Use of high-resolution drone imagery for crop estimation, health and size of GEM™ and ‘Hass’ avocado trees in New Zealand

Jonathan Dixon[1], Moeava de Rosemont[2], Jordane Champion[3]

[1]Seeka Ltd, Te Puke, New Zealand. [2]Digisky, Tauranga, New Zealand. [3]Silava, Latvian State Forest Institute, Latvia

BACKGROUND

USE OF DRONE IMAGERY IN NEW ZEALAND AVOCADO ORCHARDS

- Seeka uses drone imagery to GPS map orchards and has a database with orchard details of hazards and maps for operational activities
- Drone imagery has further potential to improve orchard management
- Identify issues early or that are hard to measure
- Most New Zealand avocado orchards are small (<10 hectares) requiring imagery to measure individual trees
- The objective of this study was to evaluate high resolution drone imagery for tree height and volume changes that are hard to measure visually and predicting crop load for Hass and GEM™ trees

METHODS

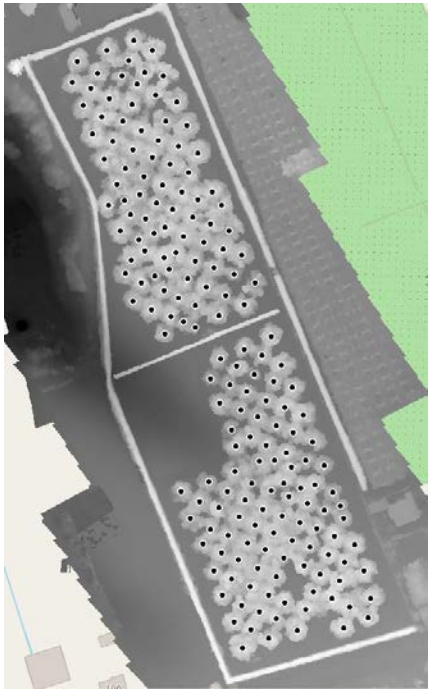
DRONE IMAGERY AND ANALYSIS

- Imagery was collected using a DJI Phantom 4 Multispectral drone flying at 85m altitude, front overlap ratio of 80%, lateral overlap ratio of 70% from the ground surface, unwanted data filtered at 30cm above ground
- The cameras collected images taken at the following wavelengths: Visible light (RGB), Red Edge 730nm, 16nm bandwidth, Blue 450nm, Green 560nm, Red 650nm, 15nm bandwidth and Near Infra Red 840nm with 26nm bandwidth
- Images were taken in clear sunny weather corrected for the time of day, season and angle of shadows
- Pixel resolution was 5cm per pixel for canopy images and 10cm per pixel for terrain imaging, there were hundreds of measurements per tree, tree height was the highest point
- Each tree was approximated by a 2 to 5m (depending on tree age) diameter circle where spectral data was used to calculate Normalised Difference Vegetation Index (NDVI), Normalised Difference Red Edge (NDRE), and Green Normalised Difference Vegetation Index (GNDVI)
- The drone was flown multiple times corresponding to the tree growth cycle
- Analysis of the images was conducted using Agisoft Metashape Pro (V1.8.3) and QGIS (V3.24.3) software

FLIGHT 27/1/2022 MATURE HASS

TREE IDENTIFICATION

Orthophoto



Digital Surface Model

FLIGHT 23/1/2023 MATURE HASS

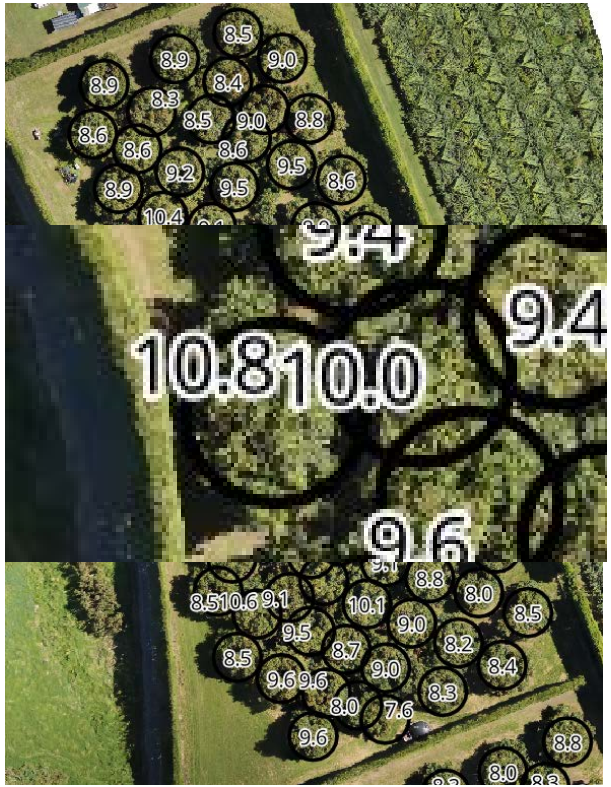
TREE HEIGHT

Drone imagery shows:

•Trees are too tall relative to shelter height (11-12m)

•Trees were pruned to a nominal 6m height in June, trees are now close to original height at 18/5/2022

•A heavy crop (>30t/ha) has been set, growth on trees, may imply more pruning was needed and less fertiliser to manage apparent excess vigour



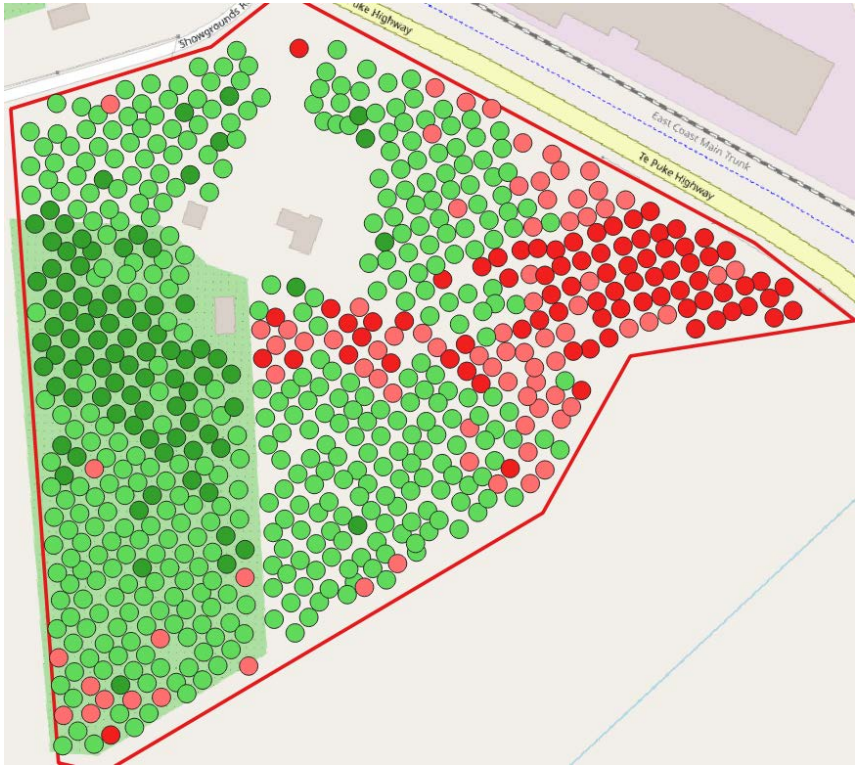
VOLUME DIFFERENCE 9/2/2022 TO 18/5/2022

IDENTIFY PRUNED TREES AND LOW GROWTH TREES – A TOOL TO MEASURE PRUNING

Tree volumes changes can show what was removed by pruning and as a proxy for crop load

Tree colour
- Dark Red: over 25% volume loss
- Light Red: 0 to 25% volume loss
- Light Green: 0 to 15% volume gain
- Dark Green: over 15% volume gain

Ground truthing
- Red trees heavily pruned
- Light Green trees low growth and good fruit set
- Dark Green trees low to moderate fruit set and high vigour



TREE HEALTH YOUNG GEM™ TREES

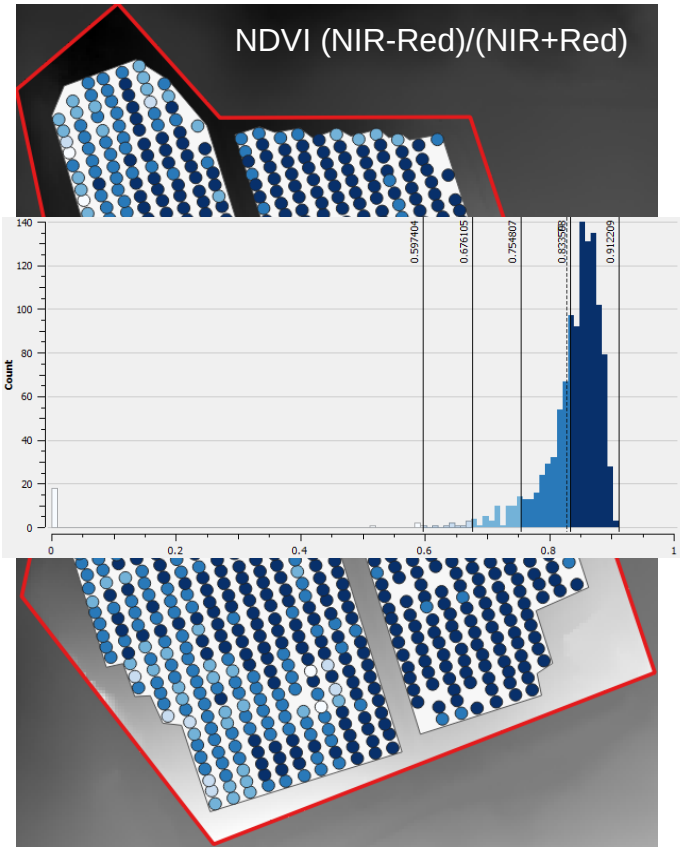
YOUNG GEM TREES AFTER FRUIT SET 27/1/2022

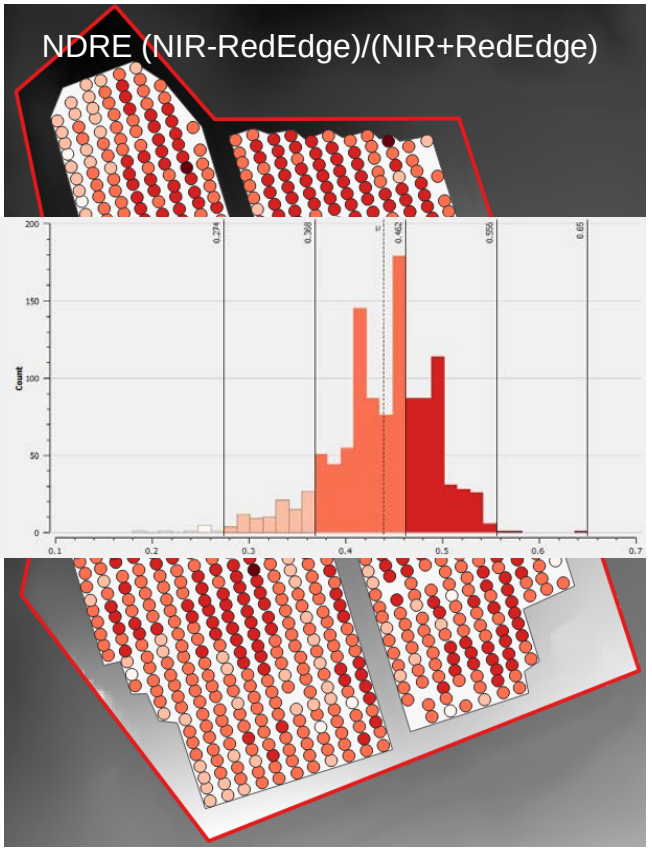
NDVI

Symbol	Values
☑	0.51870 - 0.59740
☑	0.59740 - 0.67611
☑	0.67611 - 0.75481
☑	0.75481 - 0.83351
☑	0.83351 - 0.91221

NDRE

Symbol	Values
☑	0.08938 - 0.13640
☑	0.13640 - 0.18342
☑	0.18342 - 0.23044
☑	0.23044 - 0.27746
☑	0.27746 - 0.32448





UNSEASONAL FROST 7 OCTOBER 2022

TREES WERE IN FULL BLOOM AND STARTING A SHOOT FLUSH

FROST DAMAGE ON YOUNG GEM™ TREES

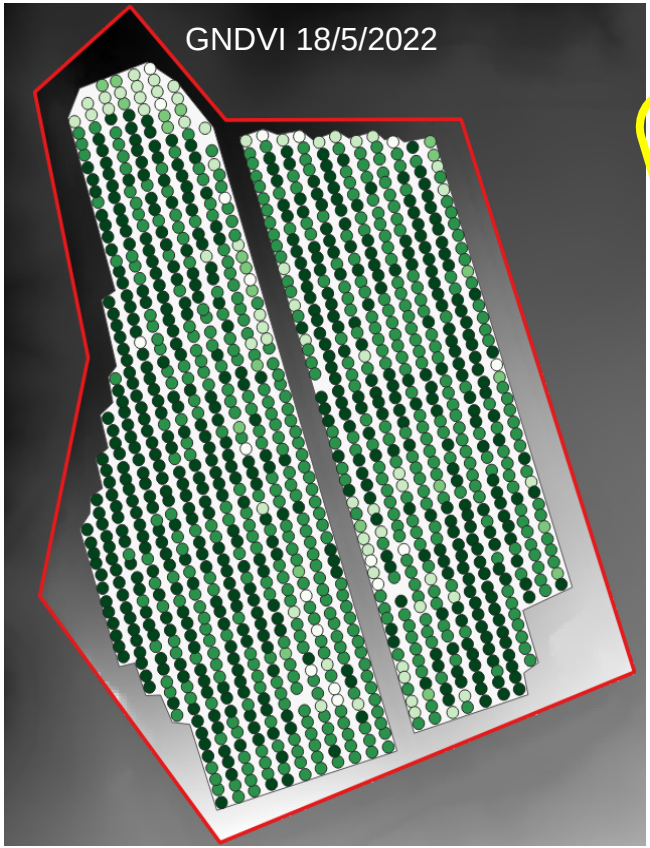
FROST DAMAGE TO FLOWERS SHOWS UP AS TREES BECOMING MORE GREEN

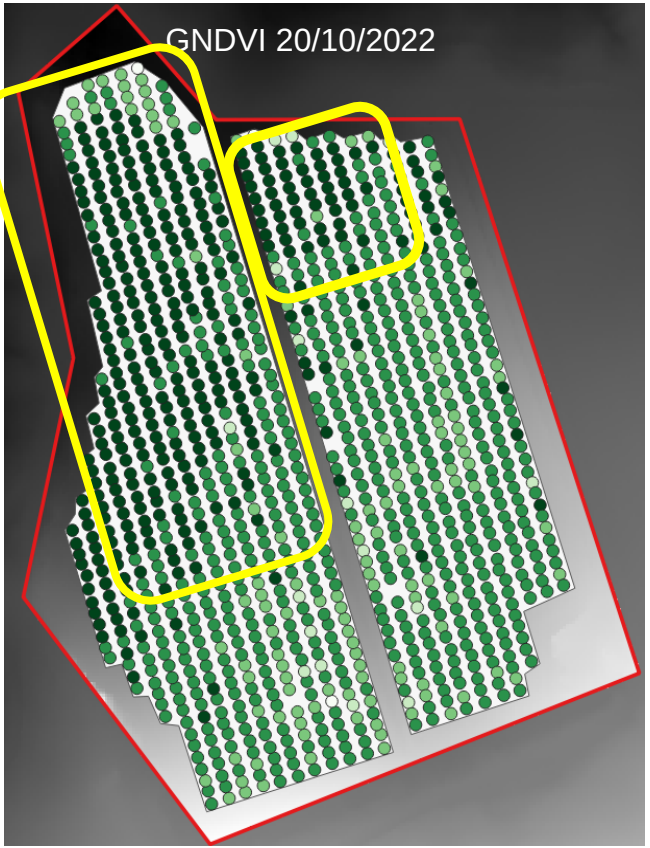
18/5/2022

Symbol	Values	Legend
☑	0.000000 - 0.763227	0 - 0.7632
☑	0.763227 - 0.776659	0.7632 - 0.7767
☑	0.776659 - 0.784412	0.7767 - 0.7844
☑	0.784412 - 0.793667	0.7844 - 0.7937
☑	0.793667 - 0.843880	0.7937 - 0.8439

20/10/2022

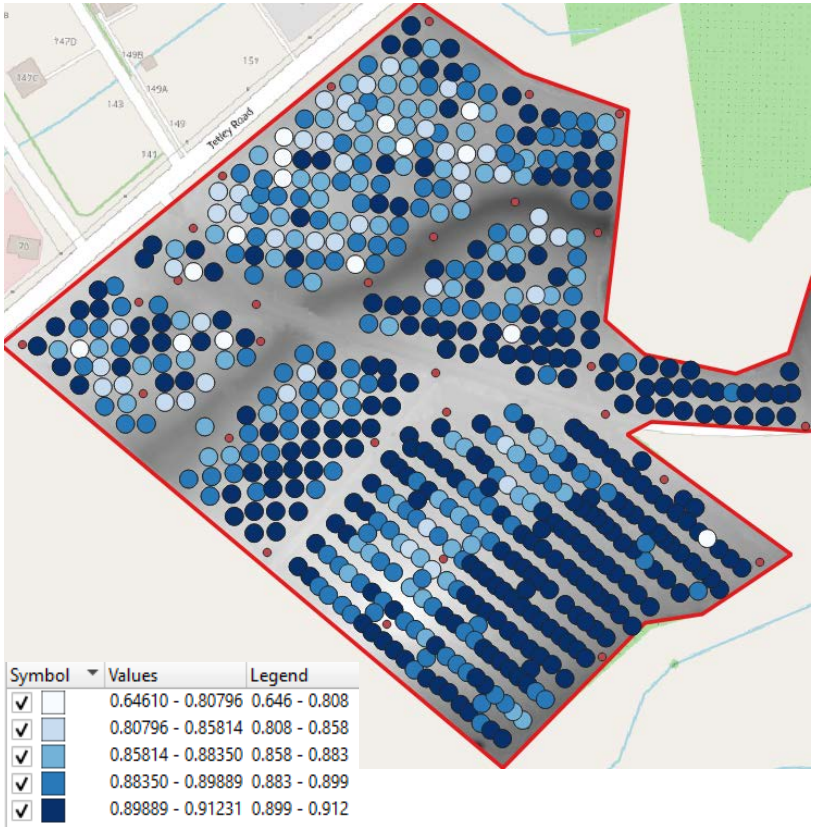
Symbol	Values	Legend
☑	0.30460 - 0.39984	0.305 - 0.4
☑	0.39984 - 0.49509	0.4 - 0.495
☑	0.49509 - 0.59034	0.495 - 0.59
☑	0.59034 - 0.68558	0.59 - 0.686
☑	0.68558 - 0.78083	0.686 - 0.781





CROP ESTIMATION MATURE HASS

HASS 20 YEARS OLD USING NDVI 18 MAY 2022



- Tested NDVI, GNDVI and NDRE to predict individual tree crop load
- This orchard had a wide range of leaf vitality and crop loads
- Tested the prediction against a “ground truth” assessment of individual tree crop load estimates in late February on two orchards
- Classified crop load as None, Light, Medium and Heavy
- Used orchard average against historical yield for crop estimate
- NDVI was best at crop prediction across all orchards

CROP ESTIMATES

MATURE HASS

Orchard	NDVI predicted estimate	Yield estimate t/ha	Average Yield t/ha	Notes
A	Medium	9.0	11.1	Reference
B	Heavy	22.0	11.8	Matches ground truth
C	Heavy	34.0	13.4	Matches ground truth
D	Heavy	23.0	11.0	ON crop expected
E	Light	12.0	16.3	ON crop expected

- Prediction based on the 18 May 2022 flight
- NDVI estimates will be confirmed at harvest

CONCLUSION

USES AND PRACTICAL IMPLICATIONS

High resolution drone imagery has practical use for small avocado orchards

Continue investigating using drone imagery for:

- Measuring if pruning targets for tree height and volume have been met
- Determining if shelter trees are the right height relative to the avocado trees
- Crop estimation early when the fruit are too small to count or see easily


Seeka
SELECT EXCELLENCE