

Remote sensing of Australian plantation Forests: the resolution trade-off

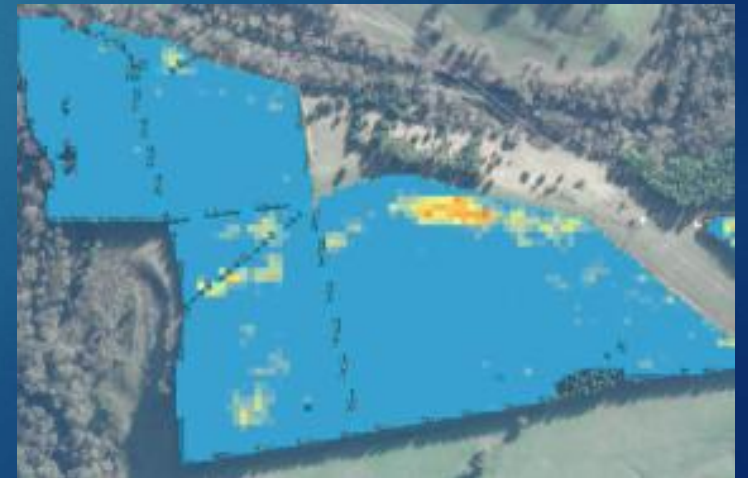
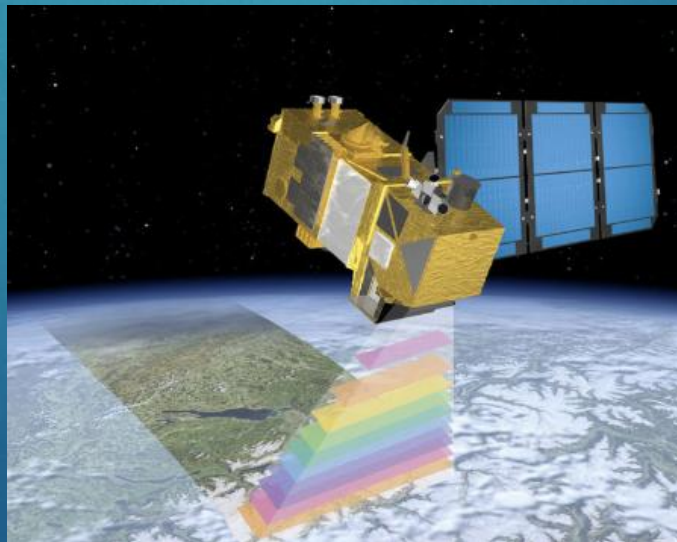
Christine Stone – NSW DPIRD Forest Science
NIFPI Project: Evaluation of Remote Sensing Approaches
for Plantation Health



Spatial and spectral resolution, and cost trade-offs of remotely sensed, optical imagery illustrated using results from the NIFPI project:

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'Evaluation of remote sensing approaches for plantation health'



Research Team

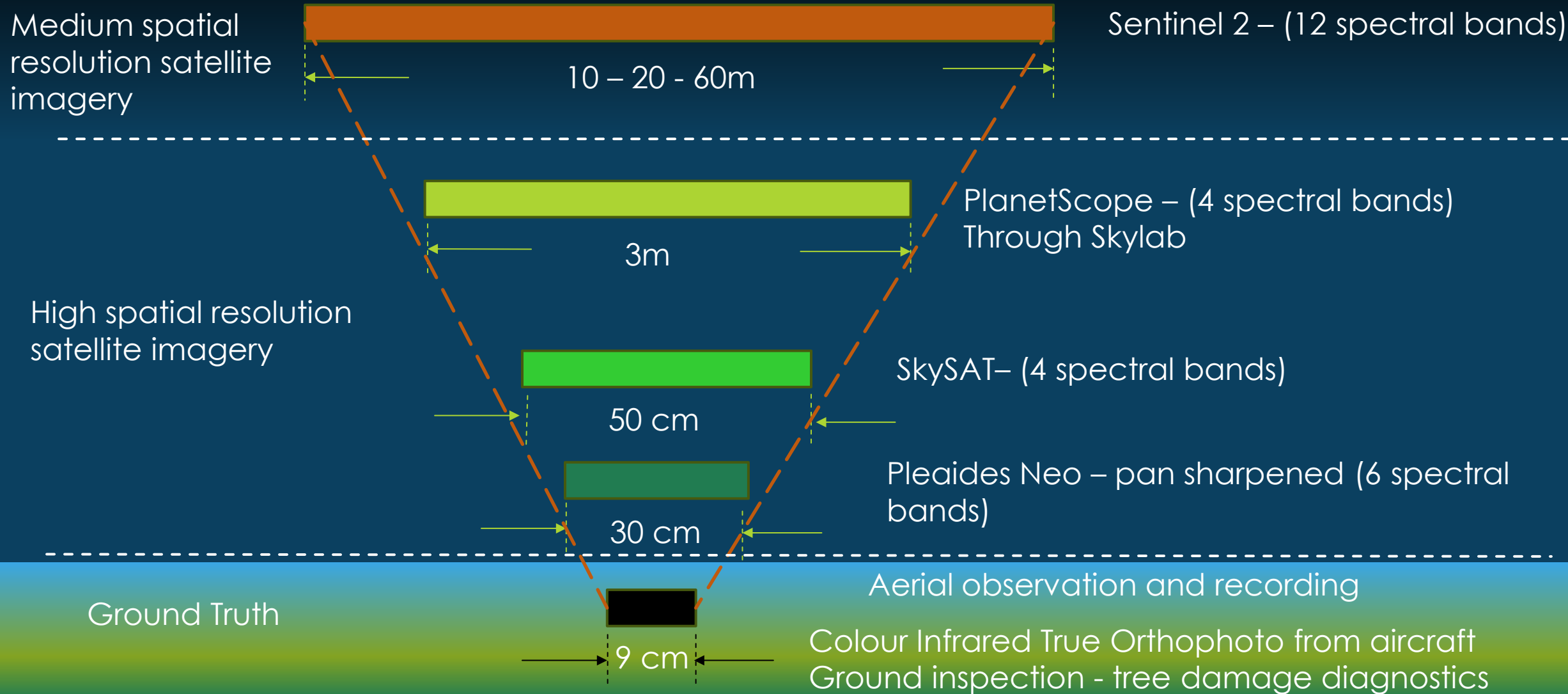
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- ▶ David Bruce, Michael Hillman, Grant Pearse – Flinders University
- ▶ Christine Stone, Mingzhu Wang, Angus Carnegie, Matt Nagel – NSW Government (NSW – DPIRD)
- ▶ Dianne Patzel – University of South Australia

Collaborating companies include

- ▶ Forestry Corporation of NSW
- ▶ HQPlantations
- ▶ Green Triangle Forest Health group
- ▶ A NIFPI funded project

Hierarchy of platforms and resolutions



Research sites across Australia in 2023 & 2024

3 regions and 12 sites

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Green Triangle (GT)

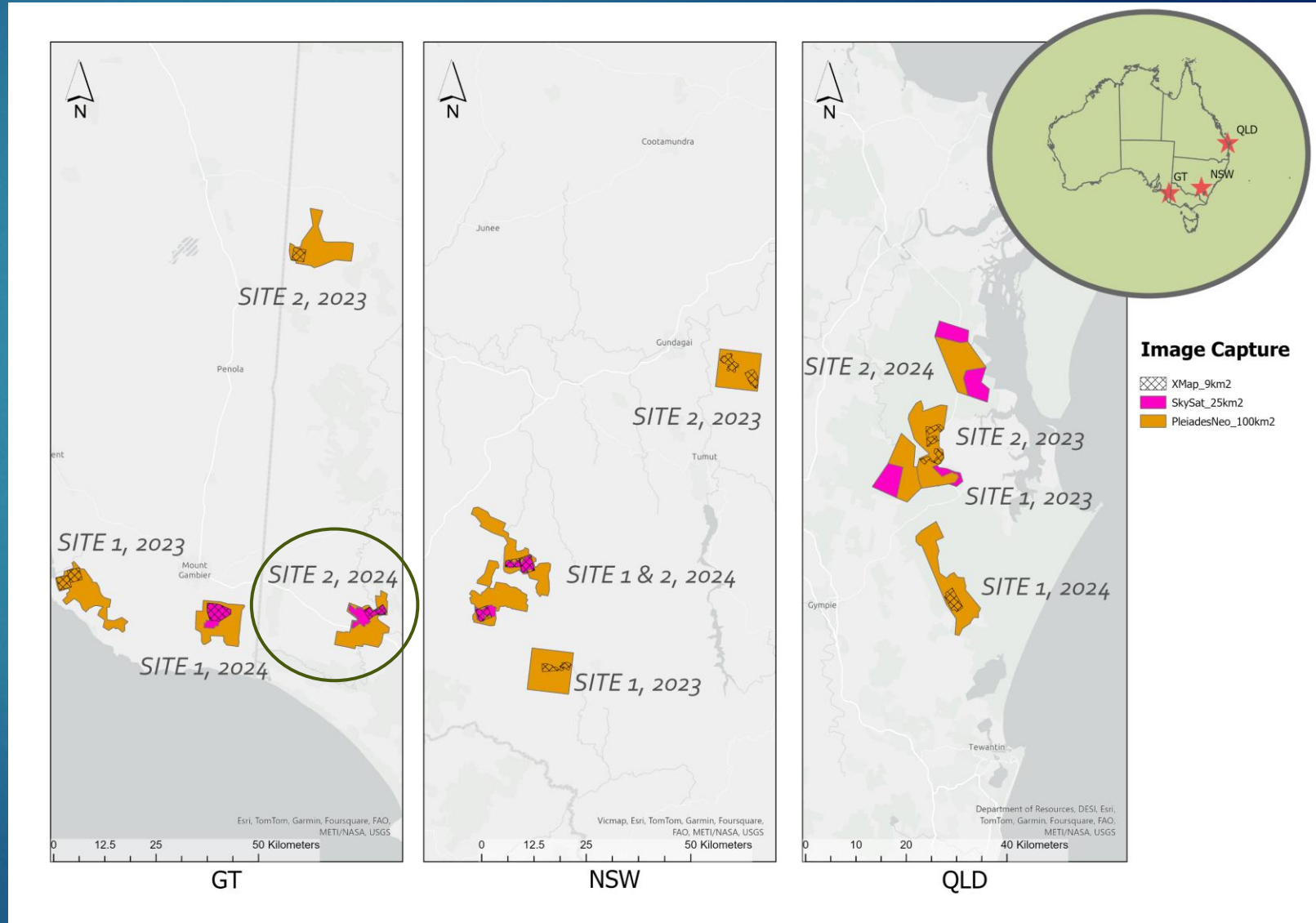
- ▶ 4 sites; 2 in SA 2 in Vic
- ▶ *P. radiata*
- ▶ **Example = 2024 GT Site 2**

New South Wales (NSW)

- ▶ 4 sites near Tumut
- ▶ *P. radiata*

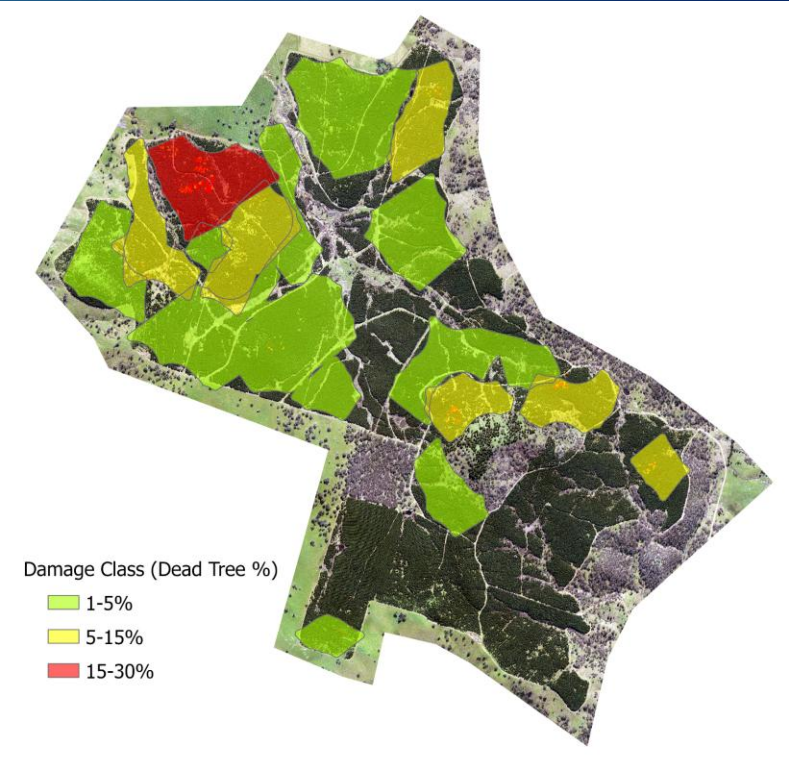
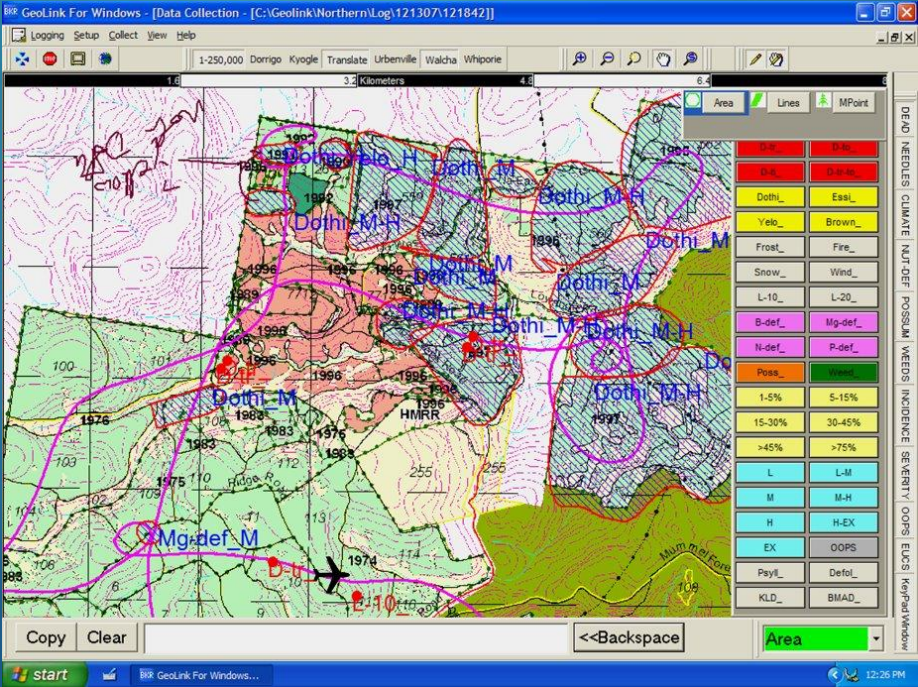
SE Qld Fraser Coast (QLD)

- ▶ 4 sites
- ▶ *P. radiata*, *P. elliotii* and other hybrids



Plantation health surveillance

Currently, plantation health surveillance in NSW and Green Triangle includes **annual aerial sketch** mapping and ground-based validation



Creating “ground truth”

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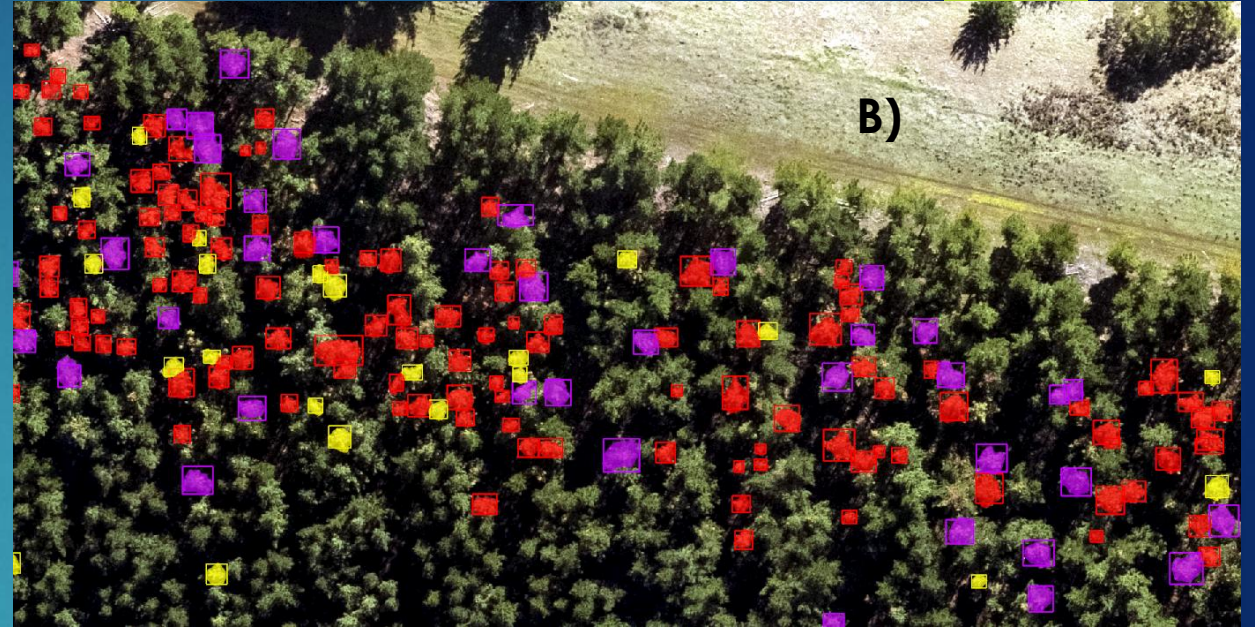
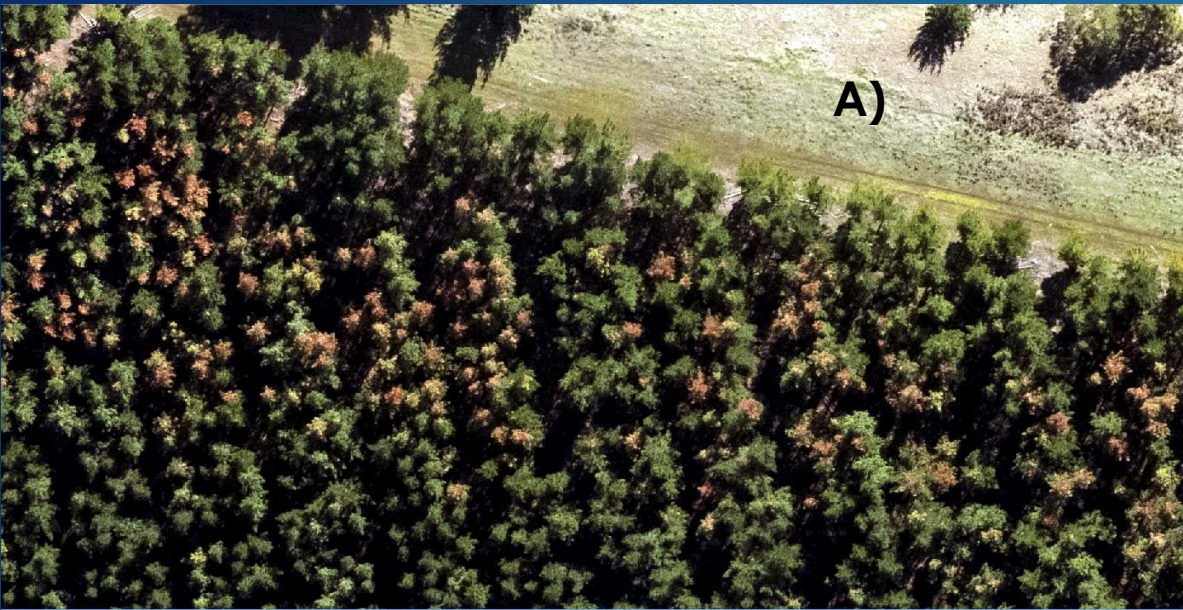
- ▶ Aerial sketch mapping – manually sketched polygons and estimated damage severity classes.
Damaging agents often diagnosed during the flight
- ▶ Aerial camera imagery and AI analysis
Spatial resolution 9.5 cm, Spectral bands = Blue, Green, Red

Study site example of canopy disturbance



Damage symptoms = Dead and dying trees, briefly presenting yellow needles on branches & entire crowns, before needle turn red/brown in colour.

Disturbance agent = *Diplodia sapinea* (a fungal needle blight)



Individual tree crown assessment

A) RGB aerial image (9 cm pixels)

Modelled crown detection, segmentation and classification

B) YOLO algorithm (object based) + SAM = bounding boxes + classification + crown segmentation

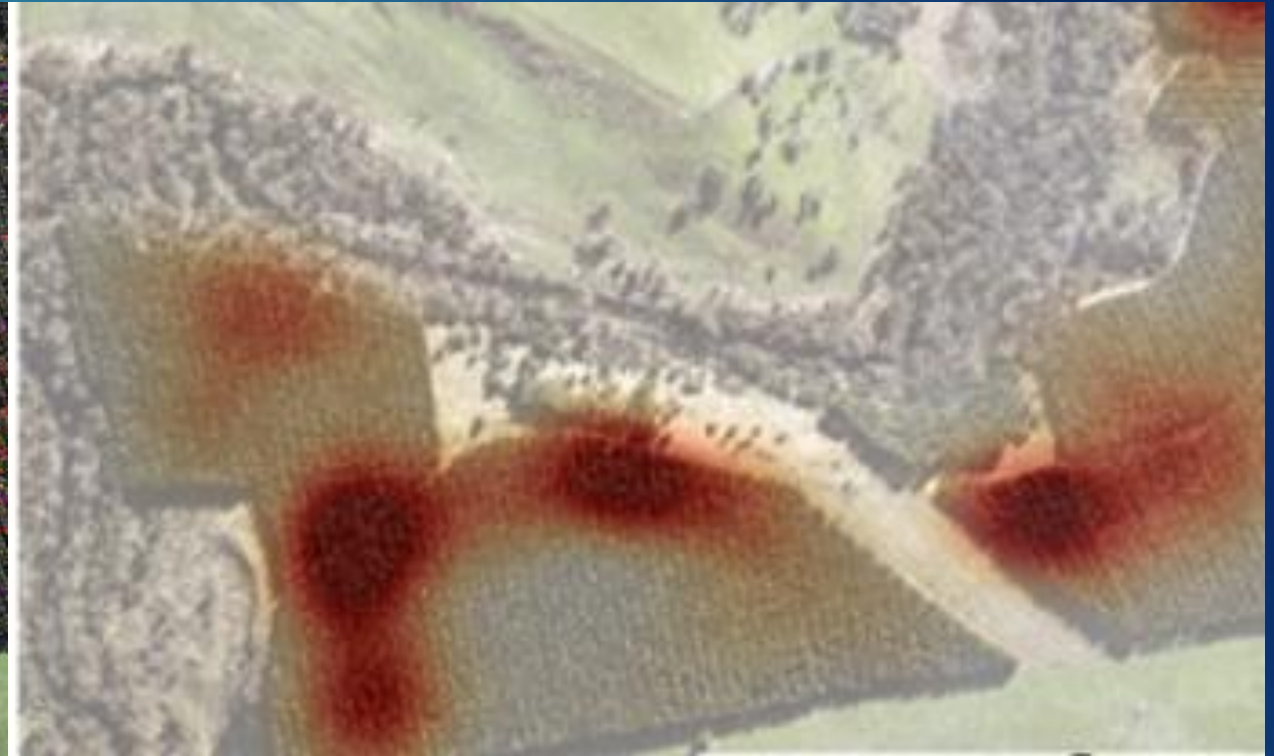
C) Segformer algorithm (pixel based classification)

Allows for training/validation of satellite imagery and targeted on-ground inspections

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Classified aerial imagery



'Heat map'

Future directions:

Apply to UAV camera imagery

Integrate modelling workflow with ALS data from ALS/camera systems

Medium resolution satellite image acquisition and processing – *Sentinel-2*

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- ▶ 12 spectral bands, 10 or 20m pixels, 5-day revisit time
- ▶ Data accessed in cloud through **Open Data Cube** via Digital Earth Australia (DEA)
- ▶ Forest Disturbance Index (FDI) = Tasseled cap Brightness – (Greenness + Wetness)
- calculated for every pixel as a time series

FDI

Lose ability to distinguish individual trees

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Sentinel-2 10m pixel size



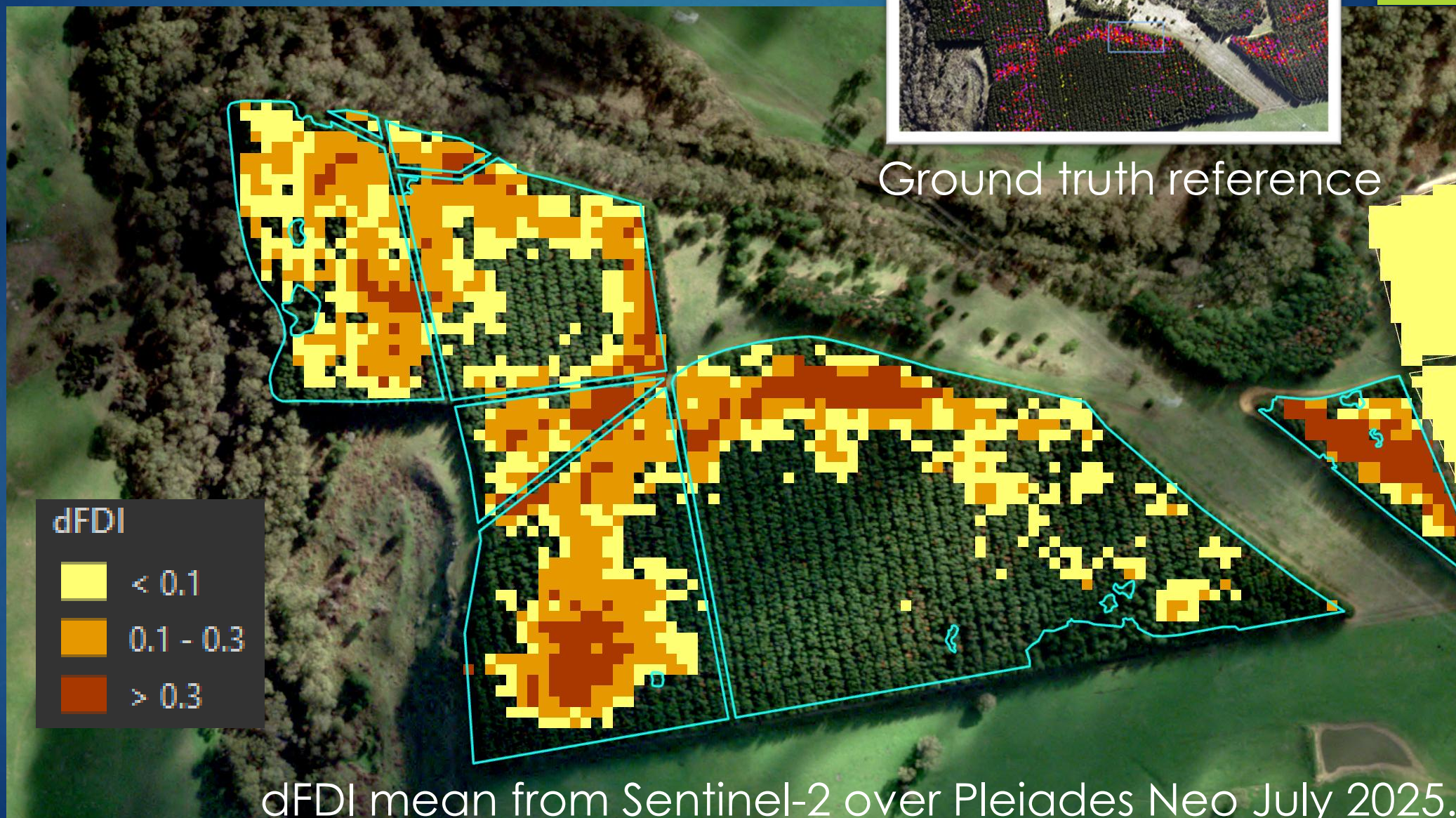
Aerial Image 10cm pixel size

FDI

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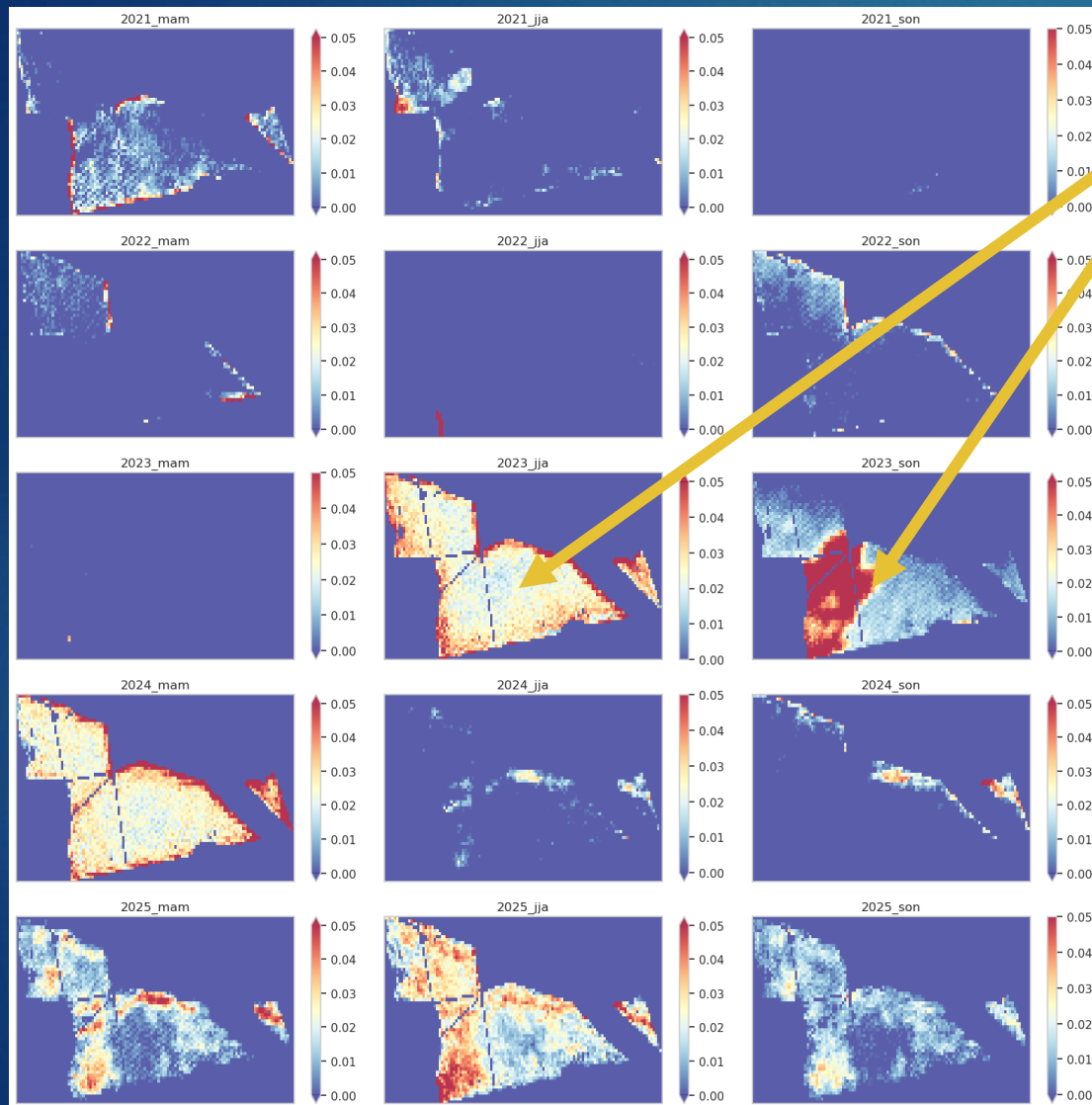
Ground truth reference



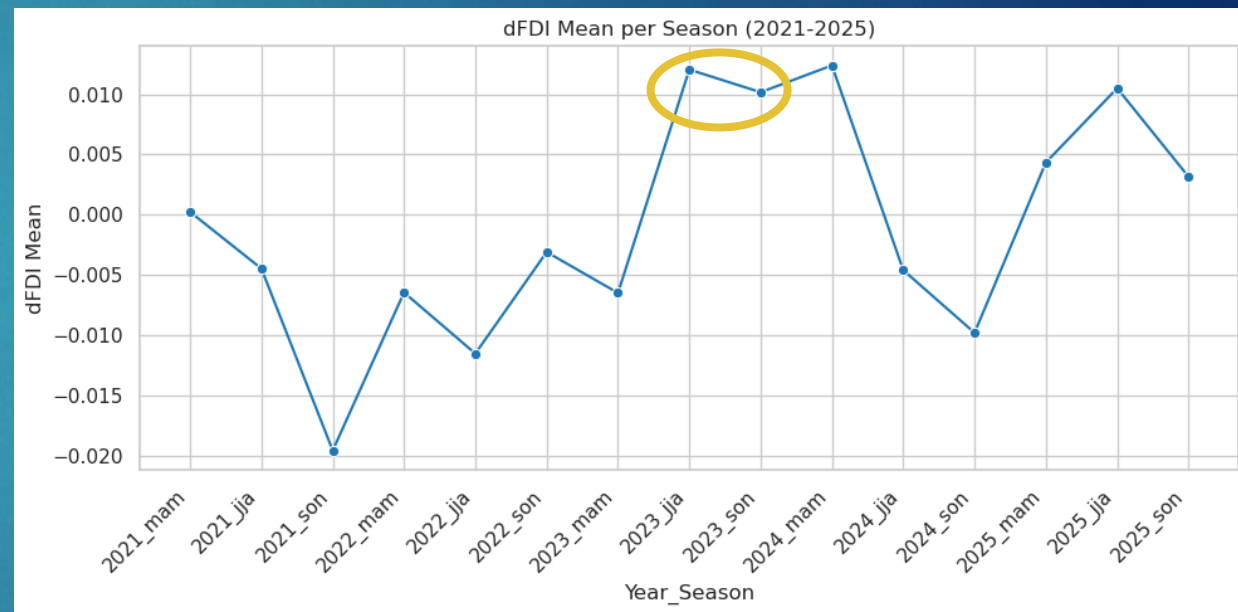
dFDI mean from Sentinel-2 over Pleiades Neo July 2025.

2021 to 2025: Δ FDI (mean) timeseries

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cloud



Dense clouds are removed and thin clouds largely avoided by use of geo-median. But thin clouds combined with few cloud free images (i.e. Winter) can remain undetected.

High resolution satellite and processing

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SkySat (July 2025)



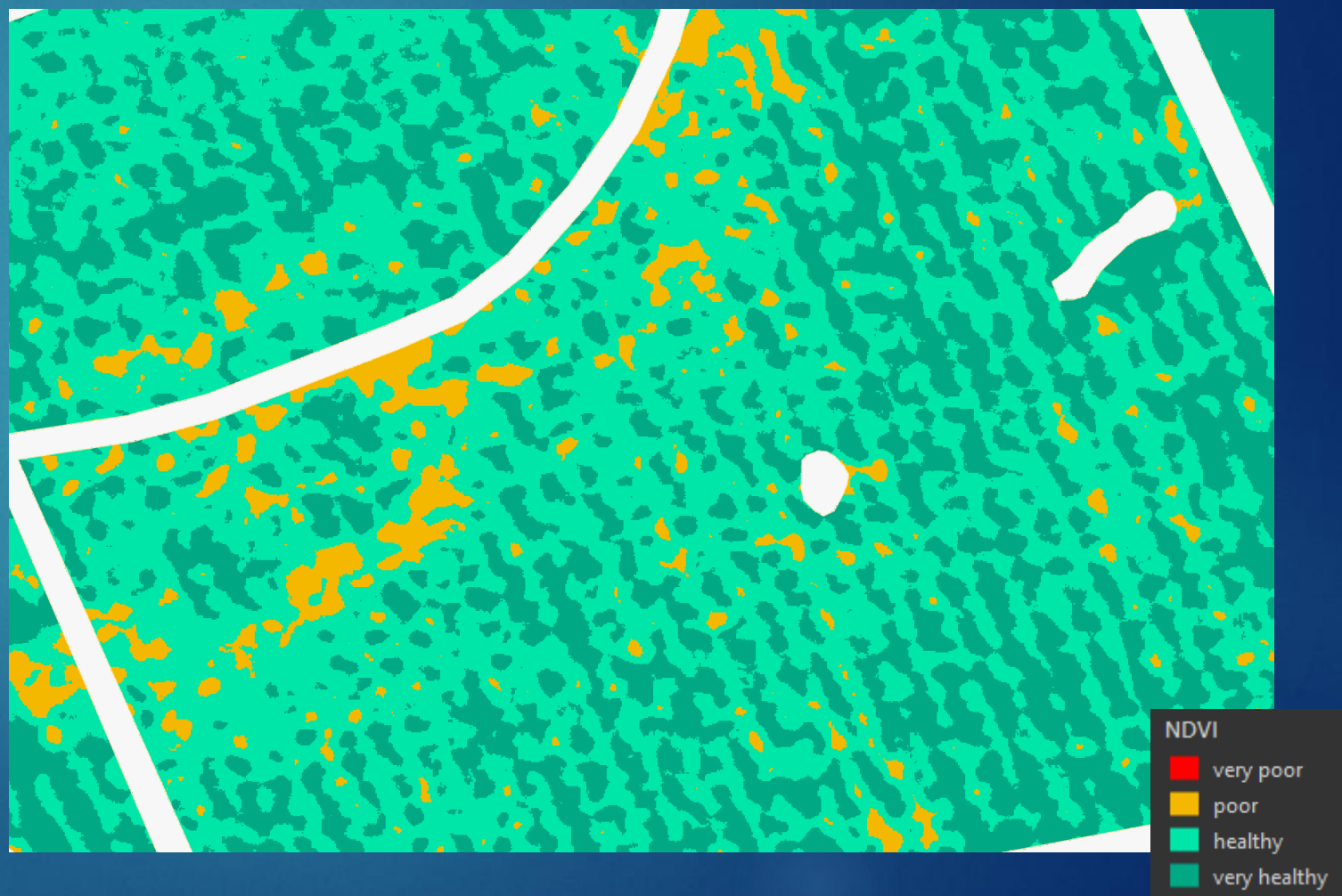
Pleiades Neo (July 2025)

SkySat

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- ▶ 0.5m spatial resolution
- ▶ Planet satellite – 21 satellite constellation
- ▶ High re-visit time (i.e. high temporal resolution)
- ▶ 4 spectral bands (Blue, Green, Red, Infra Red)

Inter row spaces are not discernible



Pleiades Neo

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- ▶ 1.2m spatial resolution
- ▶ Pan sharpened to 0.3m
- ▶ 6 spectral bands (Deep Blue, Blue, Green, Red, REdge, Near Infra Red)

- Pleiades Neo Tree Health Index (MNDVI)
- Can detect individual (post thinning) crowns
- Image alignment and masking critical.

Inter row spaces evident



Functionality Comparisons

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	Aerial sketch mapping	Aerial imagery	Pleiades Neo satellite	SkySat satellite	Sentinel-2 satellite
Tree level (crown)	✓	✓	✓ ¹	✓ ¹	X
Revisit time	Low	Low	High ²	Very High ²	High
Change detection	X	X	✓	✓	✓
Diagnosis	✓	✓ ³	✓ ³	✓ ³	X
Coverage	Plantations	Plantations	Region	Regions	State
Relative Cost	Very High	Very High	High	Moderate	Low

¹ depends on size of tree crowns;

² challenges with geometrical precision;

³ possible if identification of disturbance of affected stand already established;

Cost Comparisons

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Cost comparison shows least expensive solution is via medium resolution satellite imagery (Sentinel 2) and most expensive is via aerial imagery. However, each solution requires qualification.

Satellite	Acquisition Costs per ha (cents)	Processing Costs per Ha (cents)	Data Storage / backup costs (cents)	Total Costs per ha (Cents)
Sentinel 2	0.0000	0.0323	0.0000	0.03
SkySAT (Subscription)	15.5114	12.4000	0.0137	27.93
SkySAT (SkyFi - one off tasking)	20.0000	12.4000	0.0137	32.41
Planet Scope (via SkyLab)				48.42
Pleaidess Neo	50.0000	10.0000	0.0547	60.05
Aerial Sketch Mapping				92.6
Aerial Imagery	262.3829	22.2222	0.0183	284.62

Increases in cost

Increase in resolution

Increase in information

- ▶ FDI (Sentinel 2):
 - ▶ **Low cost**; application over **large spatial extents**; can be used to explore across **space and time**.
 - ▶ Can be used to **identify** patches and compartments with **health issues**.
- ▶ Tasking of high spatial resolution satellite imagery (Pleiades Neo and SkySat):
 - ▶ **High cost** and thus not applicable across all plantation forests in Australia.
 - ▶ **Geometrical and radiometrical issues** (particularly SkySat) can lead to errors in reporting change.
 - ▶ **Masking** for non-tree canopy is required.

Vision for a satellite-based forest disturbance monitoring system

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Regular satellite observations of forests



High Res
satellite tasked

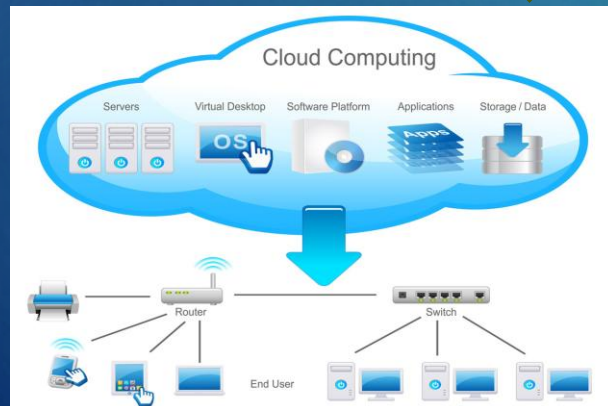
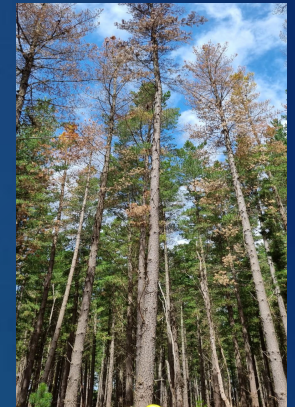
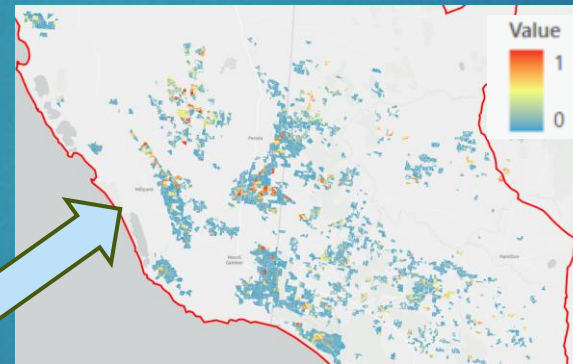
Image downlink

Image prep &
uplink to cloud



Cloud
processing

Disturbance detected



Forestry GIS
interface



High res processing



Commencement of a new FWPA funded project 'GIS-Integrated Forest Health Surveillance: A Satellite Based Operational System for Australian Softwood Plantations'

- ▶ *Objectives:*
- ▶ Implement a cloud-based forest health monitoring service for the Australian pine plantation sector based on the Forest Disturbance Index.
- ▶ Deliver a web-based portal with two-way GIS integration that allows forests to investigate detected disturbances.
- ▶ Develop a prototype high-resolution monitoring capability that automatically tasks commercial satellites for areas flagged by the FDI analysis.
- ▶ *Research team:*
- ▶ David Bruce, Michael Hillman, Grant Pearse (Flinders Uni); Pete Watt, Chaplin Chan, Andrew Holdaway (Indufor Asia Pacific); Christine Stone, Angus Carnegie (NSW DPIRD)



Thank you for listening