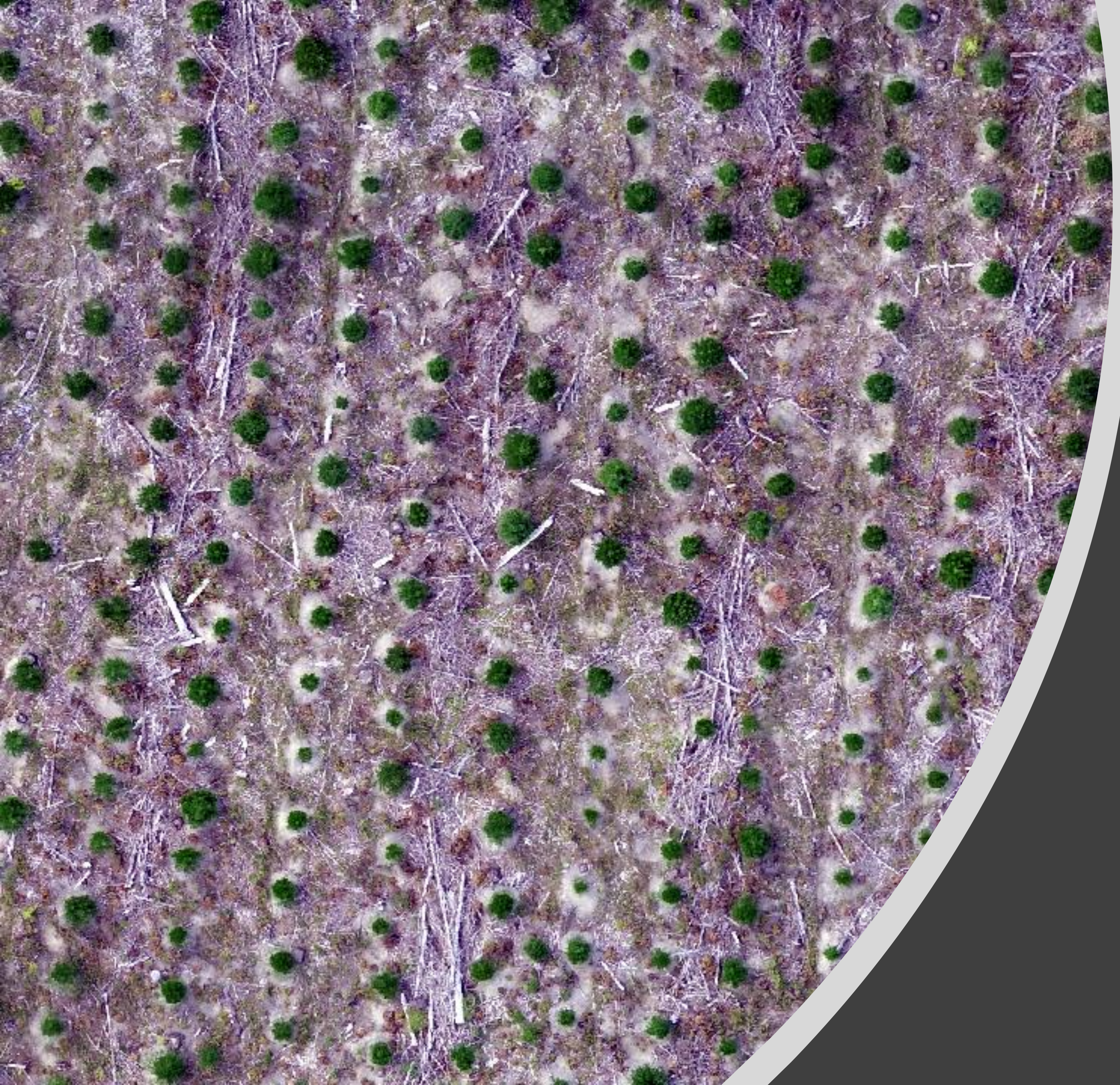
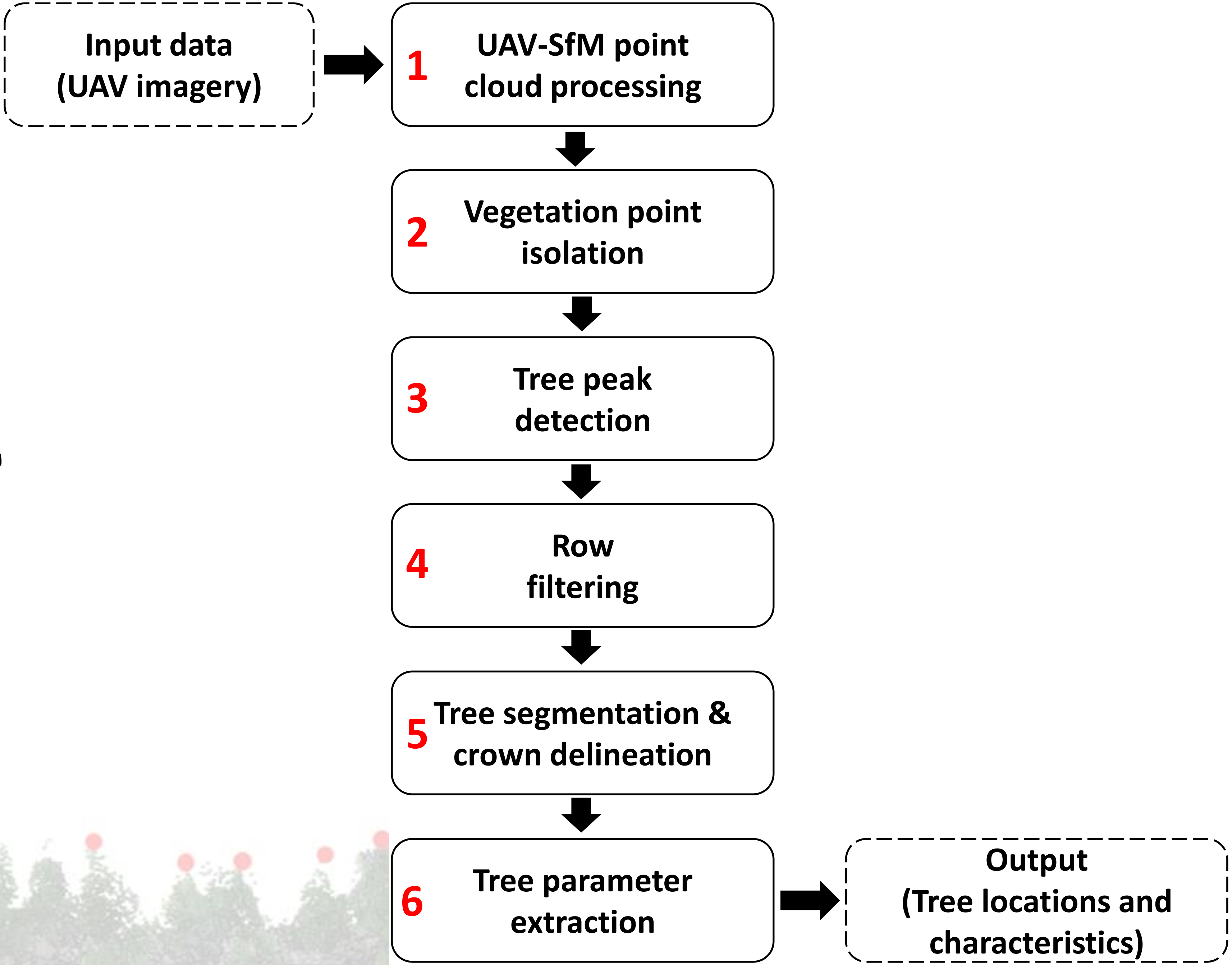


Alternative approach for tree detection using remotely sensed imagery

The pipeline



1. UAV-SfM processing

- Digital photogrammetric processing of UAV imagery to generate a **SfM pointcloud**

- Extract RGB spectral values to UAV-SfM points

- De-noise, Ground classify and Normalise point cloud

id	X	Y	Z	R	G	B
51	458901.8	5778369	0.39	23040	22784	22016
52	458901.8	5778377	0.84	11520	18688	9984
53	458901.8	5778353	0.30	36864	40192	29440
54	458901.8	5778377	0.51	9728	17152	8704
55	458901.8	5778377	1.14	12800	21504	11520

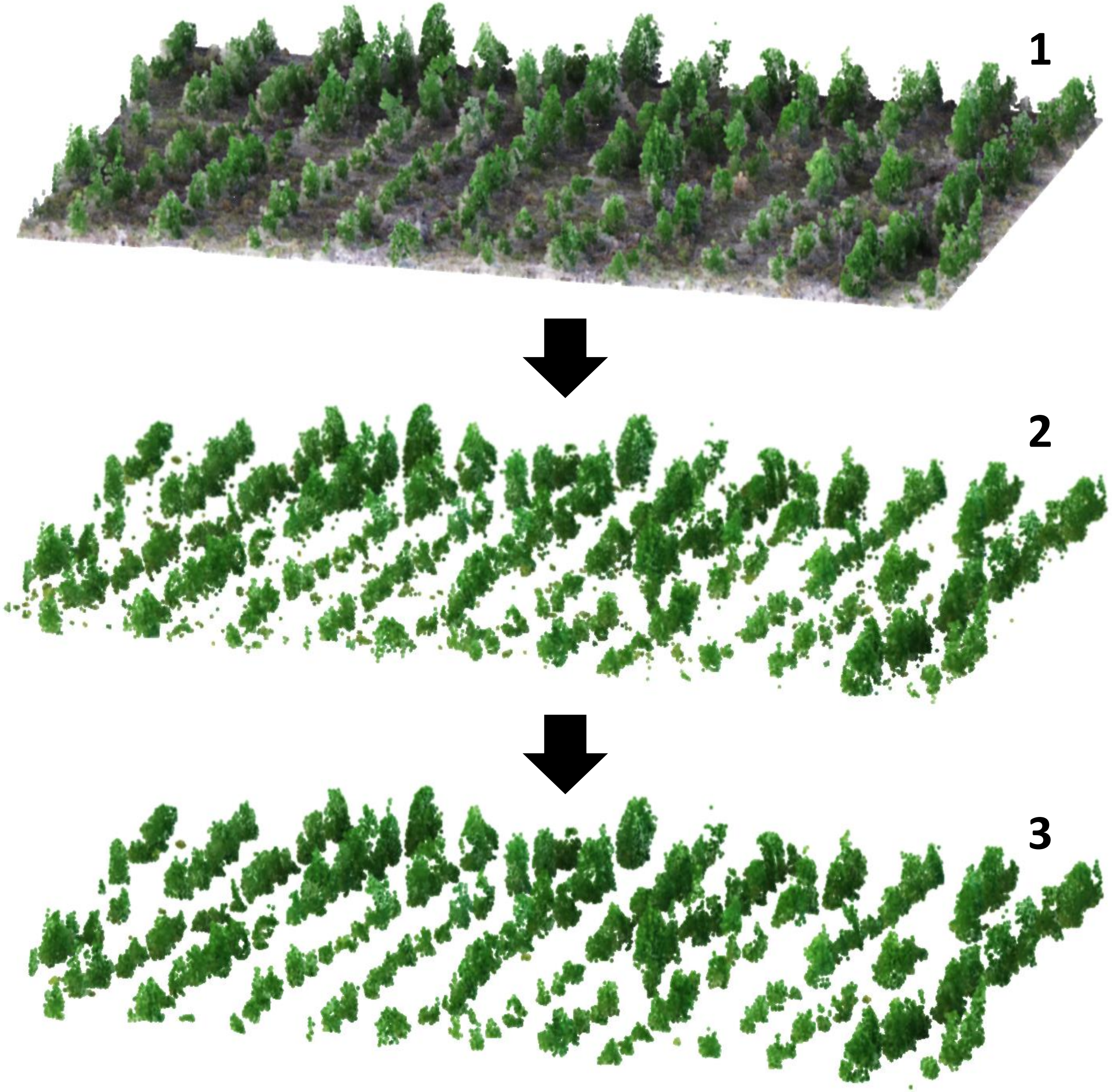
2. Vegetation point isolation

- Create a **binary mask of vegetation** using a RGB-based vegetation index and Otsu's thresholding technique

$$RGBVI = \frac{R_G^2 - (R_B * \ R_R)}{R_G^2 + (R_B * \ R_R)}$$

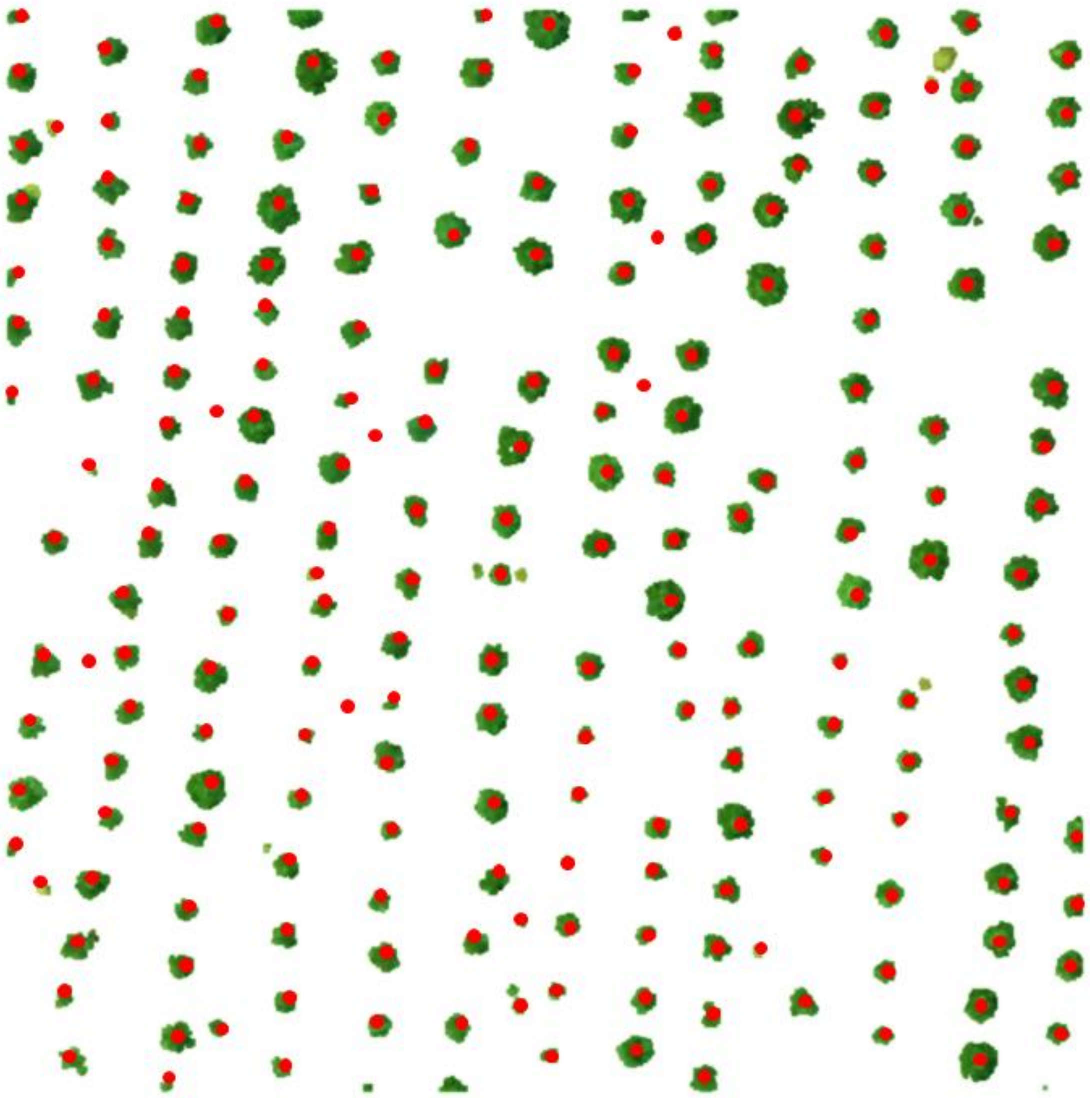
- Apply a **minimum height filter** and a **nearest neighbour noise filter**

id	X	Y	Z	R	G	B	rgbvi	class
51	458901.8	5778369	0.39	23040	22784	22016	0.01	Non-vegetation
52	458901.8	5778377	0.84	11520	18688	9984	0.50	Vegetation
53	458901.8	5778353	0.30	36864	40192	29440	0.20	Non-vegetation
54	458901.8	5778377	0.51	9728	17152	8704	0.55	Vegetation
55	458901.8	5778377	1.14	12800	21504	11520	0.52	Vegetation



3. Tree peak detection

- Assumption: the highest point of a tree is its vertex
- Implement a local maxima-based treetop detection algorithm on the isolated 3D vegetation points



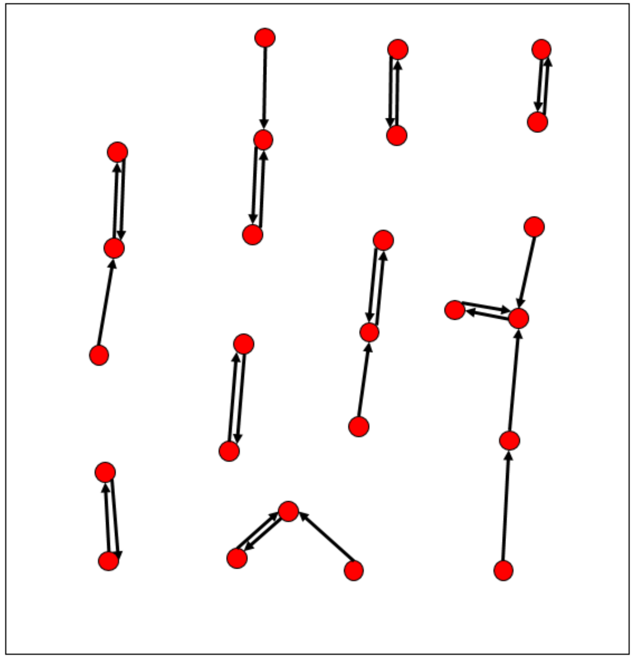
4. Row filtering

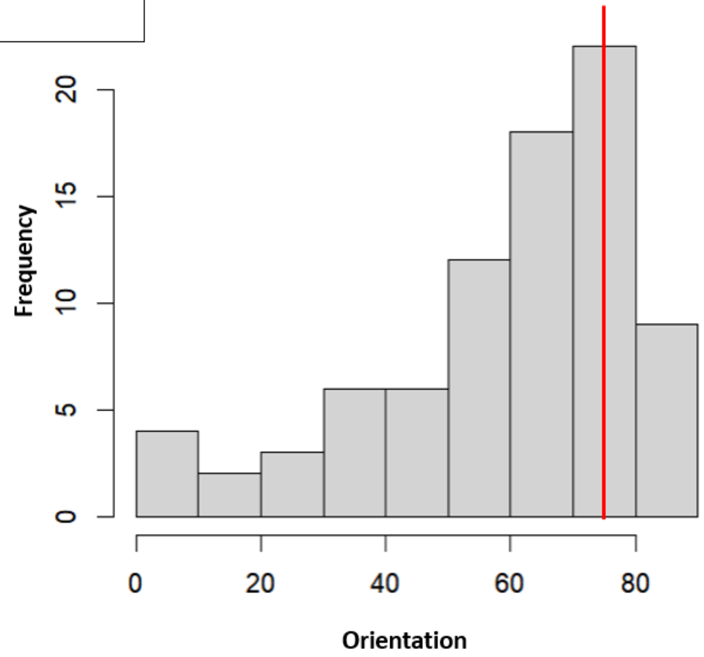
4.1 Identify the row orientation

- Assumption: Along the track distance is smaller than the across the track distance

- Identify the nearest neighbour of each tree peak point and calculate its orientation

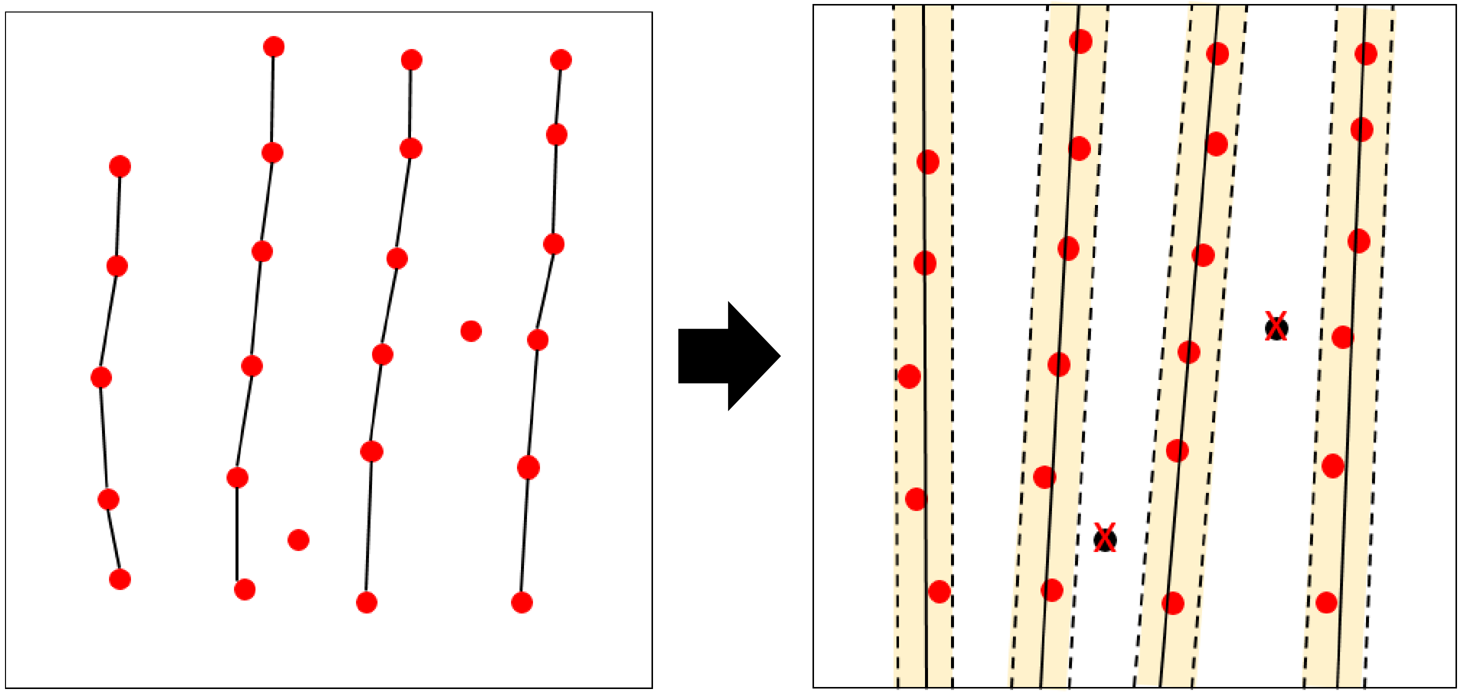
- Generate a histogram of orientation and fit a Gaussian function to find the **general orientation of the rows**





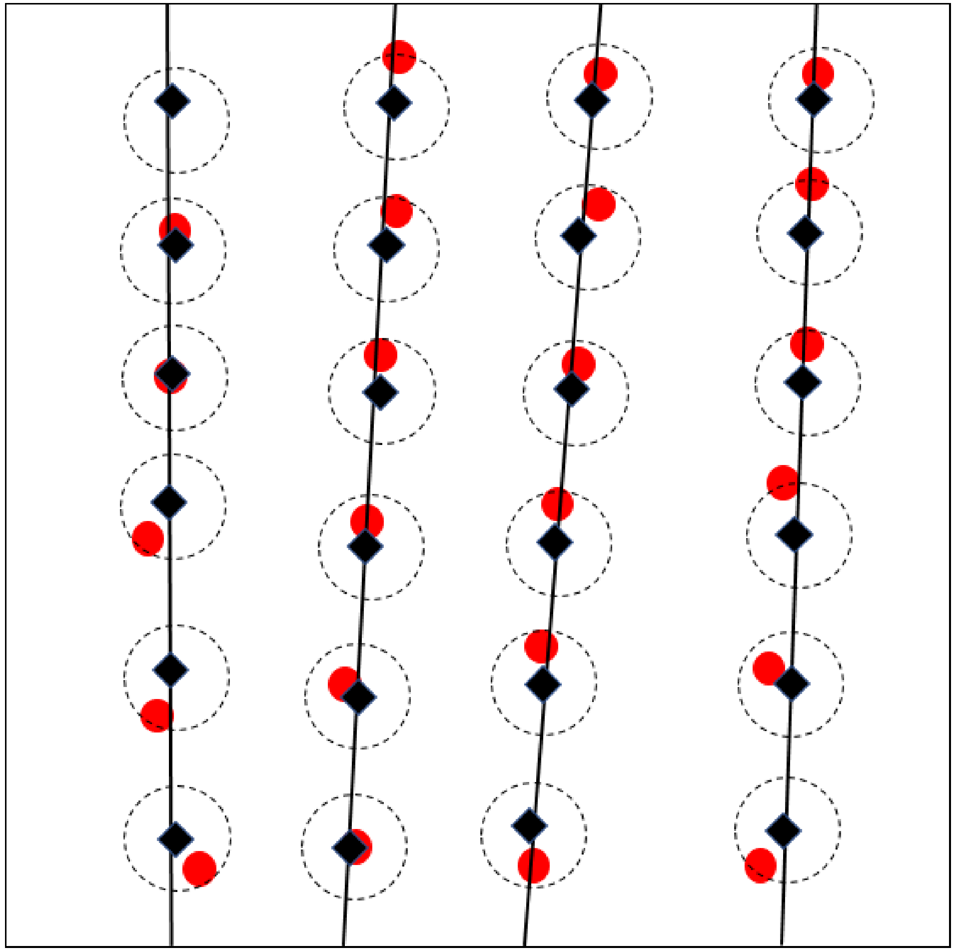
4.2 Detect the planting rows

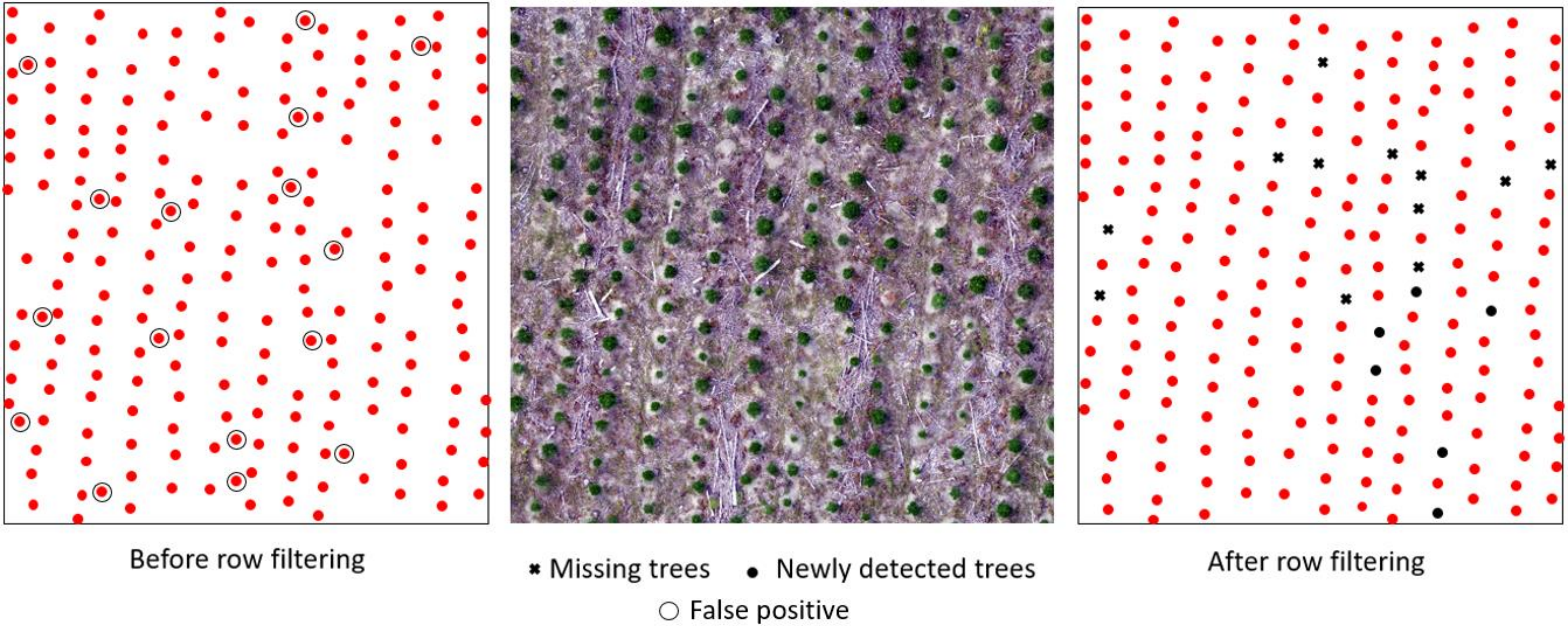
- Identify the near-collinear points that are in alignment with the general orientation
- Fit a local line to the identified collinear tree peak points
- Add a buffer to each side of the line and filter out tree peak points that don't fall within the buffer



4.3 Fine-tune the detected points

- For each tree peak point, two ‘ghost’ points are placed along the track direction in a distance similar to the average planting spacing
- Draw a circle around each ghost point and check for tree peak points within the circle
  - YES: confirm the tree peak point as a tree
  - NO: mark the ghost point as a missing tree
- For missing points: go back to the original point cloud and re-search for a tree peak point within a circle of same size
  - YES: mark the newly detected point as a tree
  - NO: confirm the ghost point as a missing tree



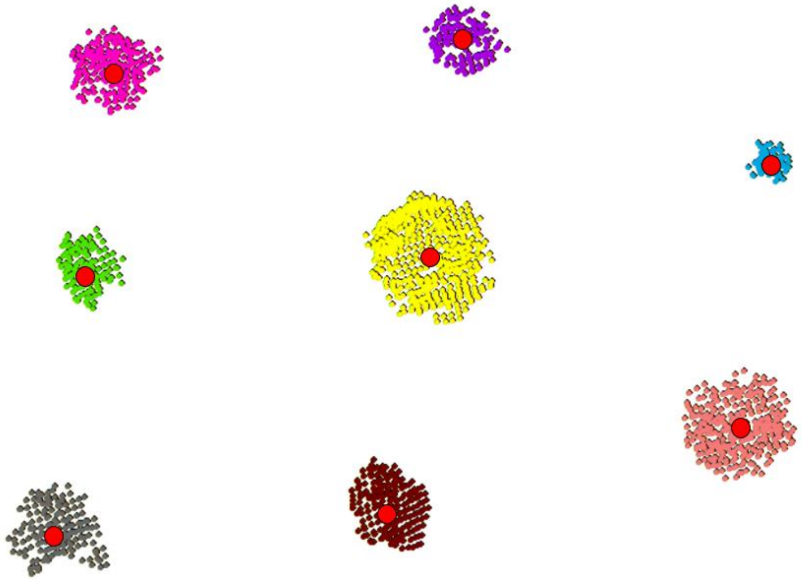

Before row filtering
Missing trees
Newly detected trees
False positive
After row filtering

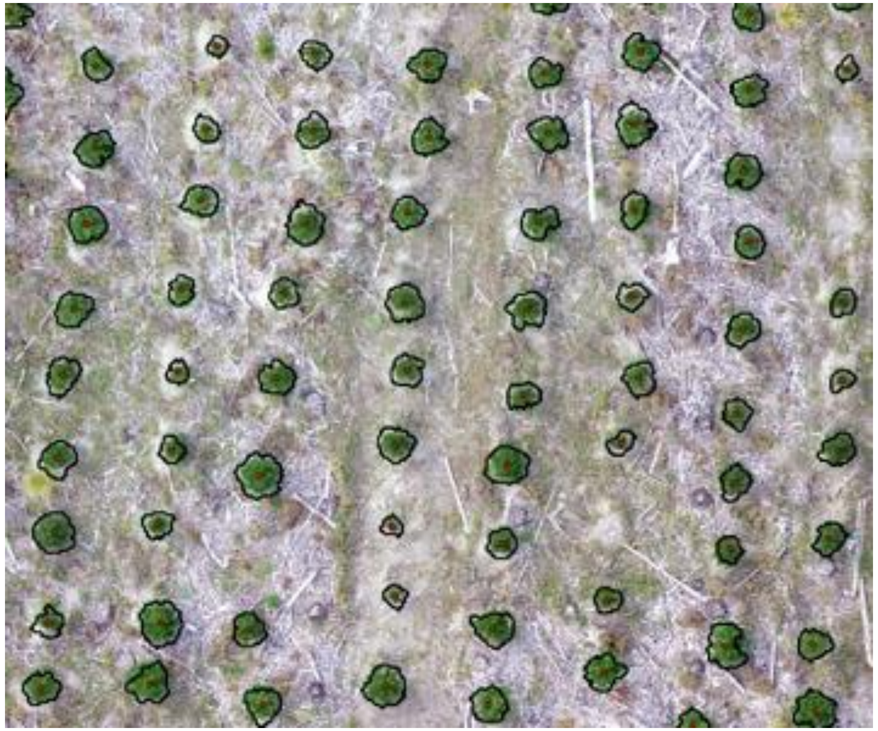
5. Tree segmentation and crown delineation

- By this step, all tree peak points have been re-tested to tackle false detections

- Using the detected tree point as a seed, implement a region growing algorithm to cluster 3D vegetation points into trees segments

- Draw a convex hull around the clusters

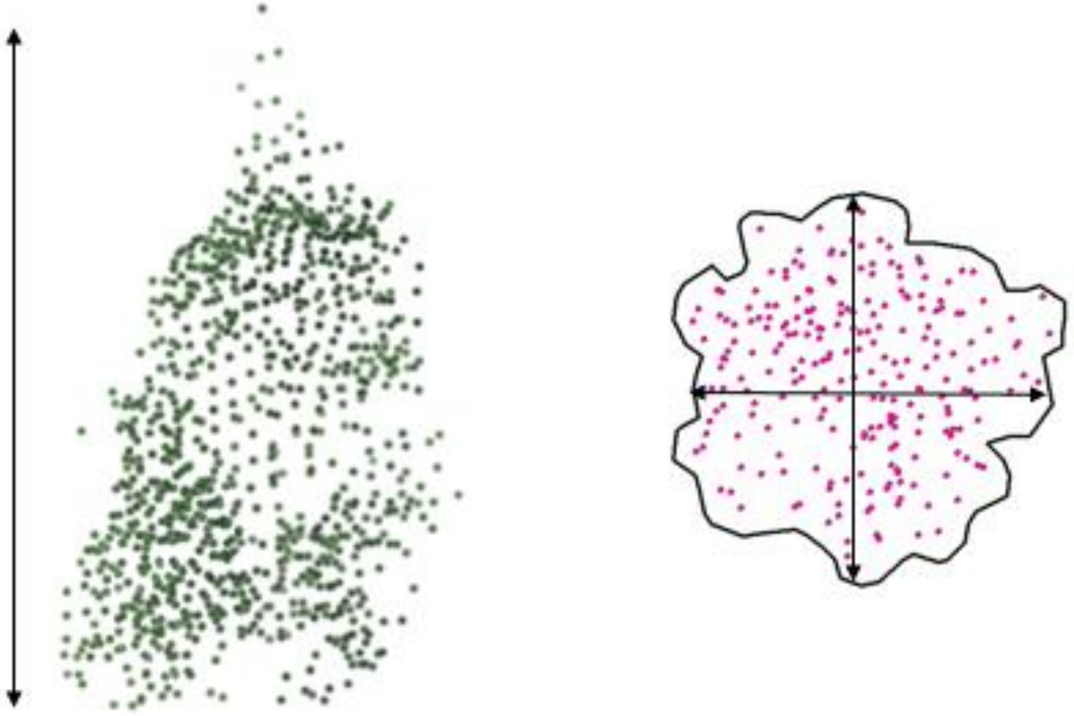


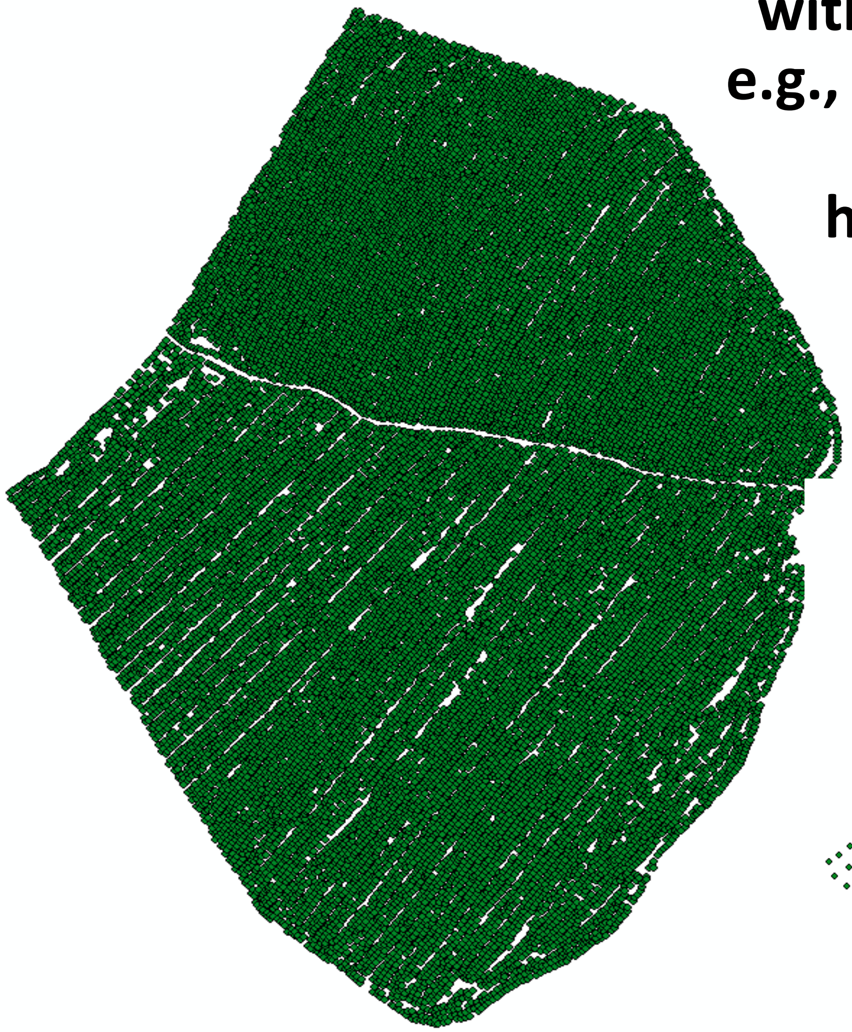


6. Seedling parameter extraction

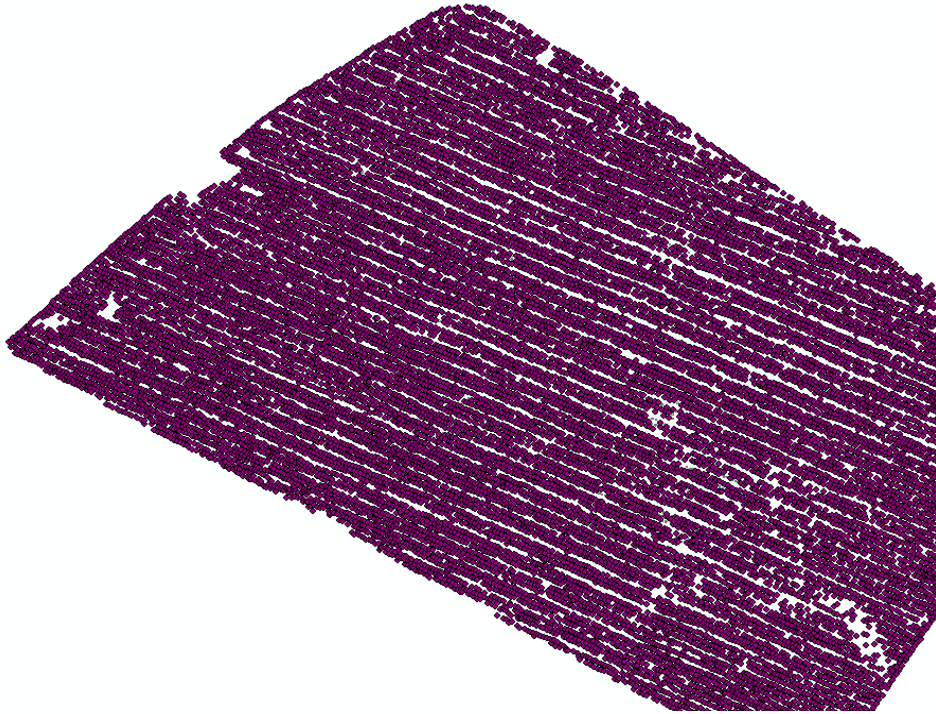
- Extract height and crown dimension parameters from segmented trees

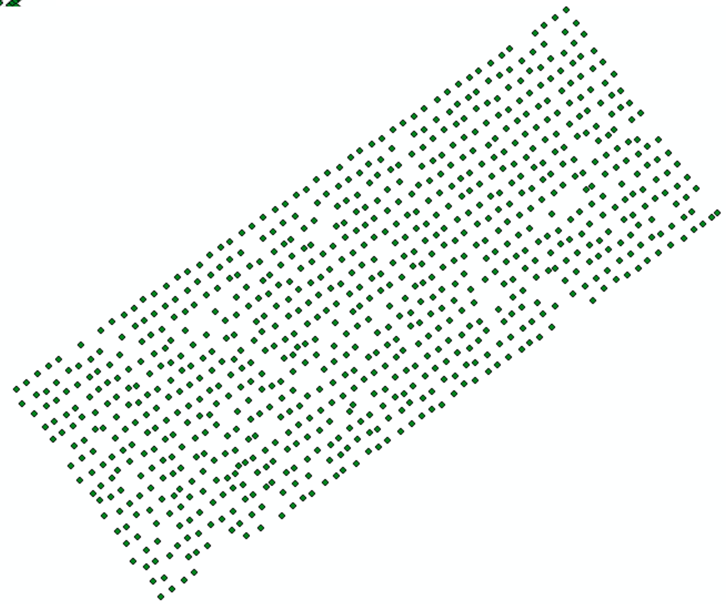
- Output:
  - A spreadsheet with XY location, height and crown dimensions
  - Vector files of detected and missing tree locations

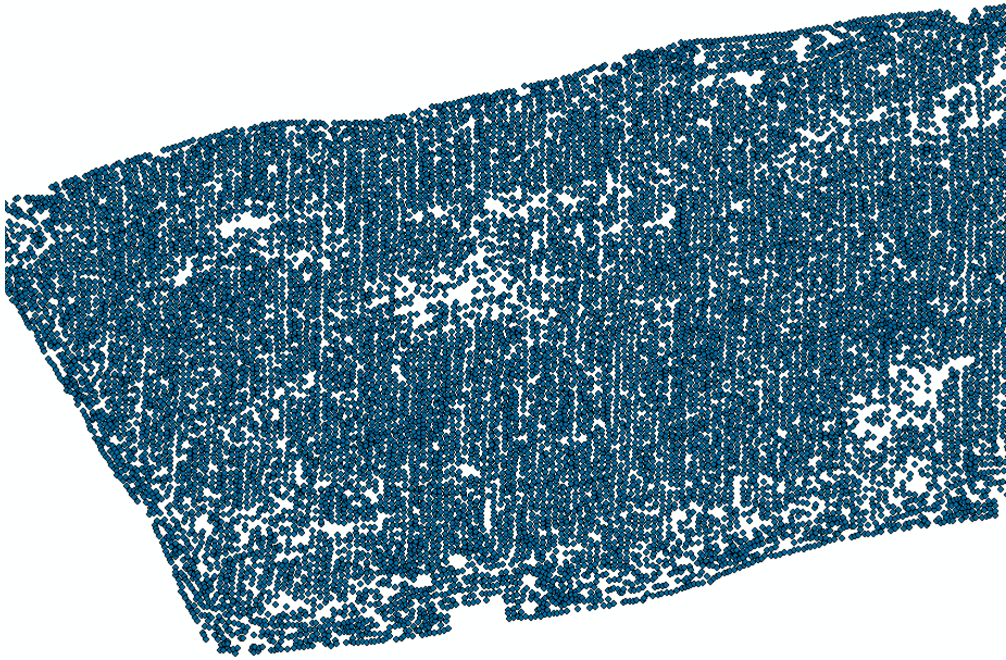




Implemented the pipeline on sites with a wide range of settings e.g., sites with varying levels of weed infestation, harvesting residues and "regens"







Detection accuracy

- Overall accuracy : >93%
- Highest accuracy was seen in a site with
  - ✓Little weeds
  - ✓Fewer number of regens
  - ✓Low level of harvesting residues
  - ✓More even planting spacing

Site		Accuracy %
Kaingaroa	Site1	92.67
	Site2	92.17
	Site3	90.70
Scion nursery	North	96.28
	South	95.89
	West	98.17
Rangipo		98.11
Tarawera		91.17
All sites combined		93.37

- Accuracy improved with each step of processing

	Accuracy %
1. Tree peak detection	87.12
2. Row filtering	90.79
3. Re-testing and fine-tuning	92.21
4. Tree segmentation and crown delineation	93.37
Final output	93.37

In conclusion

- An unsupervised approach was developed for detecting trees using the spatial, spectral and structural information contained in UAV-SfM pointclouds

- The proposed pipeline can be used as
  - ✓ A stand-alone seedling detection tool to detect trees in a range of age classes and site conditions with relatively high accuracy
  - ✓ A supplementary tool that can be implemented to generate cost-effective training datasets needed for supervised tree detection methods

- In wider application the proposed method can be adopted for
  - ✓ Survival analysis
  - ✓ Disease detection
  - ✓ Monitoring of invasive species

- This pipeline can also be modified for usage with DJI-L1 colorized LiDAR data to get more accurate tree characteristics

What’s next?

- Submit the paper
- Publish the code with free access
- Code is written in R and will be available as a collection of functions and scripts that can be run with default parameters
    - ✓ you will only need the path to your UAV-SfM point cloud and average planting spacing as the input
    - ✓ Or you can fine-tune default parameters to suit your site

Thank You!

Sadeepa Jayathunga
Sadeepa.Jayathunga@scionresearch.com