Tree-top extraction using optical airborne sensors and LIDAR:

A GIS approach to feature identification.

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Why tree-top extraction?

The need to establish a cost-effective strategy for forest mapping is promoting the development of automated or semi-automated methods to extract tree characteristics from remotely sensed data.

Utility:

- **Ecological research**
- **Forest inventories**

Previous studies

• An expert system which controls a database of image analysis routines and a multilevel, multi-paradigm representation of the forestry environment to isolate individual trees by Pinz (1989).

• The ITC (Individual Tree Crown) algorithm by Gougeon (1993, 1995)

• The STCI (Synthetic Tree Crown Image) algorithm by Pollock (1996)

• Wulder et al. (2000) Local maximum Filtering for the extraction of tree locations.

Limitations of existing techniques

- bespoke image processing software.
- operation of software is based on initial parameters.
- work in an unsupervised way.
- performance varies from stand to stand and this together with the degree of expertise they need to operate has restricted their establishment and wide use.

Aim of this study

• to develop an approach that allows the extraction of treetops and identification of tree species for the treetops from airborne remotely sensed data.

• developed this method within a GIS using common GIS techniques where the parameters used are adaptable to different forest types.

Study Site and Airborne Data

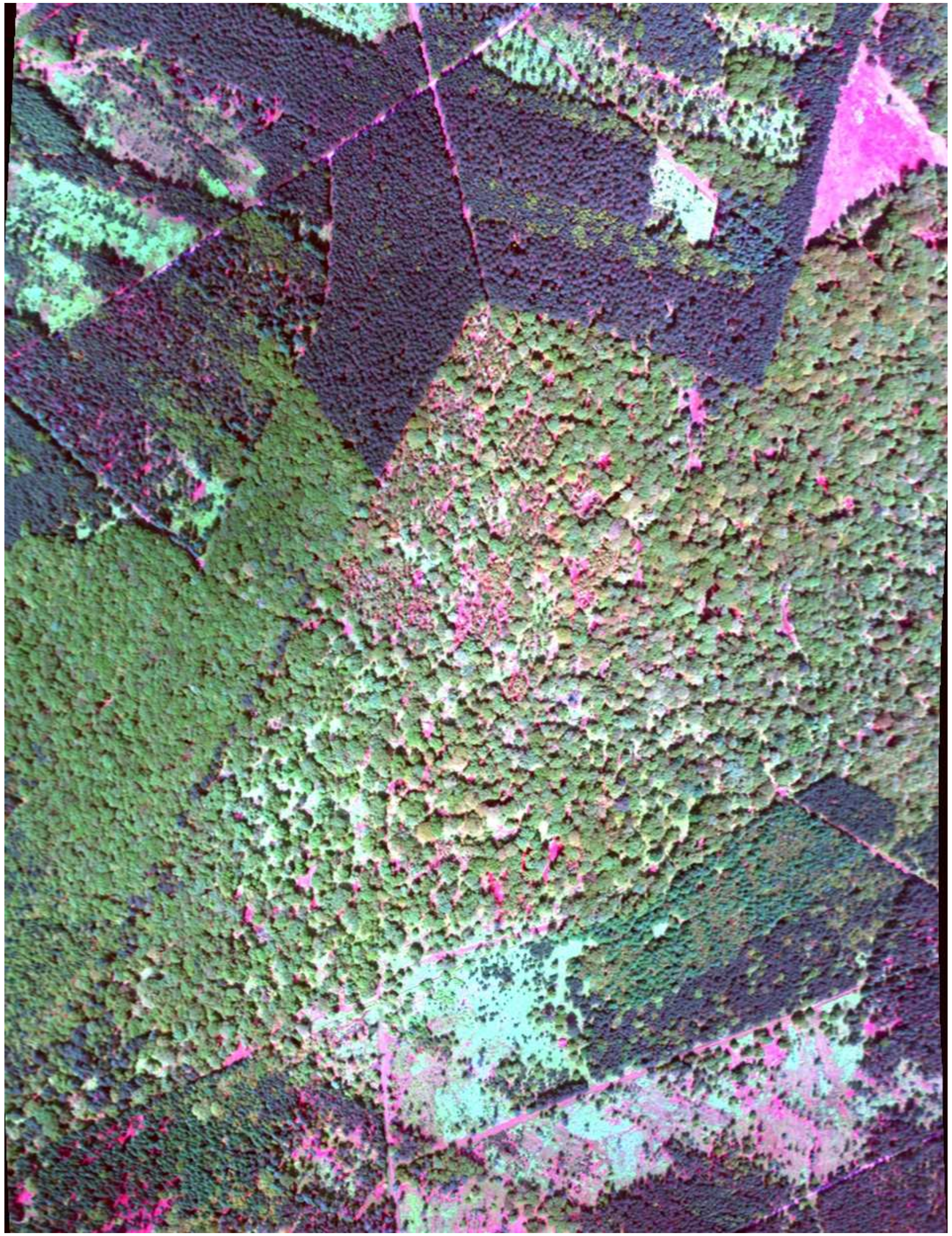
Frame Wood, New Forest, England contains several types of semi-natural deciduous woodlands.

Colour aerial photos
NERC RC-10, July 1996, scale 1:4840.

Airborne Thematic Mapper (ATM)
NERC ATM, July 1996, 2200ft alt. 1m spatial resolution.

Light Detection and Ranging (LIDAR) system
Environment Agency (EA) Optech Airborne Laser Terrain Mapping (ALTM) 1020, July 1997, 2m spatial resolution.

ATM image of Frame Wood (bands 10,6,2)



Data processing

• Geometric corrections

-Aerial photos scanned at 600 dpi producing image with 33cm pixel res. Subsets of centres of photos co-registered with LIDAR imagery.

-ATM data at level 1b geometrically corrected using GCORR program (Azimuth Systems, 1998).

-Ground control points acquired using real-time differential GPS.

•ATM optimised supervised classification for tree species coverage (Koukoulas & Blackburn, forthcoming PE&RS)

•Tree-top extraction

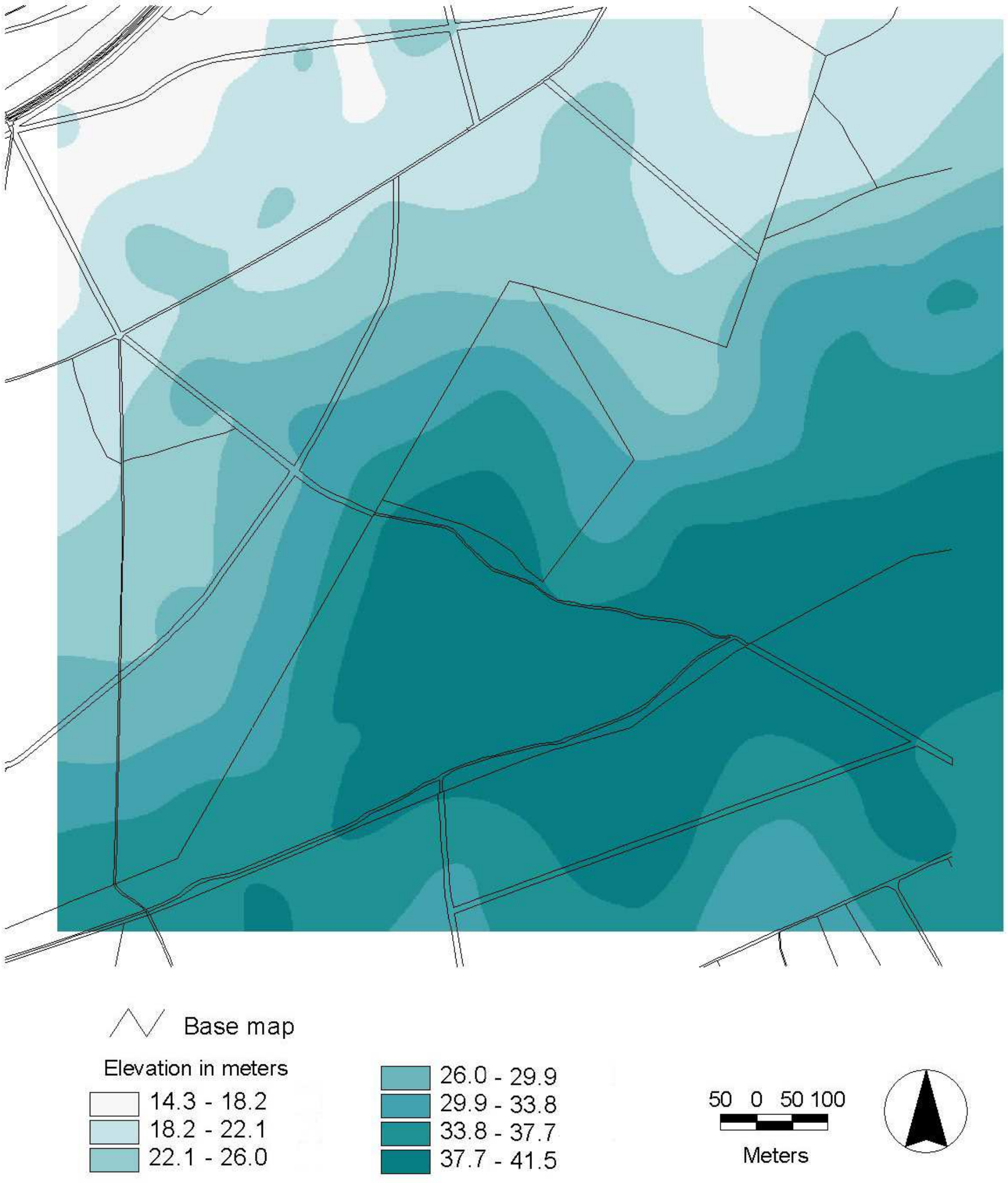
- Techniques to extract treetops from LIDAR data

Creation of Canopy Surface Model, Working within a GIS.

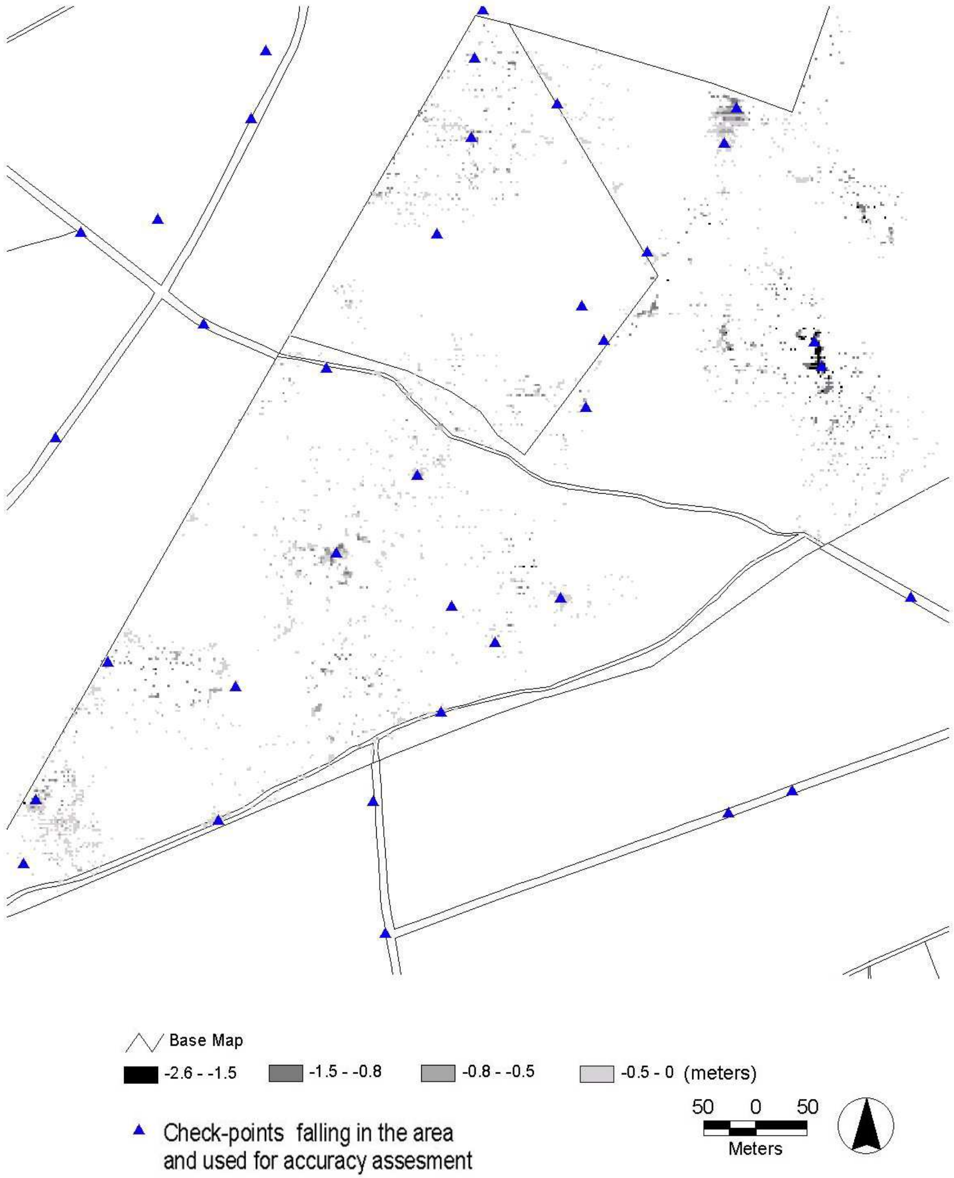
-Using ‘contouring’ for treetops extraction from aerial photos.

LIDAR image of Frame Wood (Perspective view)

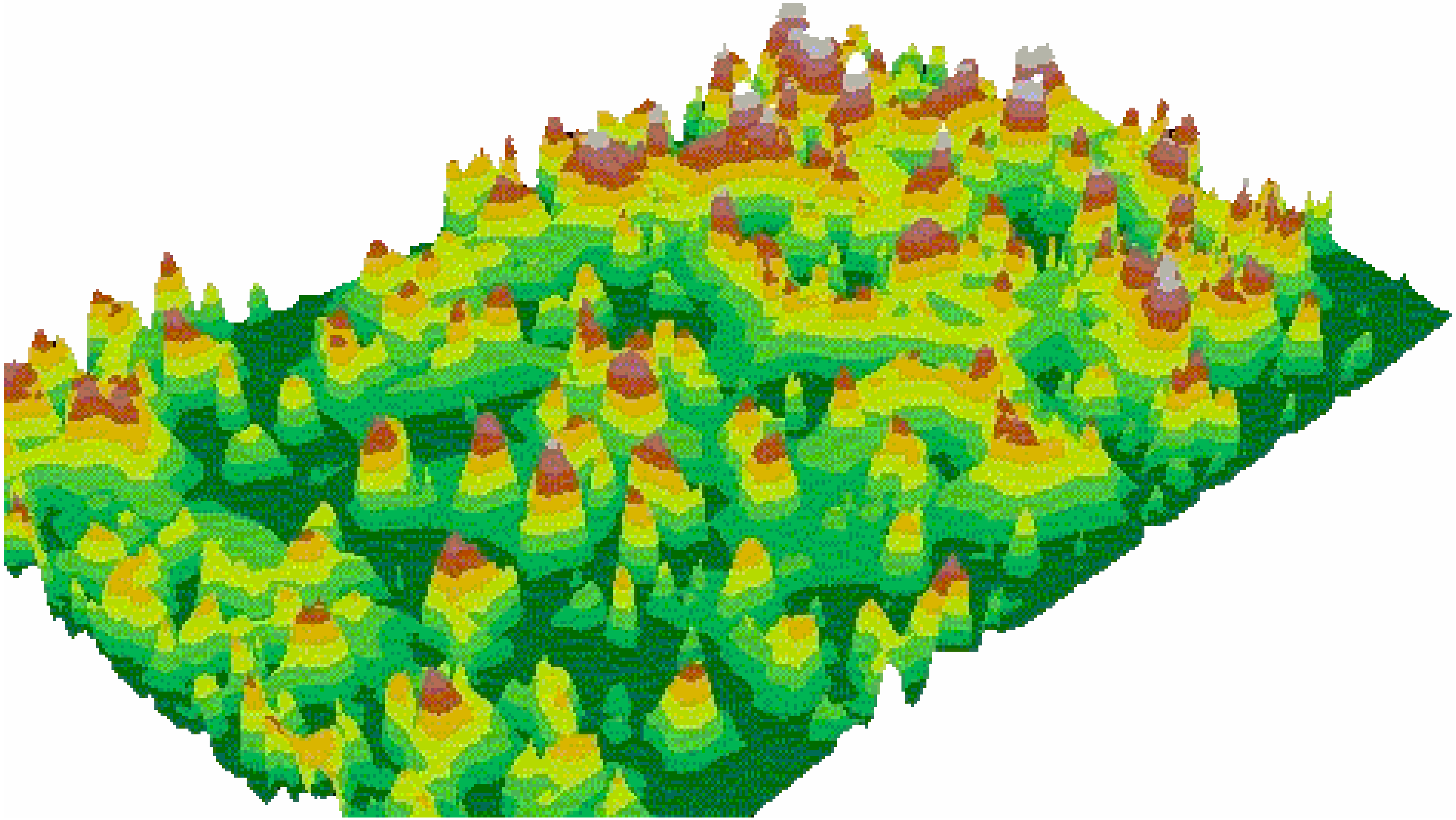
DTM created from LIDAR data and spline interpolation (RMSE: 0.5m)



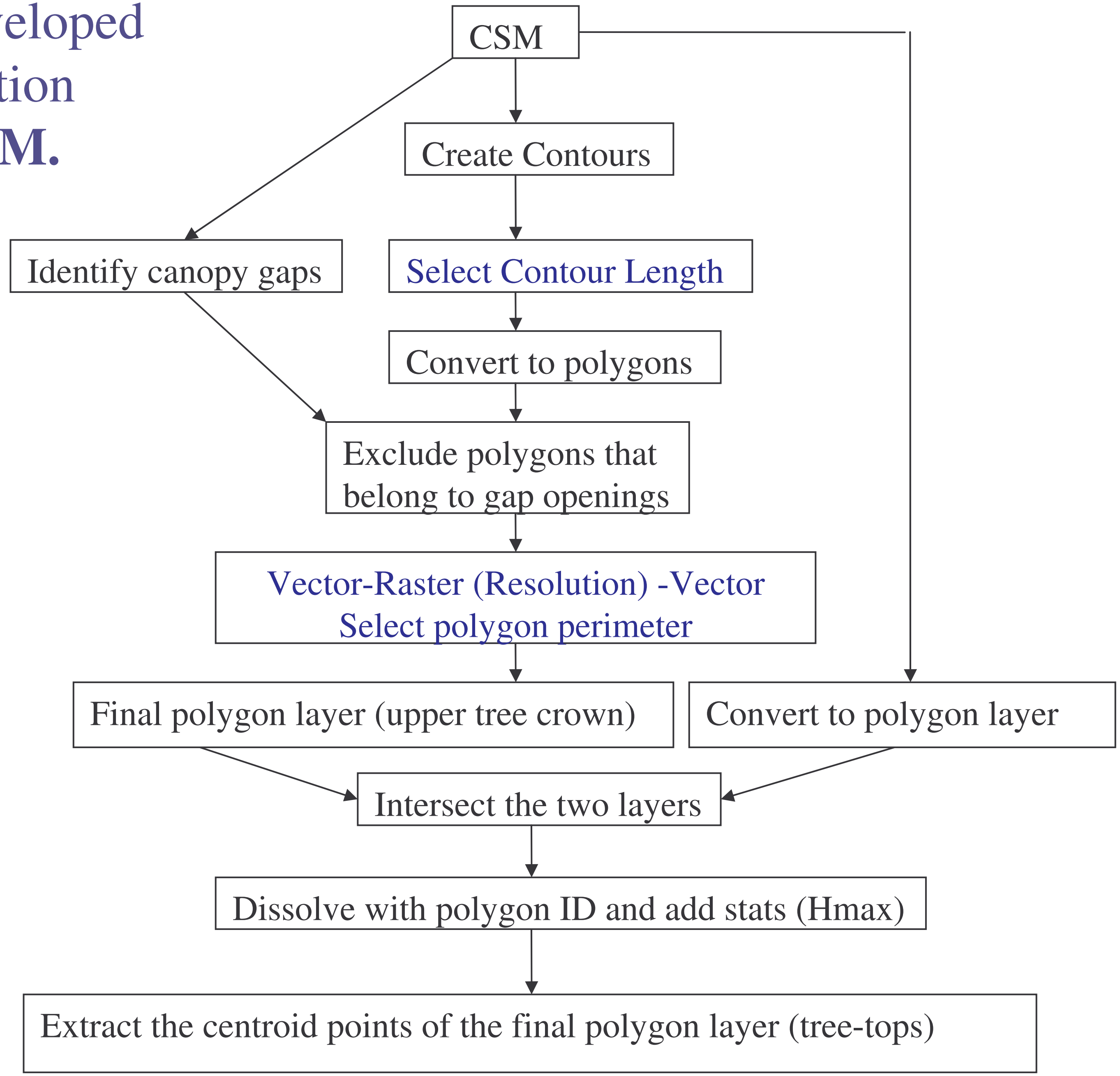
Distribution of negative elevation values as indication of errors in CSM



Canopy Surface Model (CSM) for a plot area

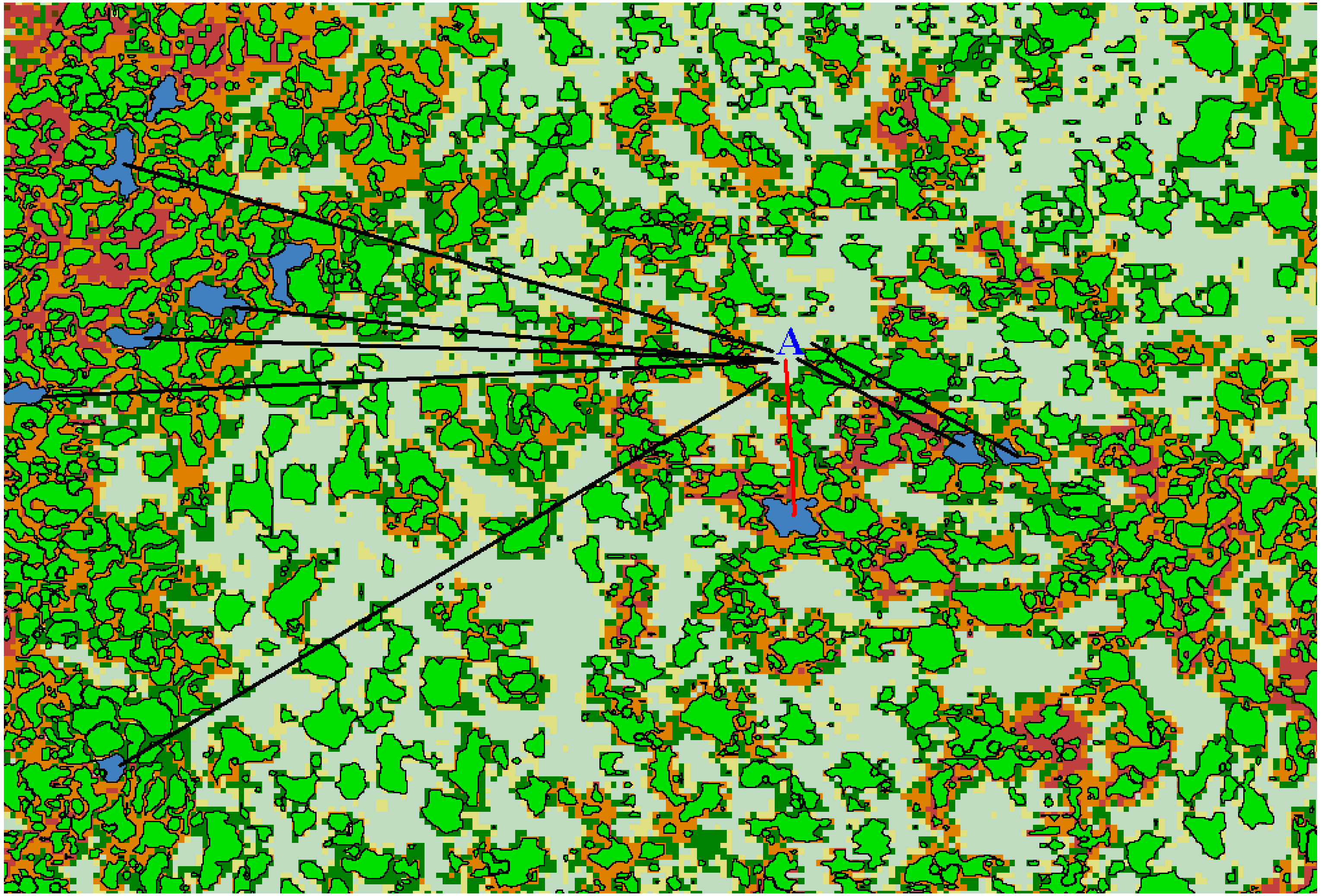


Methodology developed for treetop extraction from **LIDAR CSM.**

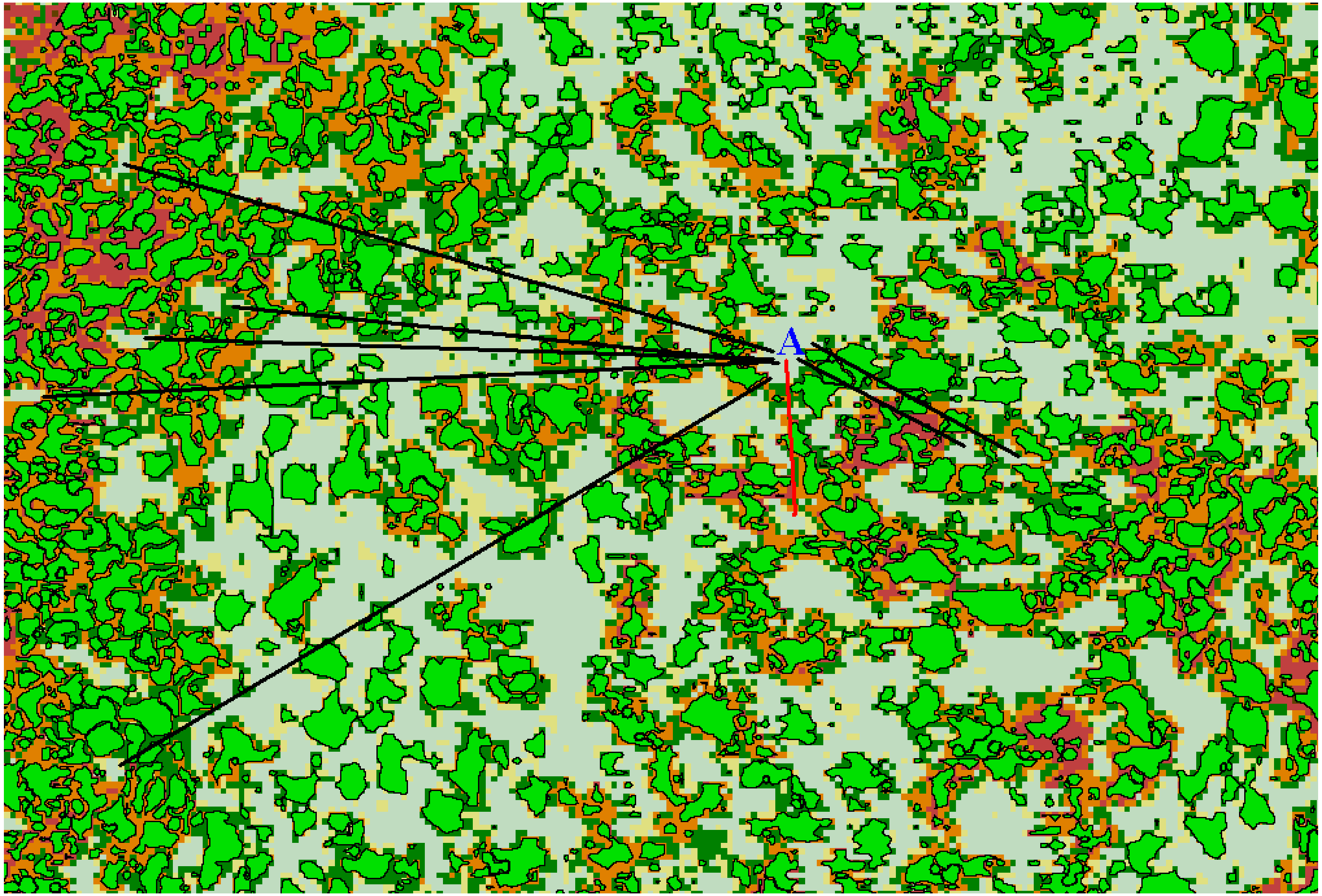


Confusion caused by contour polygons (shown with lines) representing gaps rather than canopy.

In background is CSM (darker brown represents higher values of height) overlaid by canopy polygons (bright green).

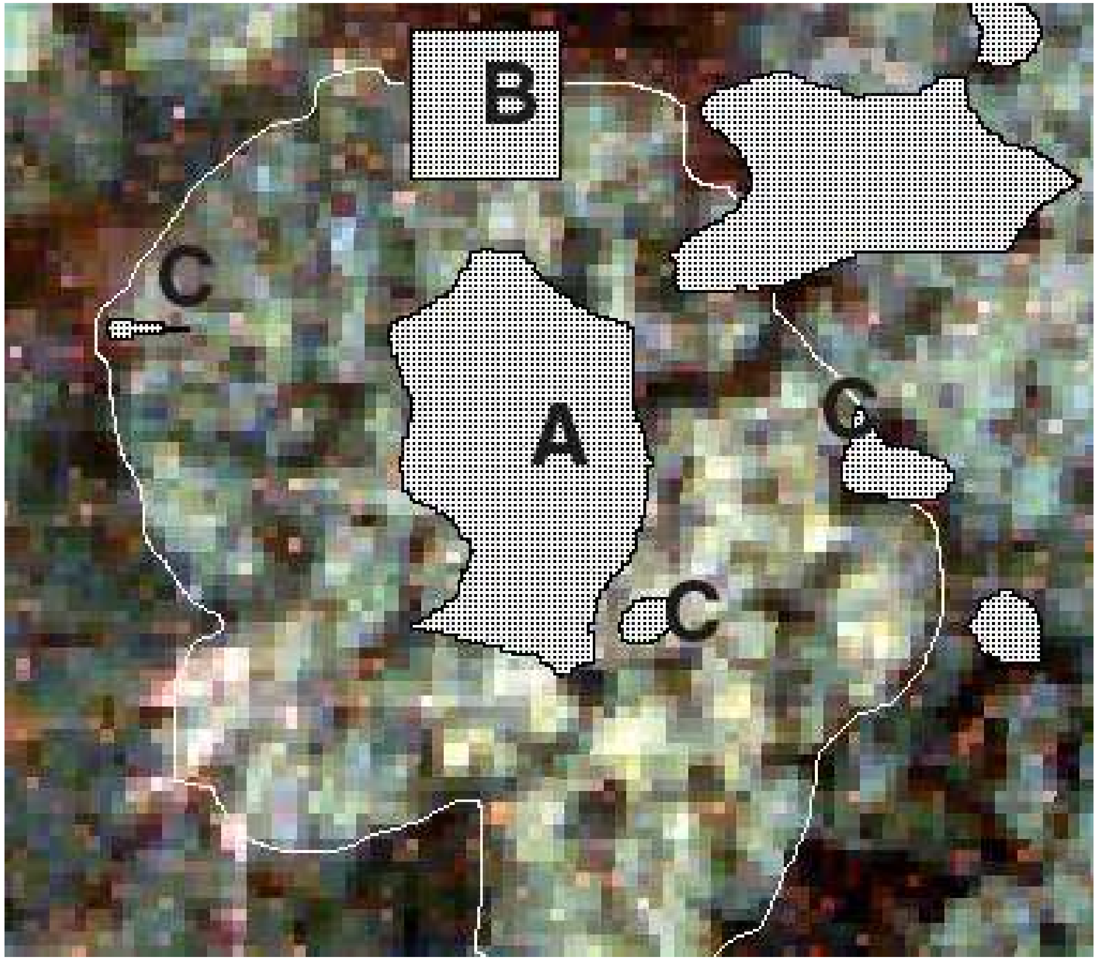


Gap contour polygons have been eliminated and the previously covered openings in the CSM are shown here.

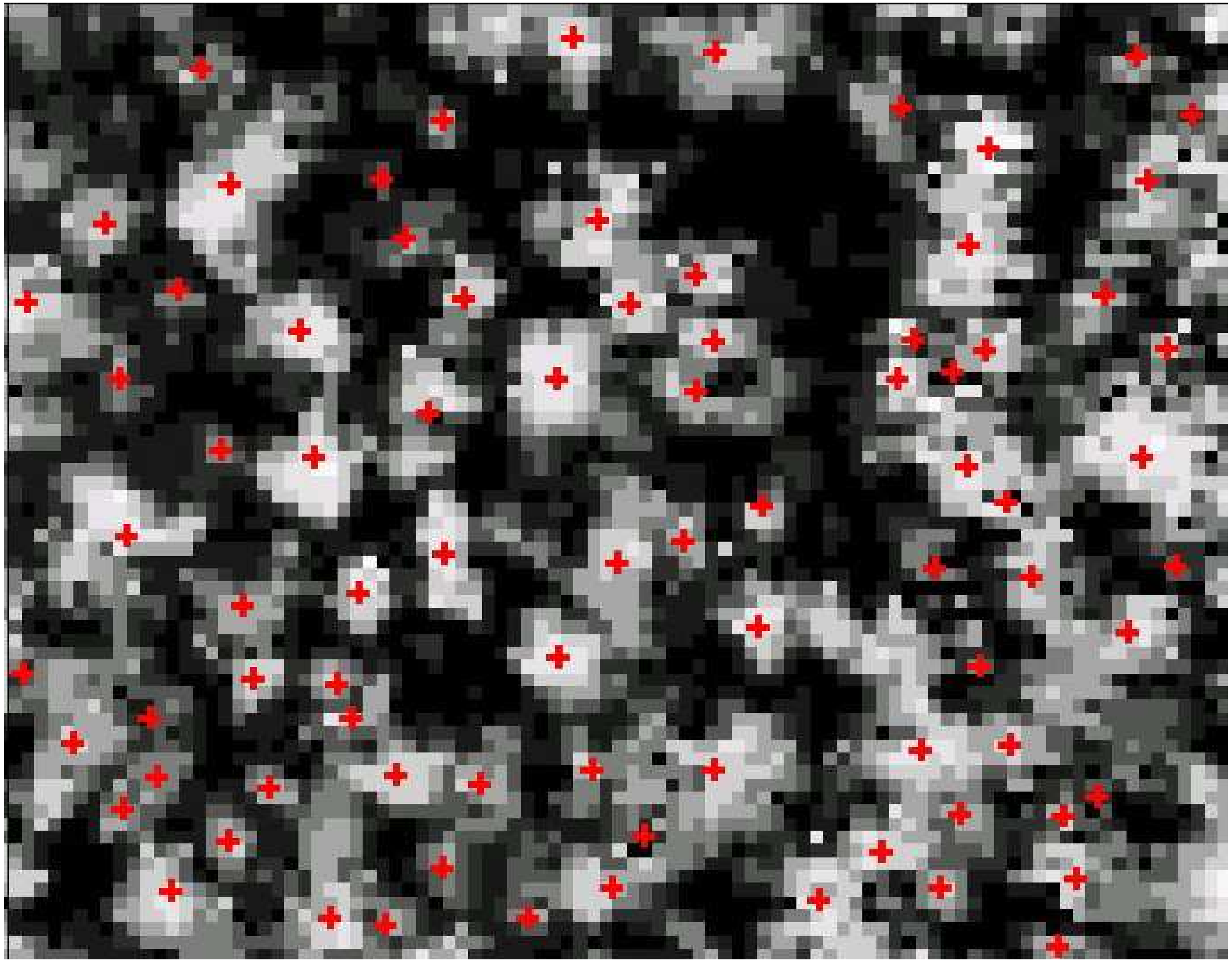


Confusion caused by some tree branches (small polygons with perimeter less than 15m, marked with 'C') in the selection of the upper canopy contour polygons (large polygons marked by A, B).

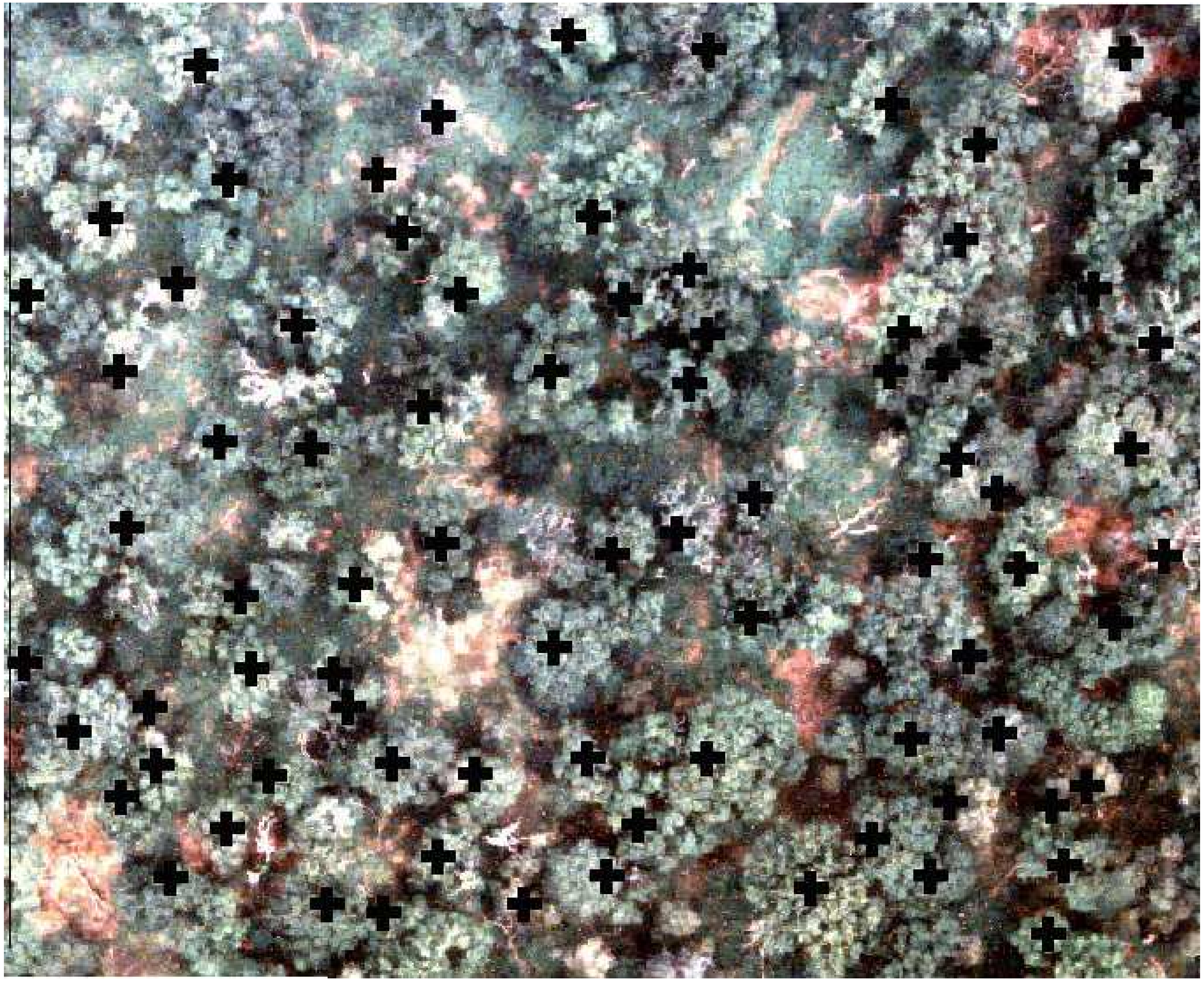
B polygon has been missed by the "15m perimeter" elimination rule but will be joined with A by converting these polygons to grid and decreasing the grid resolution.



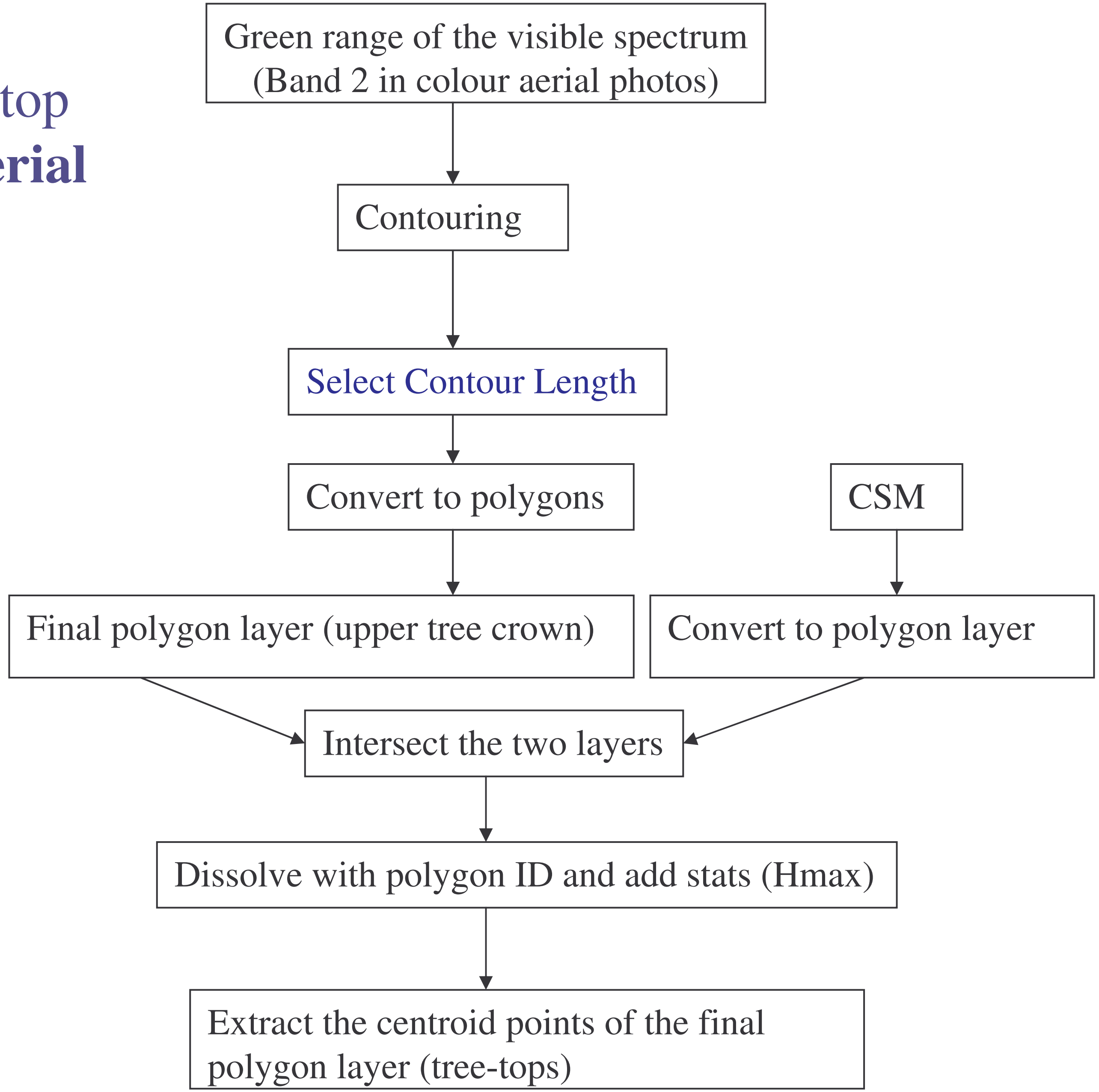
Treetops extracted from CSM (subset of CSM in the background; darker represents lower values of height)



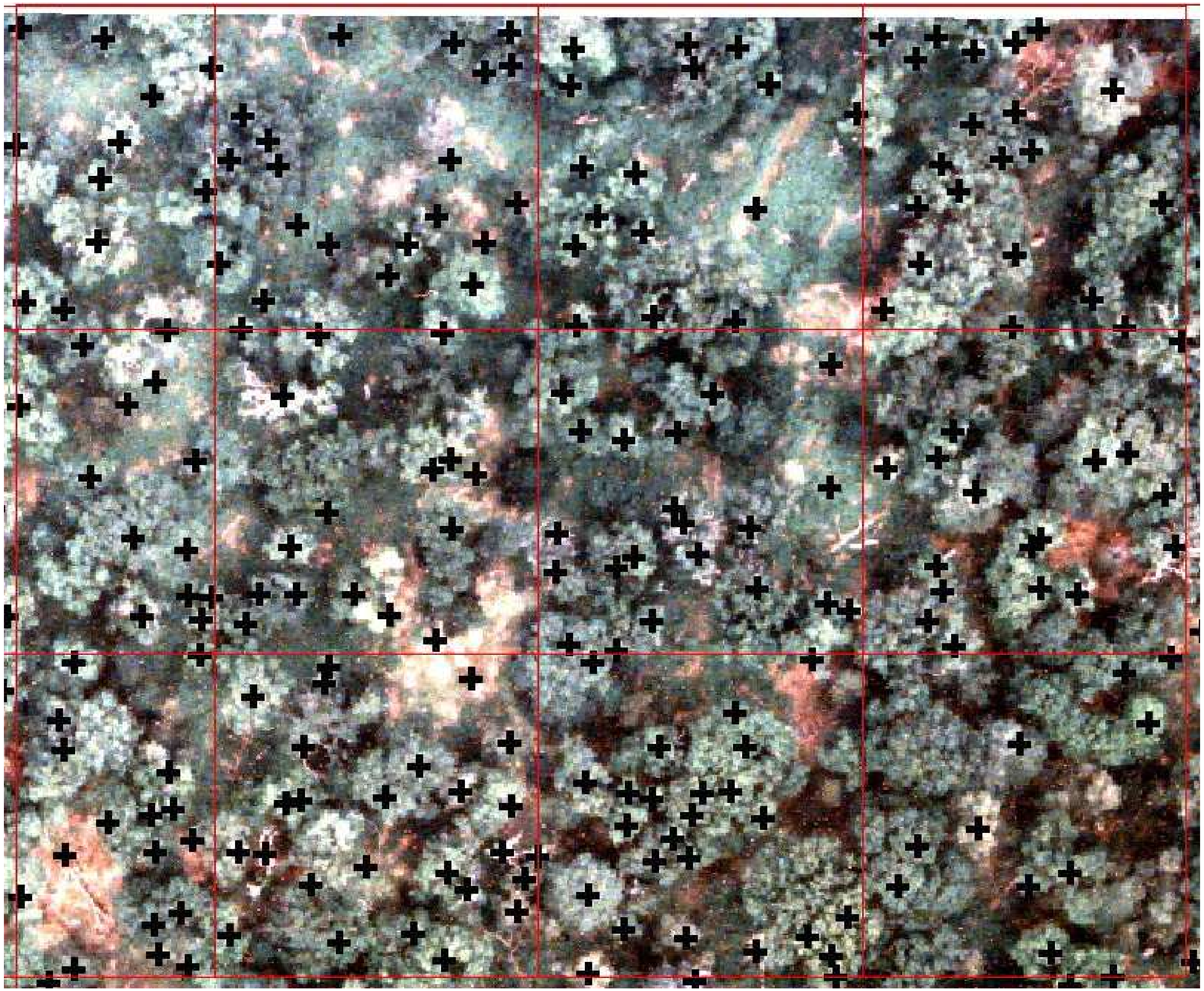
Treetops extracted from CSM, shown here on aerial photograph with which the accuracy was tested (accuracy 80%)



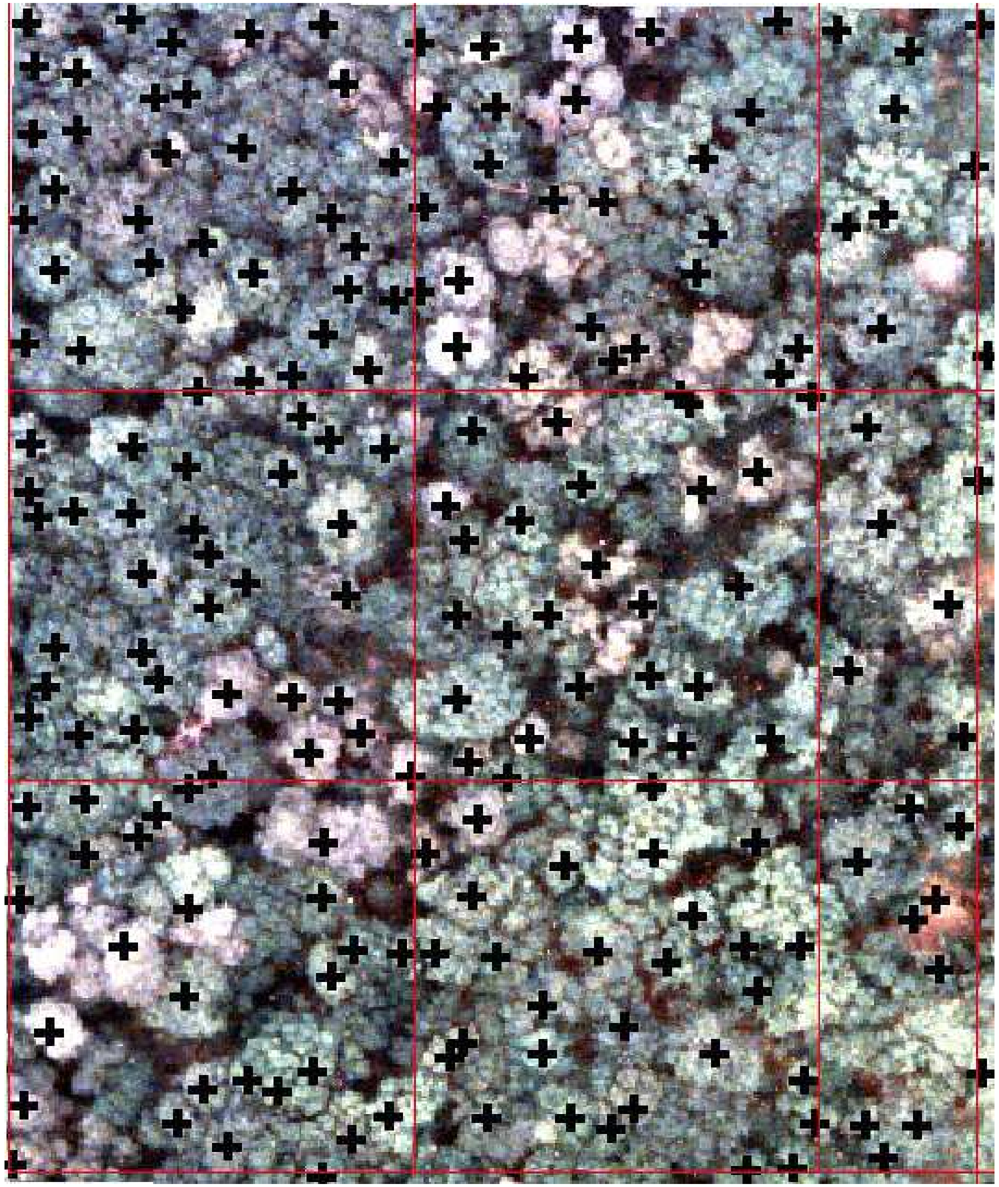
Methodology developed for treetop extraction from **aerial photos.**



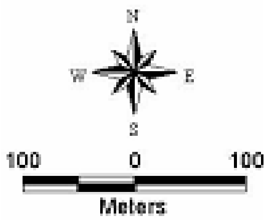
Treetops extracted from the colour aerial photograph in the semi-natural site.



Treetops extracted from the colour aerial photograph in the plantation site (oaks). (accuracy 91%)

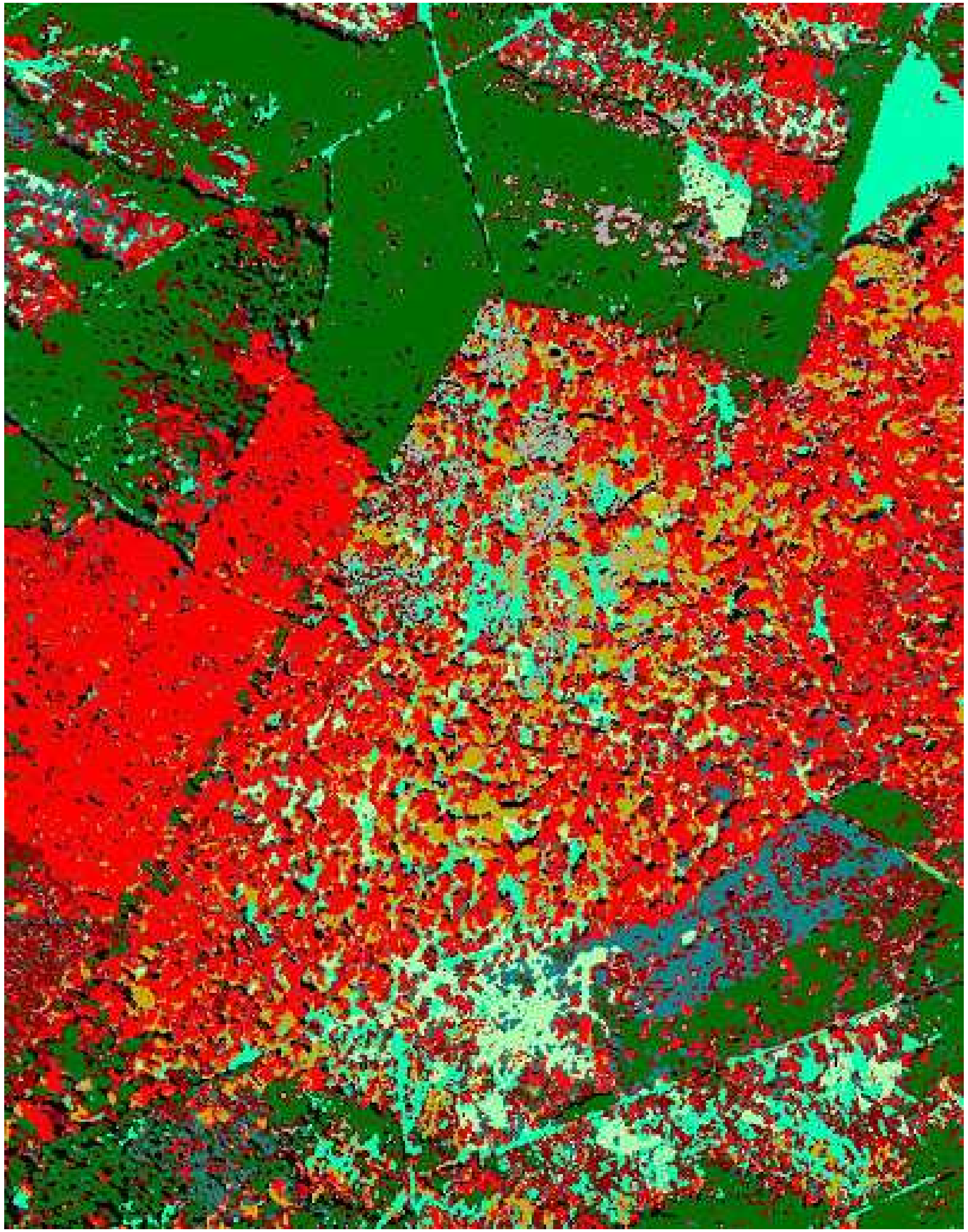


Species coverage derived from ATM



Classified ATM image using 5 bands out of 27.
Band selection based on J-M distance

Percent correct	92.46%	Percent Correct Beech	81%
Kappa statistic	91.37%	Percent Correct Oak	91%
CSI	83.77%	Percent Correct Birch	86%
GCSI B-O-B	71.96%	ICSI Beech	75.35%
GCSI B-O	76.90%	ICSI Oak	78.44%
GCSI B-G	98.19%	ICSI Birch	62.08%



Map of treetops and species distribution at Frame Wood.

Conclusions

- **Treetop locations can be successfully extracted from colour aerial photographs and LIDAR imagery**.
- The **degree of success** of the method developed for these two sensors appeared to be dependent on the **tree density**.
    - Colour aerial photographs can be used to extract treetops in dense areas (plantations) and where crowns are uniform.
    - LIDAR imagery (2m spatial resolution) are suitable for uneven aged and mature deciduous stands.
- By combining treetop location data (from aerial photographs and LIDAR) with tree species information (from ATM), **we have realised the objective of producing an accurate and comprehensive map of individual tree location, height and species distribution**.