



Institut de recherche sur les feuillus nordiques Inc.  
Northern Hardwoods Research Institute Inc.



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# Technical Note

Resource Characterization

## Canopy Cover Estimation in Hardwood Stands from Landsat Imagery

### INTRODUCTION

Canopy cover (i.e. the proportion of the forest floor covered by the vertical projection of tree crowns) can limit the growth of seedlings and saplings and is often used as treatment objective in the NHRI Silvicultural Prescription System (SPS). Assessing canopy cover in the field is time-consuming and subjective. It can also be evaluated using remote sensing technologies such as satellite imagery and LiDAR (Light Detection and Ranging). The NHRI created a tool (model) to estimate canopy cover from Landsat imagery because of the following advantages over LiDAR-based approaches:

- Images are freely available
- New scenes from Landsat 8 OLI (Operational Land Imager) are available every 16 days
- Archived images are available dating back to 1972

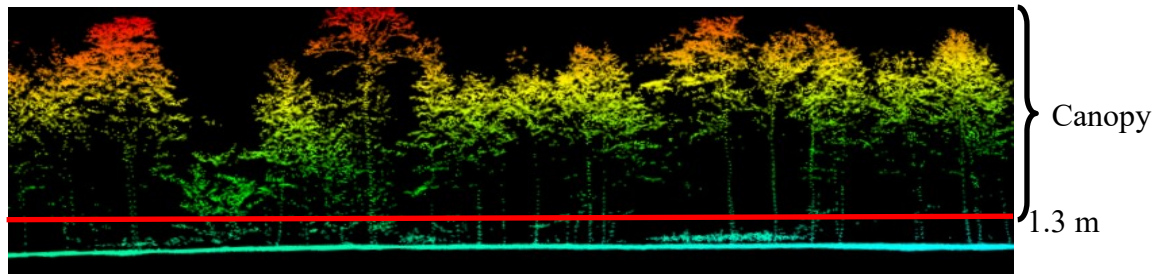
### HIGHLIGHTS

- Estimation of canopy cover from Landsat images in hardwood stands are accurate to  $\pm 8\%$ .
- Inputs needed:
  - ☐ Landsat image of the target area,
  - ☐ CHM (Canopy Height Model) from at least  $0.81\text{km}^2$  derived from leaf-on data taken in the same general period as the Landsat image or coming from an area where no changes occurred in the landscape between the acquired date and the image date.
  - ☐ CHM can be derived from point clouds from UAV (Unmanned Aerial Vehicle) data and/or LiDAR. Costs will vary.
- Output: GIS compatible layer of canopy cover estimation to the resolution of the Landsat pixel (30 x 30m).

## METHODOLOGY

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The model created to estimate canopy cover from Landsat imagery uses spectral variables, stand characteristics (i.e. stand structure, species composition, dominant species, and development stage) derived from the NB GIS forest inventory, topography (i.e. slope, hill-shade, and aspect), and ecosite. Note that in our case, canopy cover is considered to be the proportion of canopy (> 1.3 m) in a pixel of 30 m x 30 m (Figure 1).



**Figure 1.** Thresholds height distinguishing canopy and background to estimate canopy cover from Landsat image

To first estimate canopy cover, some pre-processing of the Landsat image is necessary to decrease the impact of external factors such as atmosphere. Once this is done, an area is chosen to train the model. There are four criteria to look for before choosing this area:

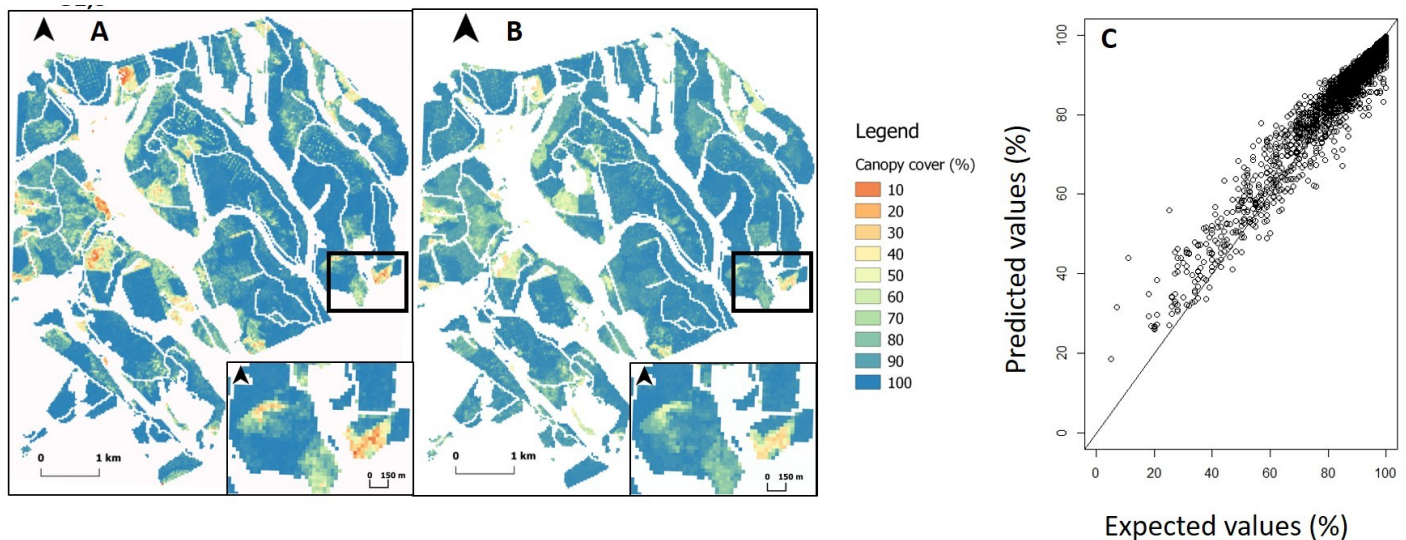
1. The area must be at least  $0.81 \text{ km}^2$ ,
2. The area needs to overlap the Landsat image being used to estimate canopy cover from (target image),
3. The Canopy Height Model (CHM) needs to be derived from data that is taken the same year as the target image or be from an area where no changes in the landscape occurred between acquired date and target image date. CHM can be derived from LiDAR and/or UAV data, this may have a cost associated.
4. The CHM needs to be derived from data taken during the leaf-on season and in hardwood stands.

Once the model is trained for the selected Landsat image, the model can be run on the entire scene to estimate canopy cover for each 30 m x 30 m pixel. Due to its complexity, the model needs to be run by NHRI, the output that the client gets is a GIS compatible layer (raster) where each pixel contains the canopy cover estimates giving by the model.

## RESULTS

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Canopy cover estimates were accurate within  $\pm 8\%$  using a 1.3 m height threshold to distinguish canopy from background. Note that this model was built for hardwood-dominated stands only and will not provide the same accuracy in mixedwood and conifer stands. Figure 2 shows a typical output a client can have and the accuracy of the estimate.



**Figure 2.** Canopy cover estimate from a Landsat OLI 8 image A) Predicted values of canopy cover (%), B) Expected values of canopy cover (%), C) Predicted values vs. expected values of canopy cover (%).

## CONCLUSION

A model to estimate canopy cover from Landsat imagery was created, accurate within  $\pm 8\%$  using a threshold height distinguishing canopy and background of 1.3 m. This model cannot be used directly on another Landsat image, each Landsat image requires its own model to be trained with a CHM derived either from UAV or LiDAR data for a portion of the target image. LiDAR based models are more accurate. Nonetheless, this model is useful in cases where a change in the canopy cover happened between two cycles of LiDAR data (10 years) or where there is no LiDAR data. Also, Landsat images are available since 1972, so it is possible to estimate canopy cover from previous years if a CHM of the same period exists where no changes in the landscape occurred since the image acquired date.

## FOR MORE INFORMATIONS, CONTACT:

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