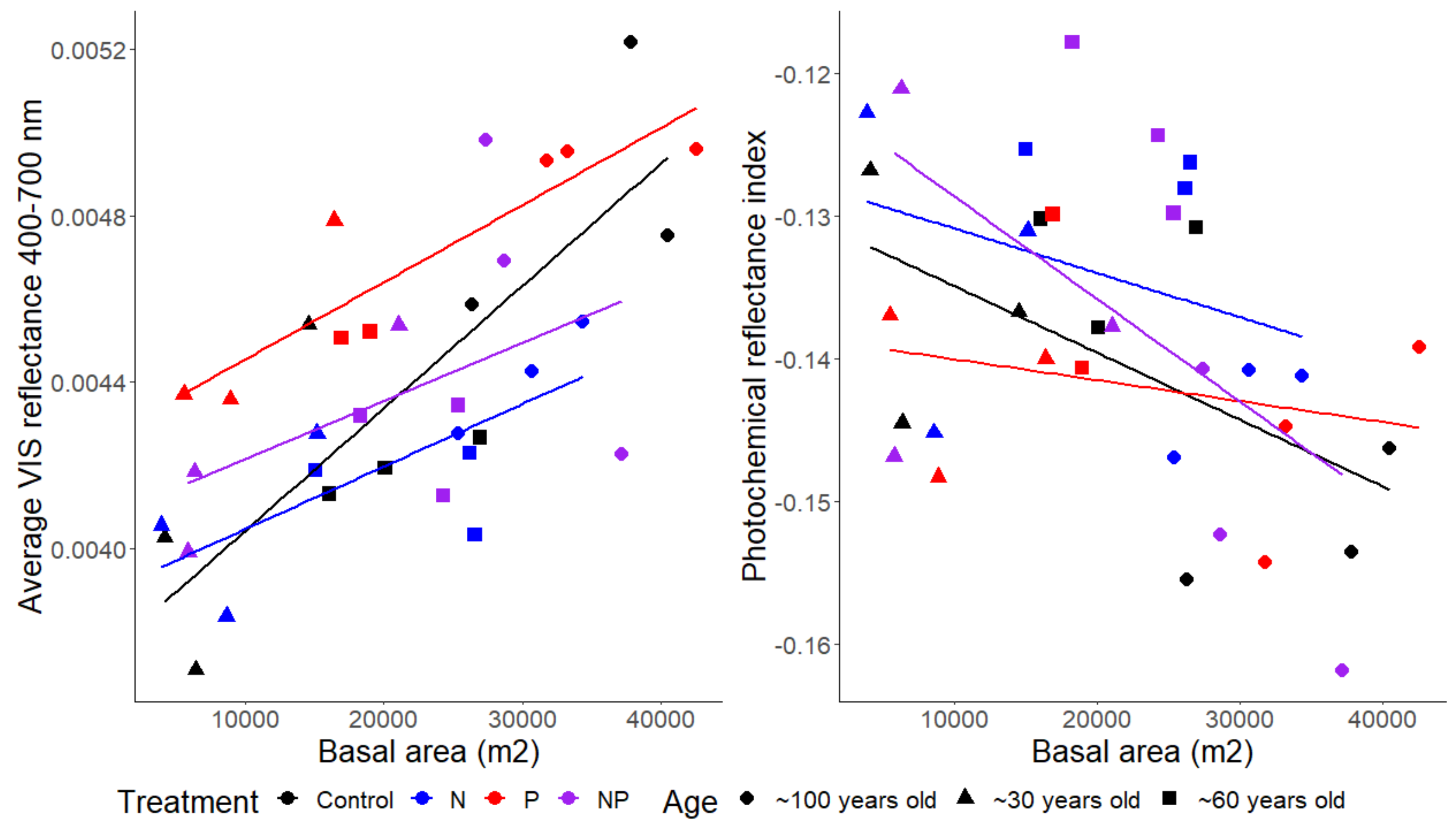
A false colored image using the 3 most important wavelengths from PLSDA model: reflectance at 1125 nm, 925, and 1545 nm.

Results

LDA ordination for nutrient treatment with soil N availability



- Treetop spectra from nutrient plots were readily grouped into nutrient addition using linear discriminant analysis.
- Field measurements of resin-available N (gray numbers) support linkages of above and below ground processes.



- The average reflectance in the visible (400-700 nm) increased with P ($p = 0.001$) and decreased with N addition ($p < 0.001$).
- The photochemical reflectance index (530+570)/(530-570) was higher with N addition ($p = 0.02$) indicating higher photosynthetic efficiency.

Discussion

The spectral properties of nutrient addition in these forests were readily predicted, suggesting unique spectral signatures associated with small-scale gradients in resource availability.

Airborne imaging spectroscopy shows promise for better informed forest management.

Acknowledgements

This material is based upon work supported by the *National Science Foundation Long-Term Ecological Research Network (DEB-1637685) and Collaborative Grants to ESF (DEB-0949324), and the USDA National Institute of Food and Agriculture (2019-67019-29464).*