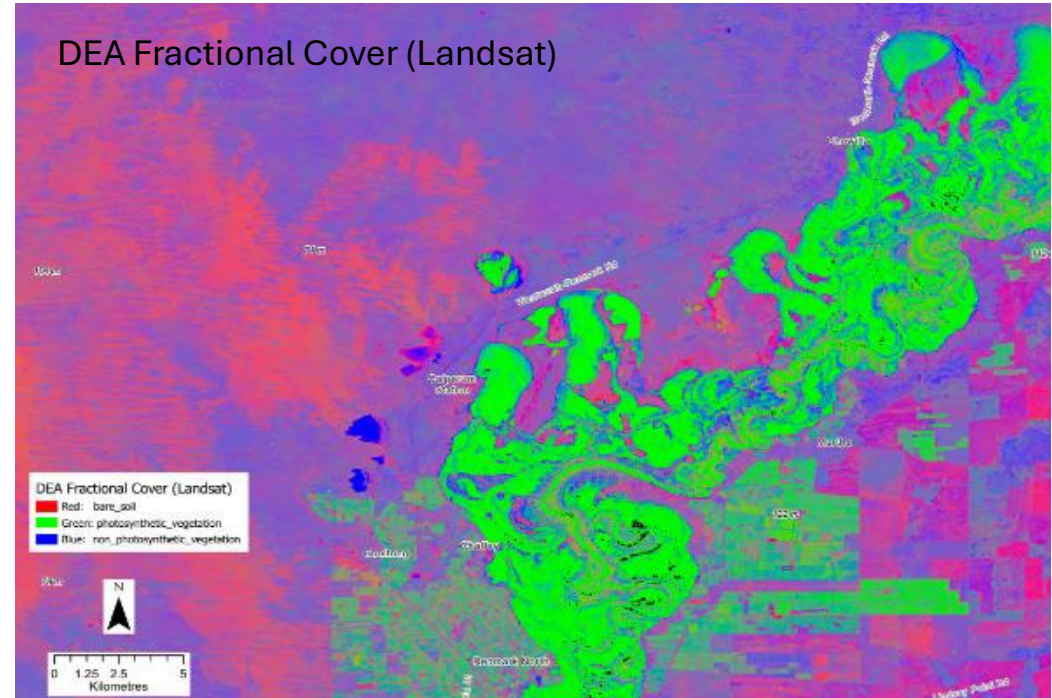
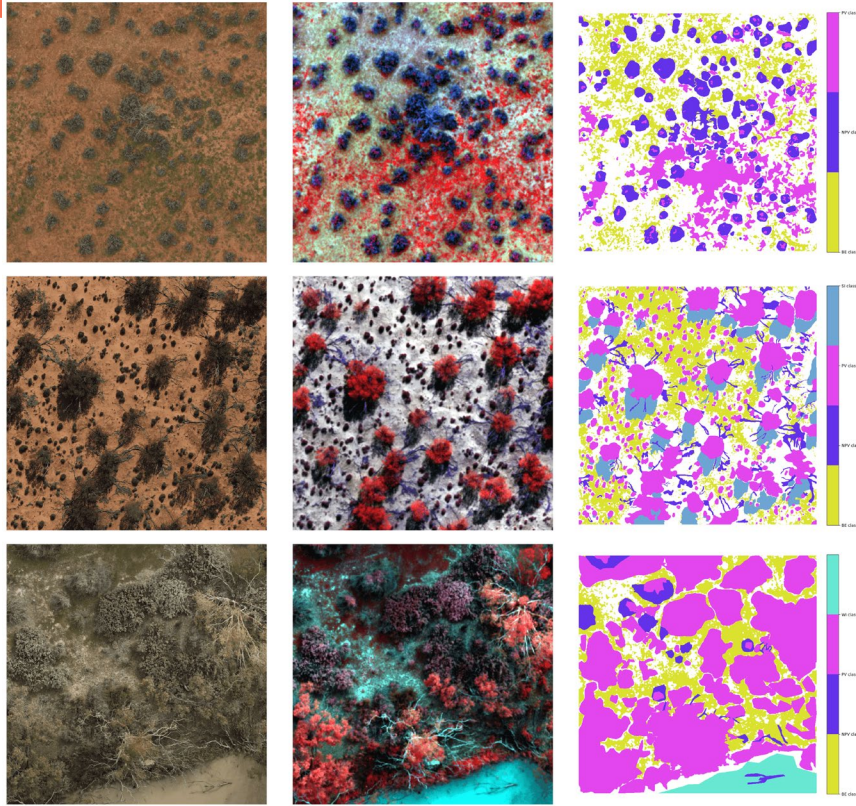
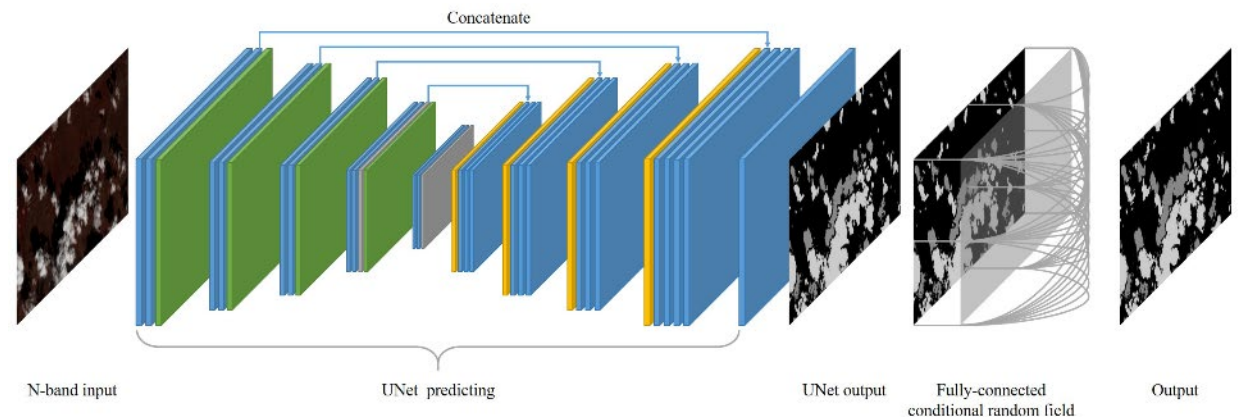


Deep learning for fractional vegetation cover (FVC)

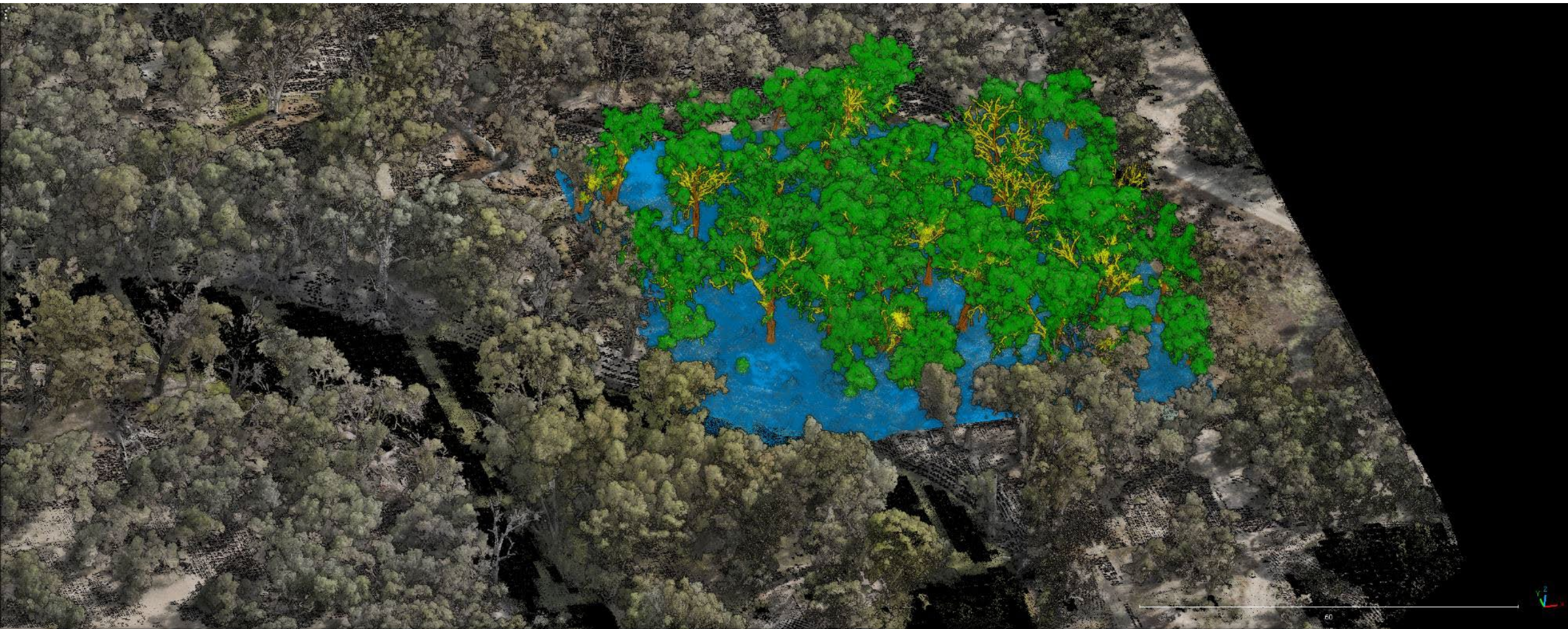


Robust Convolutional Neural Network (CNN) for detection and classification of ecosystem building blocks

UTAS PhD project: Laura Sotomayor Ramirez



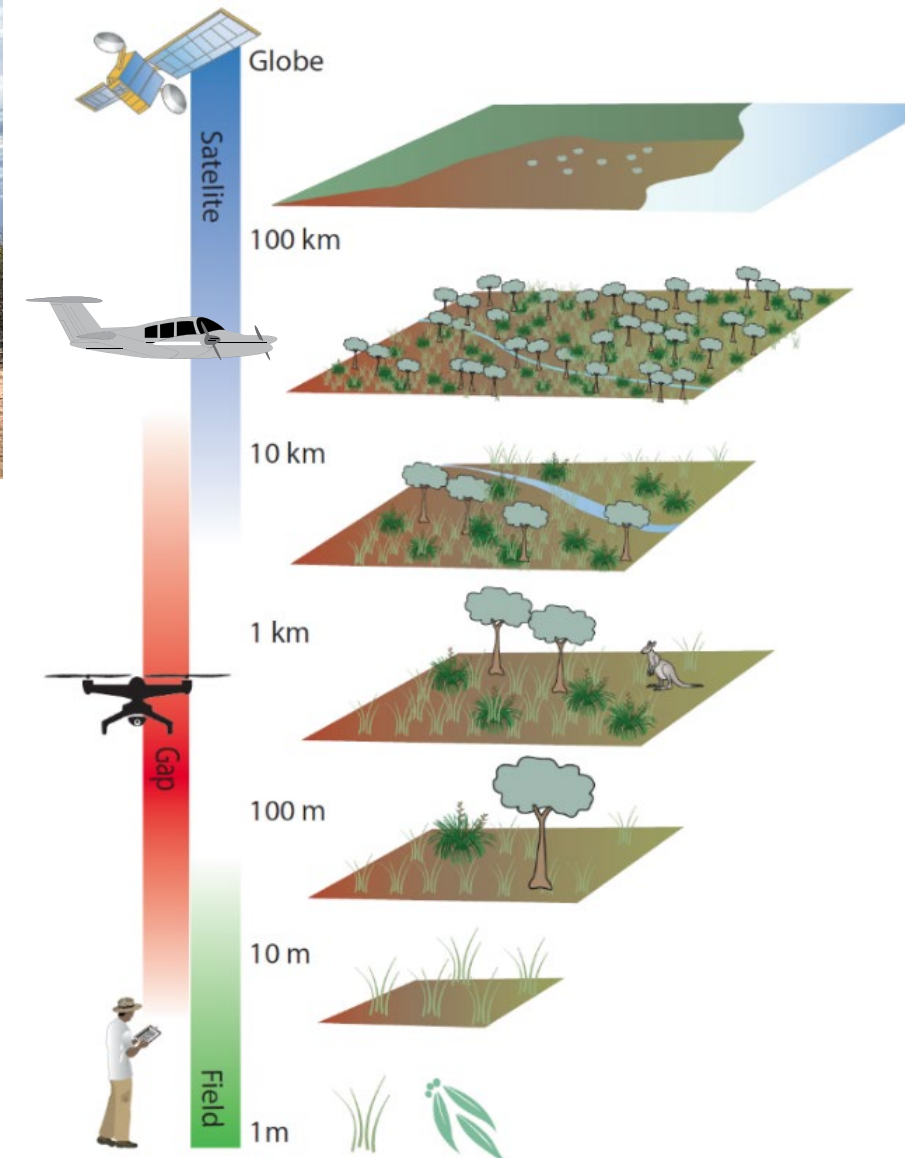
Panoptic 3D point cloud segmentation



Acknowledgements: ForestSens



tern ecosystem sensing facility









Thanks!



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<https://www.linkedin.com/in/arkolucieer/>



Ben Sparrow, Juan Carlos (JC) Montes Herrera, Carla Franson, Troy Bektas, Gigi Lynn
Poornima Sivanandam, Krishna Lamsal, Alice Robbins,
Ryan Haynes, James Gregory, Chris Callaghan, Caitlyn Smart, Darren Turner

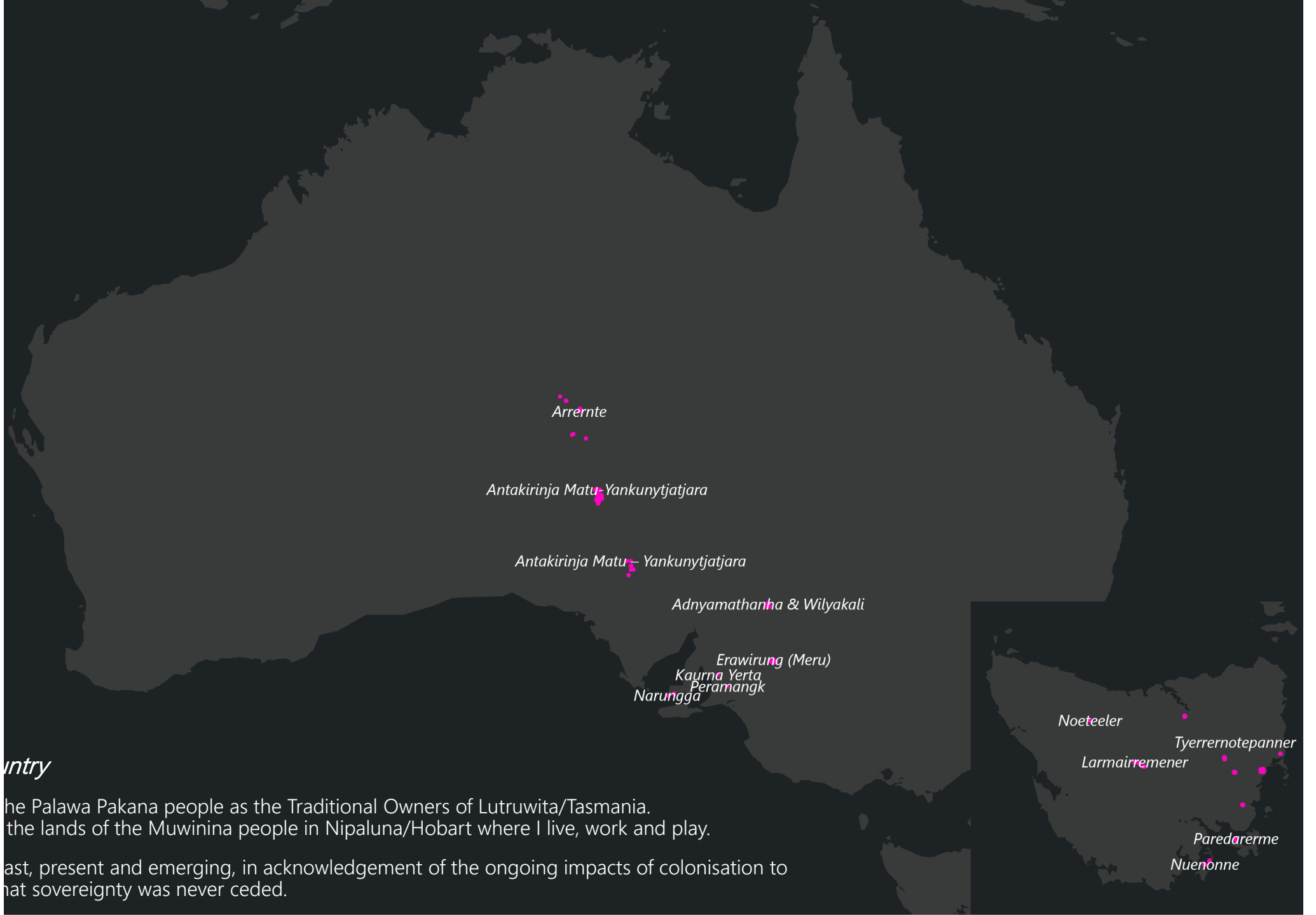




NatureScan

Remote Sensing and AI-Powered Drone Solutions for Advanced Biodiversity Monitoring

Professor Arko Lucieer (UTAS), Associate Professor Ben Sparrow (AU), Alice Robbins (UTAS), Chris Callaghan (AU), Ryan Haynes (UTAS), James Gregory (UTAS)



untry

the Palawa Pakana people as the Traditional Owners of Lutruwita/Tasmania.
the lands of the Muwinina people in Nipaluna/Hobart where I live, work and play.

past, present and emerging, in acknowledgement of the ongoing impacts of colonisation to
that sovereignty was never ceded.

The NatureScan Team

- Arko Lucieer: Professor of Remote Sensing
- Ben Sparrow: TERN Surveillance and TERN Cal/Val Lead
- Alice Robbins: Research Associate in Drone Remote Sensing
- Chris Callaghan: Spatial Field Ecologist
- Ryan Haynes: Research Fellow in Drone Data Analytics
- James Gregory: Research Associate in Drone Data Platforms



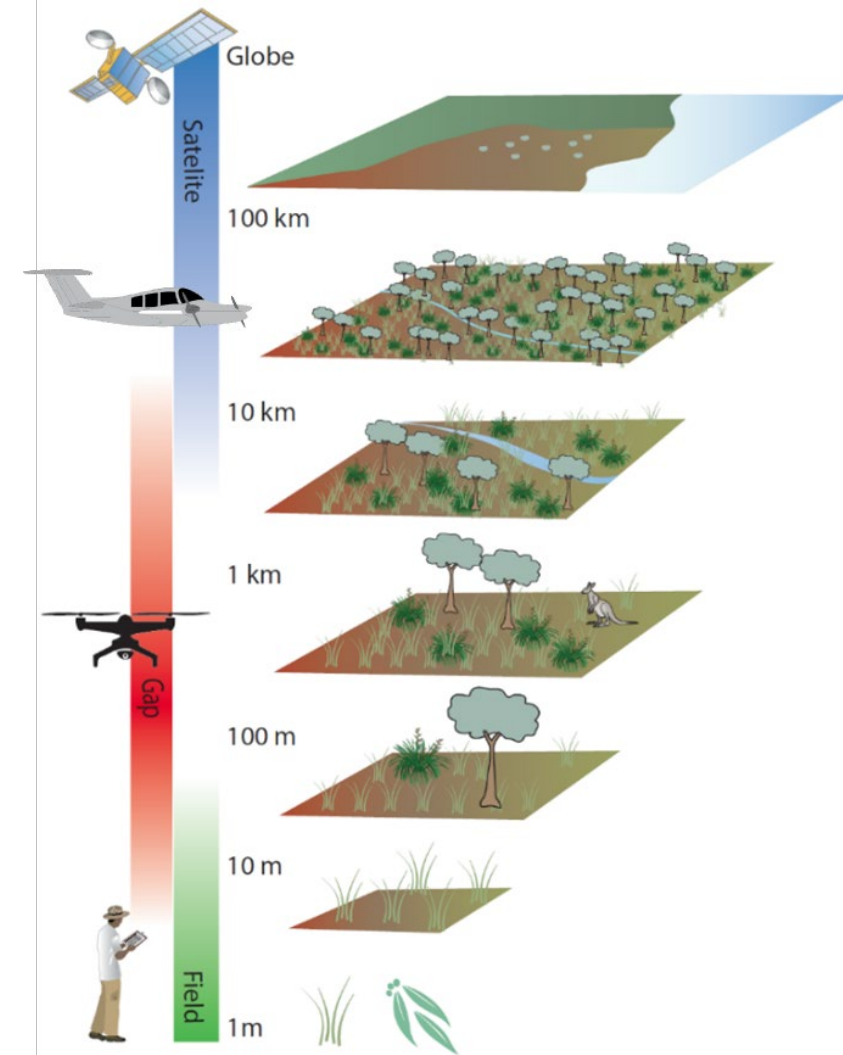
NatureScan: drone remote sensing for comprehensive biodiversity monitoring

- Drones fill a scale gap in ecological monitoring between field and satellite scale observations.
- Project aims to advance biodiversity monitoring in Australia using consumer grade drones, expertise in field ecology, artificial intelligence and remote sensing.
- User-friendly and robust collection and processing protocols for the DJI Mavic 3 Multispectral drone to derive Essential Biodiversity Variables across diverse ecosystems.
- Analysis-ready data products that best represent ecosystem structure, function and composition.
- Validated by spatially accurate ecological field observations



DJI Mavic 3 Multispectral drone

- RGB camera – 20 MP
- Multispectral camera – 5 MP
 - Green 560 nm
 - Red 650 nm
 - Red Edge 730 nm
 - Near-infrared 860 nm
- RTK module for centimetre-level positioning.



Credit: Arko Lucieer

Drones for ecological monitoring



Phase1: hardware & protocols



DJI Mavic3M RTK
Low-cost high-accuracy user-friendly drone equipment
10 – 50 ha at 1 – 5 cm spatial resolution



TERN protocols for collection and processing adapted to new hardware and specific needs of the NatureScan project

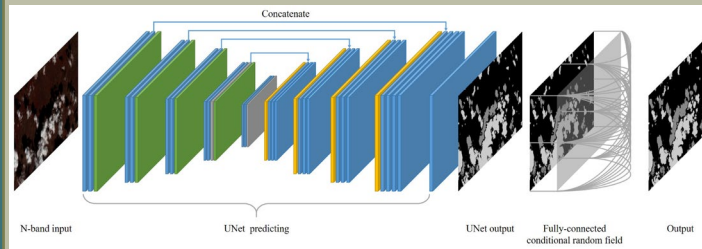


Establishment of data upload and processing workflows to produce analysis-ready datasets

- RGB orthomosaic
- Multispectral orthomosaic
- 3D photogrammetric point cloud



Phase2: EBV extraction with AI



Four ecological scales defined:

1. Sub-individual
2. Individual
3. Sub-community
4. Community (1 hectare plot scale)

Structural Metrics:

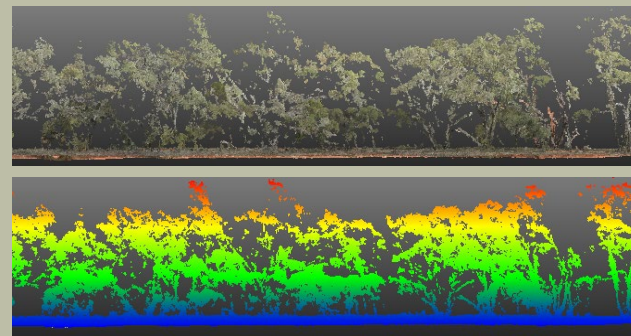
- Canopy height
- Canopy cover
- Vertical variability
- Growth form abundance
- Coarse woody debris

Compositional Metrics:

- Broad Taxonomic Group
- Structural variability
- Native vs non-native
- Spectral diversity

Functional Metrics:

- Vegetation indices
- Fractional Photosynthetic Cover



Phase3: Cal/Val & data collection



- Field observations for training of AI models, and validation of remote sensing products to inform biodiversity.
- Data collection across ecoregions and NVIS Major Vegetation Groups.
- Assess EBV models across a diverse range of ecosystems.
- Evaluate monitoring capability in context of Nature Repair requirements

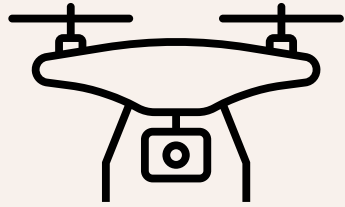


Phase4: Accessibility, (Indigenous) Engagement & Training

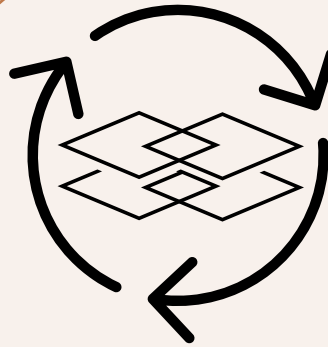


- Drone data collection protocol – published Oct 2025.
- Drone data processing protocol – will be available in early 2026.
- Partnerships with conservation organisations, private landholders and Traditional Owners.
- Engagement with Indigenous Australians through a knowledge sharing workshop
- Development of web based geospatial data interface for visualisation and analysis.

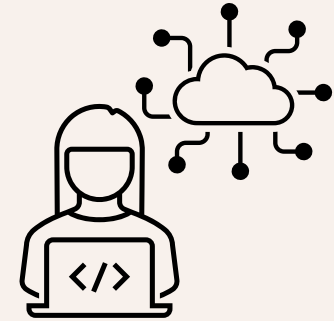




Data collection



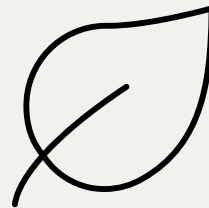
Processing



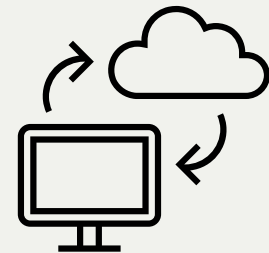
Analysis-ready data



Essential Biodiversity
Variables



Validation with
field data



Open-source data and
project outcomes

Pre-flight desktop assessment



Site selection



Topographic change



Solar angle and phenology



Data collection



Flight parameters



Flying height vs pixel size



Vegetation structure



Metadata scheme



Flight KML and parameters



Environmental conditions



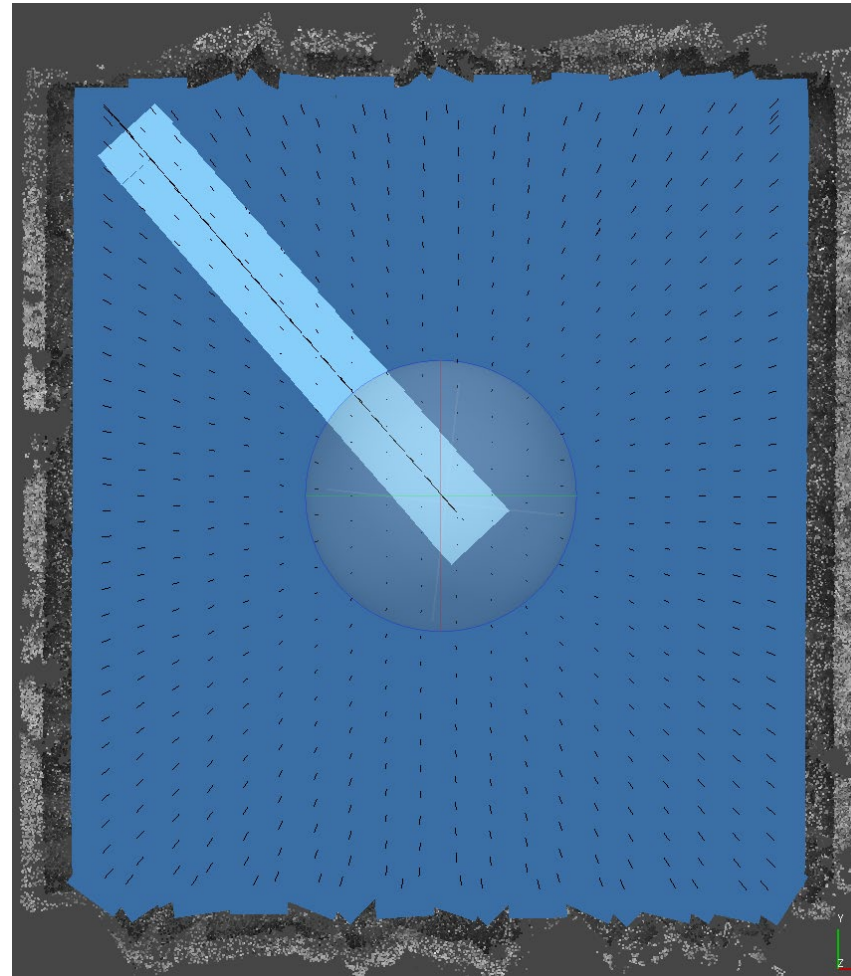
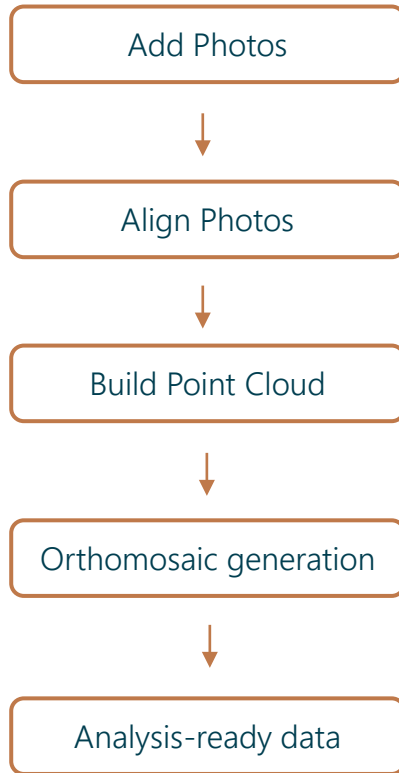
Base station



Drone data collection protocol

RGB and Multispectral Drone Data Collection for Ecological Monitoring





- Developing drone data processing protocol for Agisoft Metashape – will be published in early 2026.
- Structure-from Motion (SfM): 3D position of a point resolved from a series of overlapping images.
- Generate an orthomosaic: overlapping images stitched together to produce a continuous image, which is corrected for distortions and can be used for direct measurements.
- Analysis-ready data products that provide a measure of ecosystem structure, function and composition

Processing: Structure-from Motion





Add Photos?



Align Photos?



Build Point Cloud?



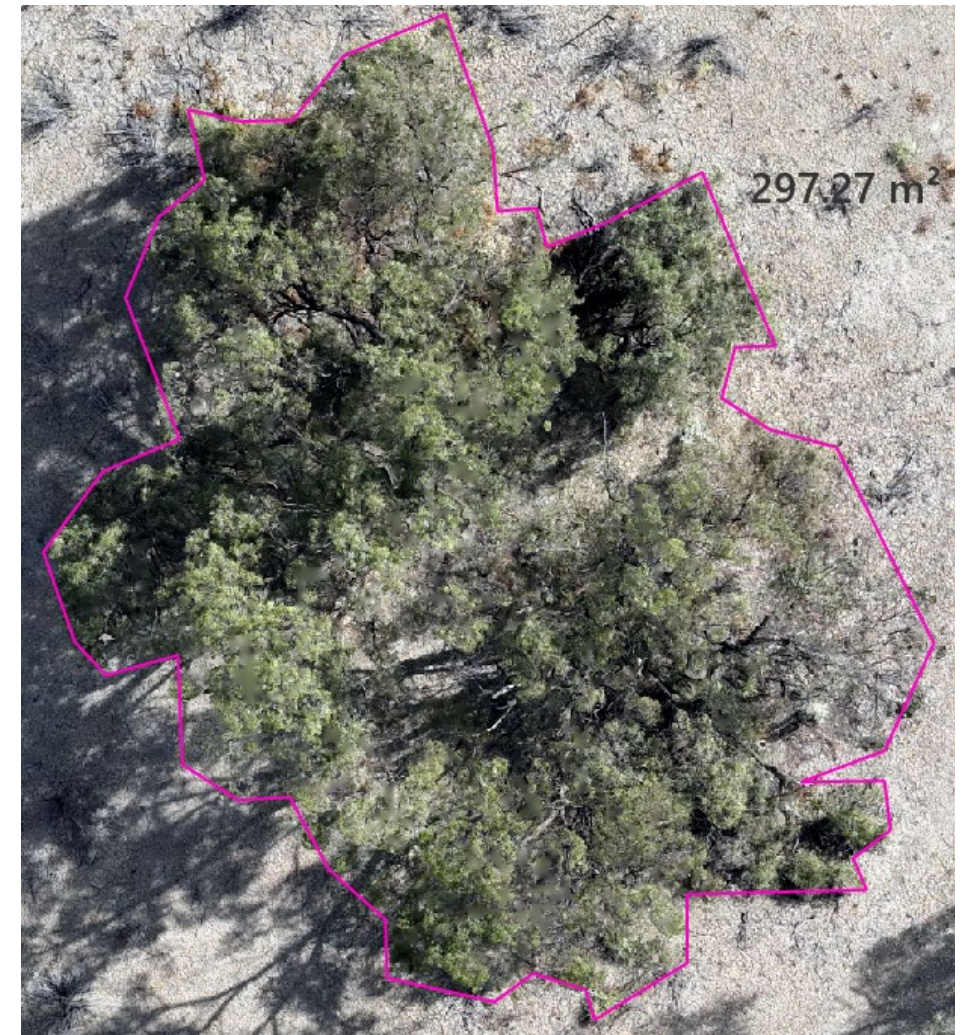
Orthomosaic
generation?



Analysis-ready data???



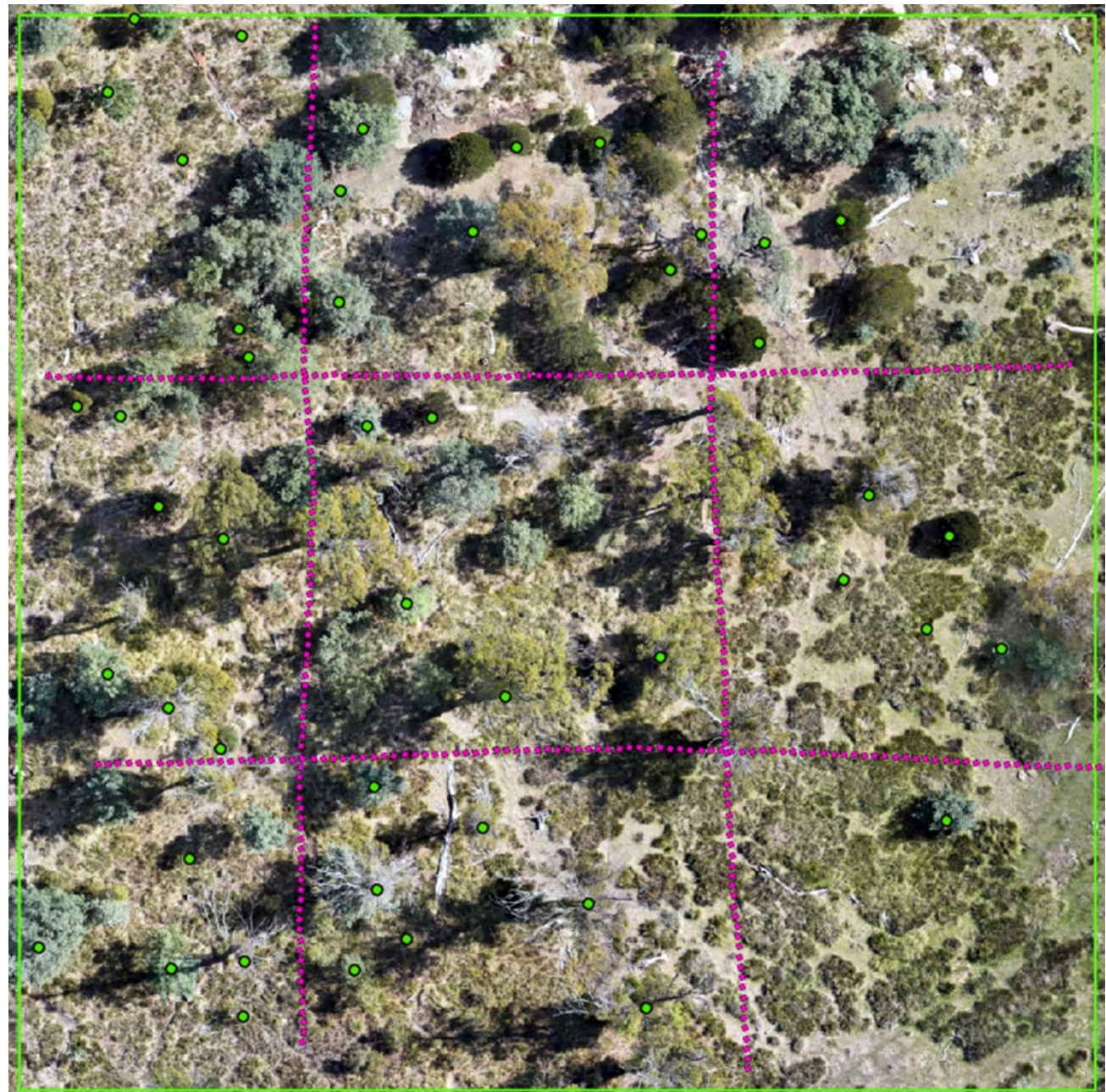
- Geometric alignment:
 - Impact of Image Alignment parameters
 - Impact of image stack (jpg, tif, or jpg and tif)
- Orthomosaic product
 - Geometrically aligned and accurate RGB and multispectral orthomosaic products
 - Ecologically accurate and representative of ecosystem structure, function and composition
- Dense Point Cloud
 - Geometric accuracy
 - Representative of ecosystem structure



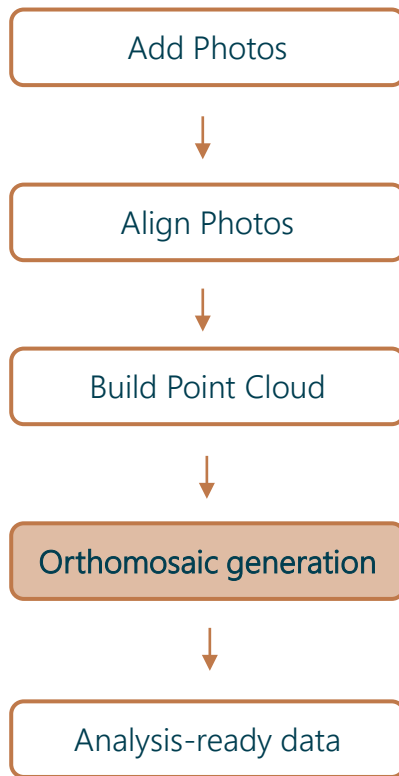
Processing: Structure-from Motion for ecological modelling



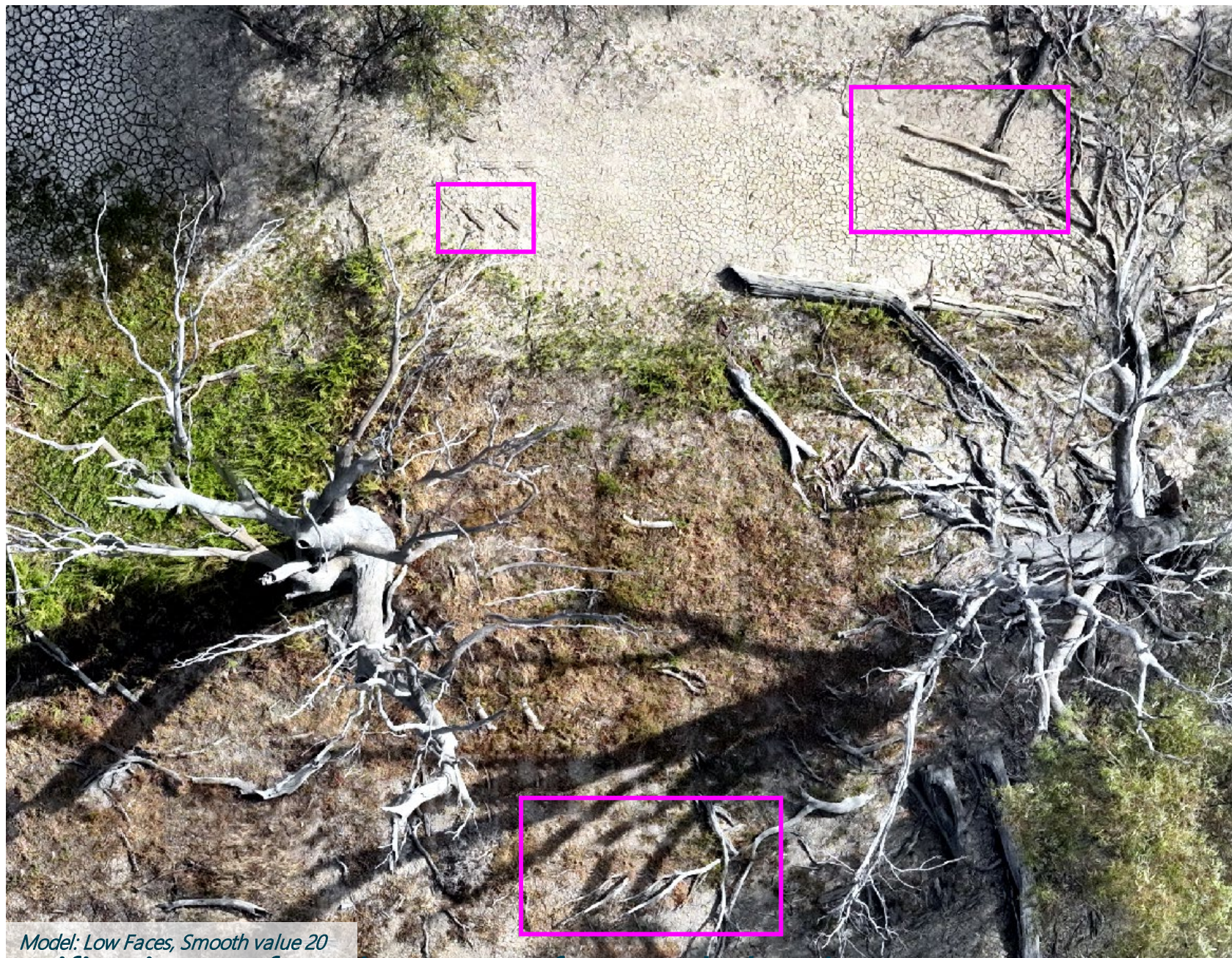
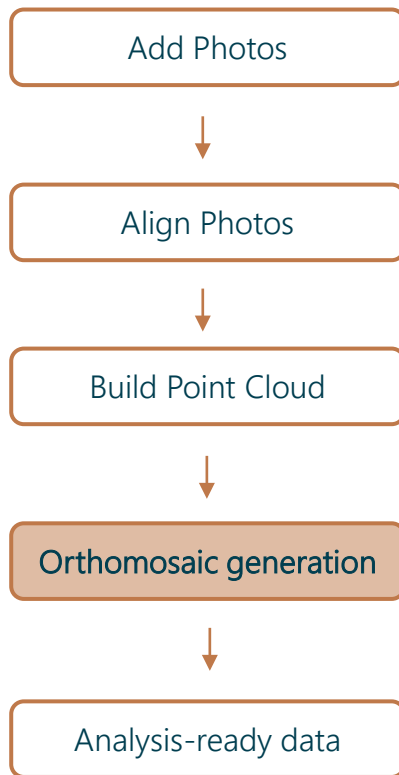
- Three sites of increasing complexity: low, medium, tall
- Five drone flights:
 - Four DJI M3M at two elevations and orientations
 - One DJI M350 with DJI L2 (LiDAR sensor)
- 25-30 GCPs
- Hashtag transect: 404 points with field observations



Processing: Structure-from Motion for ecological modelling



 Processing: Orthorectification surface: pixel smear and distortion



Processing: Orthorectification surface: image artefacts and ghosting



Add Photos



Align Photos



Build Point Cloud



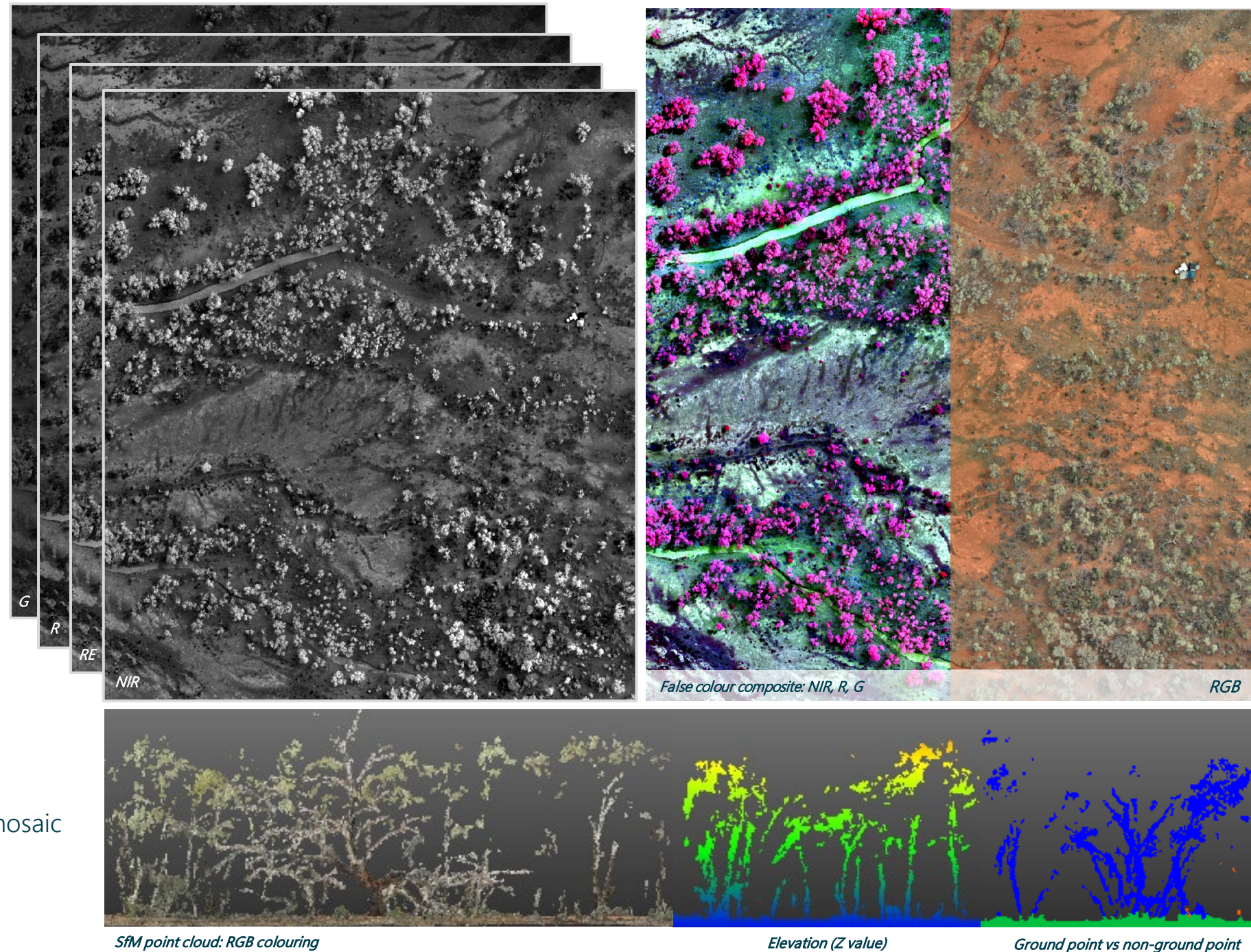
Orthomosaic generation



Analysis-ready data

- RGB orthomosaic
- 4-band multispectral orthomosaic
- Dense SfM Point Cloud

Analysis-ready data

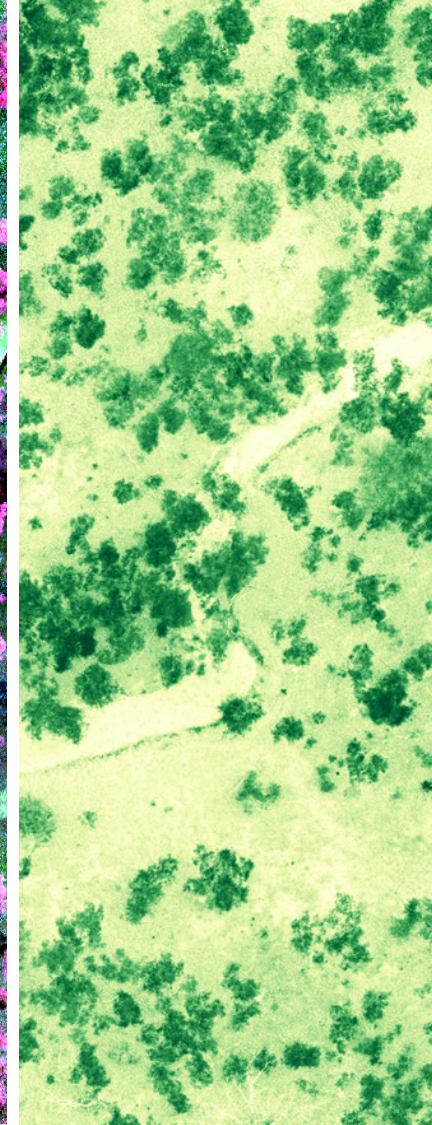




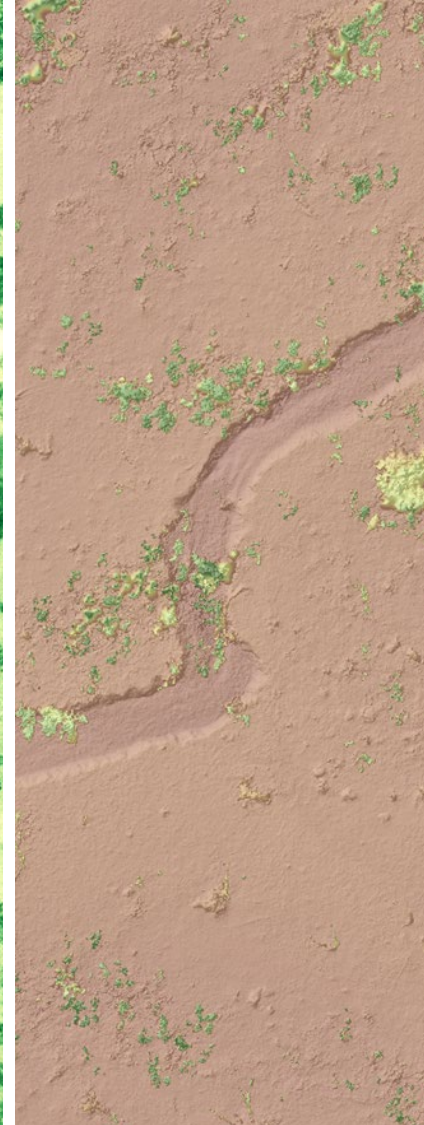
RGB orthomosaic



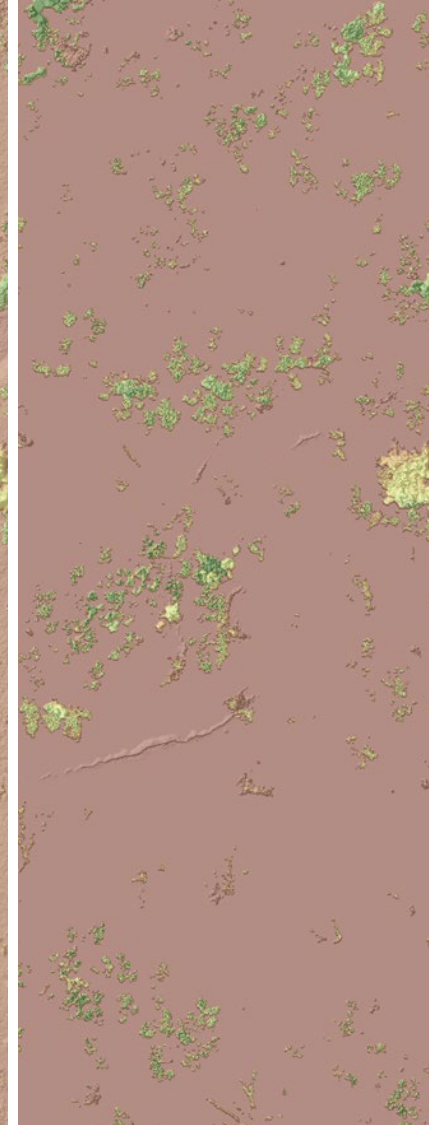
4-band multispectral orthomosaic



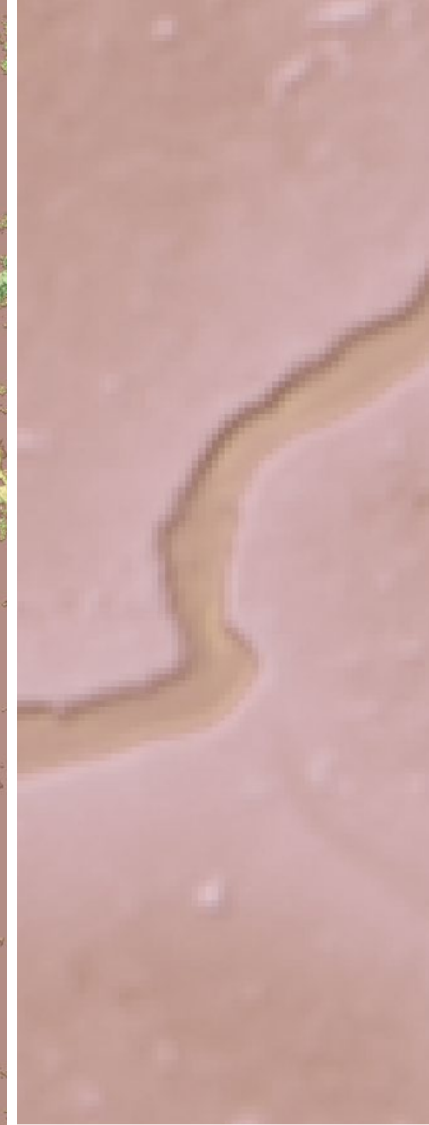
NDVI



Digital Surface Model



Canopy Height Model



Digital Elevation Model

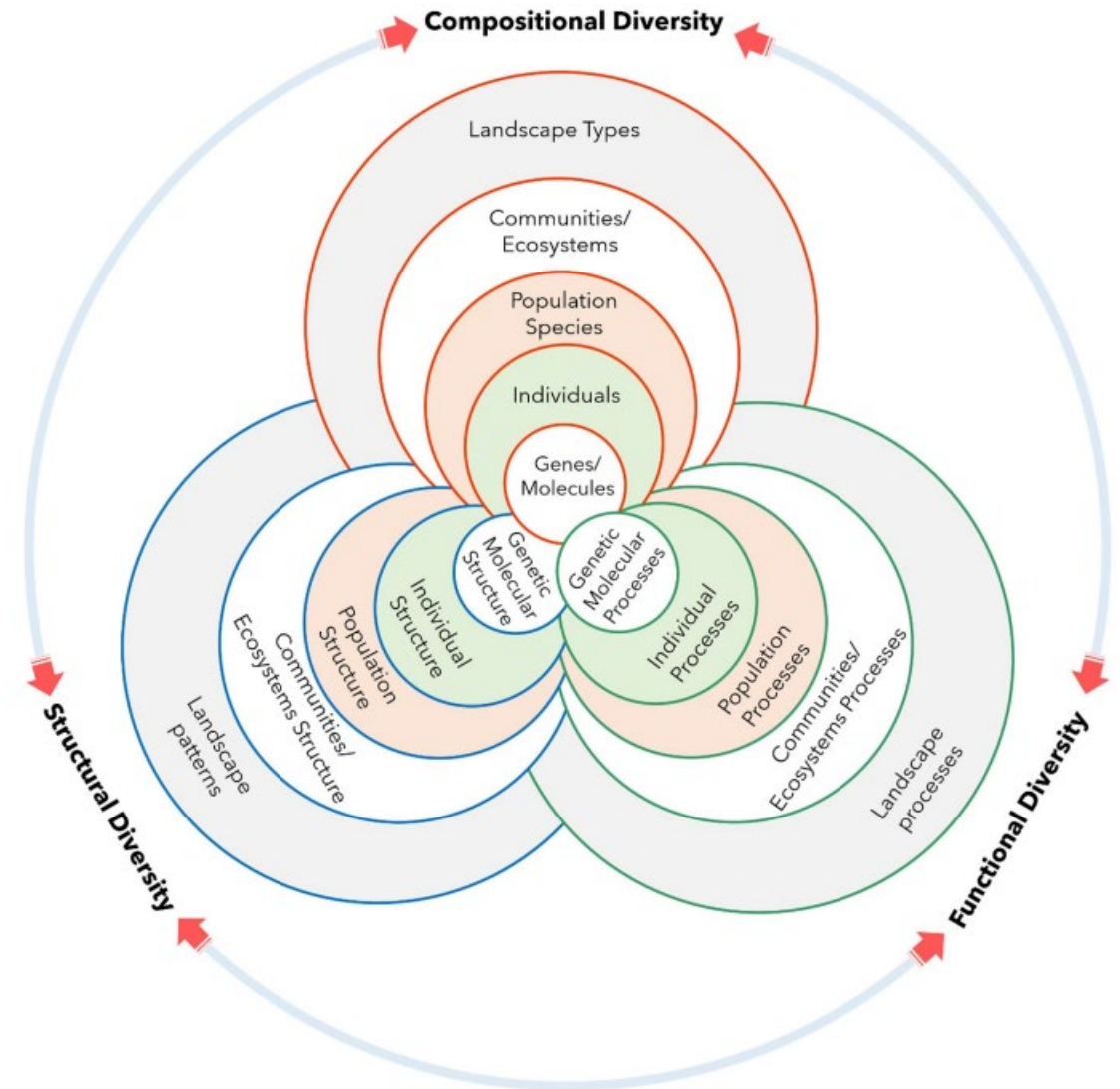


Essential Biodiversity Variables

- Canopy cover
- Fractional photosynthetic cover
- Health (Normalised Difference Vegetation Index)
- Structural variability
- Canopy height

Guide for selection of indicators

1. Sensitivity to change
2. Significance of change
3. Broad geographic distribution or widely applicable across ecosystems
4. Continuous assessment over wide range of stress
5. Relatively easy to measure
6. Easy and cost effective to measure, collect, assay and/or calculate
7. Be possible to differentiate between natural cycles or trends, and those as a result of anthropogenic stress
8. Data availability
9. Policy relevance

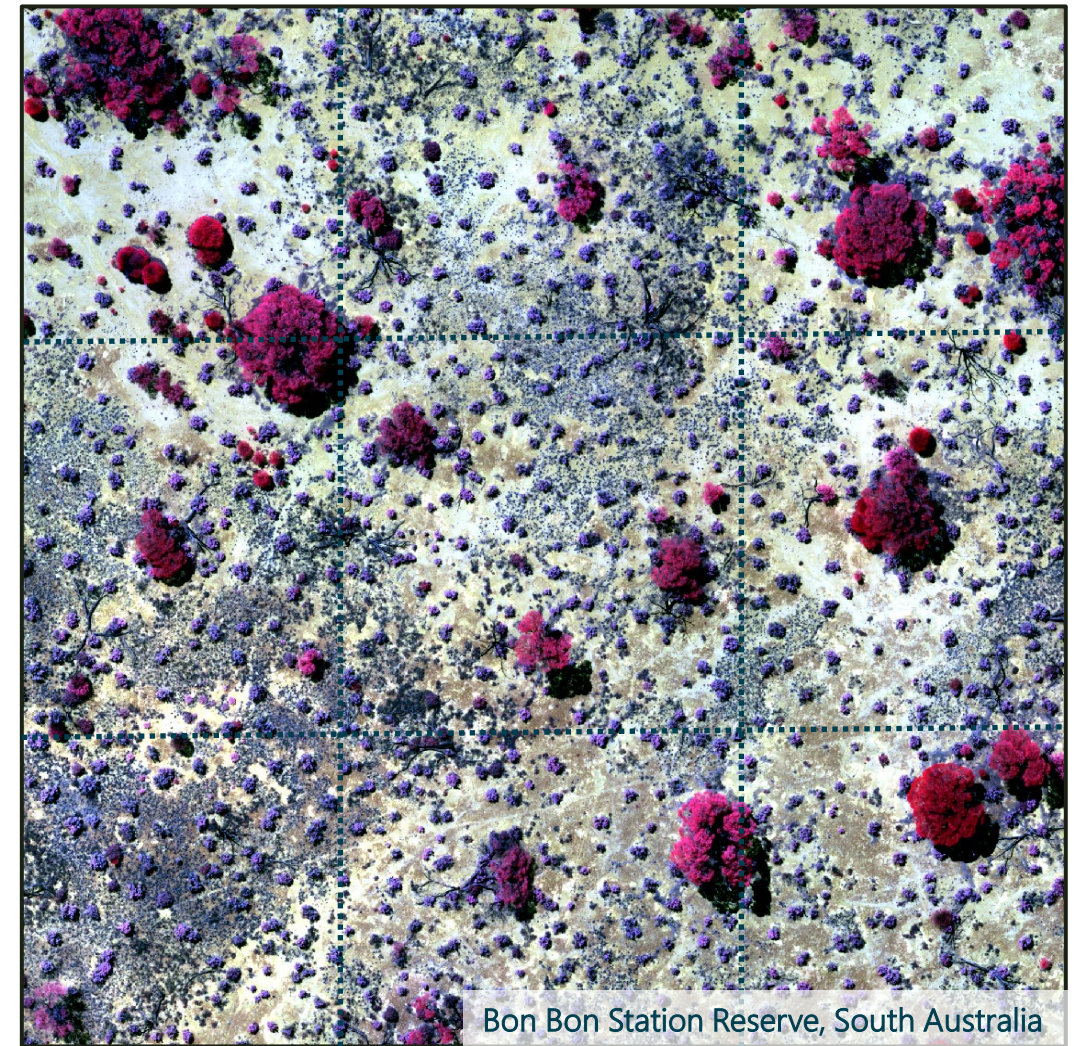


Scale	Structural diversity	Compositional diversity	Functional diversity
Sub-individual	Coarse woody debris 🍃 Standing dead 🍃	Leaf vs wood Photosynthetic vs non-photosynthetic	Ground cover (soil crust) 🍃
Individual	Coarse woody debris 🍃 Growth form 🍃 Standing dead 🍃 Vegetation volume	Broad taxonomic groups 🍃 Native vs non-native 🍃	Health 🍃 Recruitment and mortality 🍃 Vegetation indices
Sub-community	Canopy cover 🍃 Canopy height Coarse woody debris 🍃 Growth form abundance 🍃 Standing dead 🍃 Vegetation volume Vertical variability	Functional group variability Native vs non-native (relative abundance) 🍃 Population Density Spectral diversity Structural variability 🍃	Canopy cover 🍃 Fractional Photosynthetic cover 🍃 Native vs non-native (relative abundance) 🍃 Phenological change 🍃 Vegetation indices
Community / Plot scale (1 ha) (vegetation type that is consistent and homogeneous)	Canopy cover 🍃 Canopy height Coarse woody debris 🍃 Growth form abundance 🍃 Vegetation volume Vertical variability	Fractional Vegetation Cover Functional group variability Population Density Spectral diversity Structural variability 🍃	Canopy cover 🍃 Fractional Photosynthetic cover 🍃 Native vs non-native (relative abundance) 🍃 Phenological change 🍃 Vegetation indices

Essential Biodiversity Variables and Validation with Field Data

🍃 Remote sensing product that can be validated by field observations

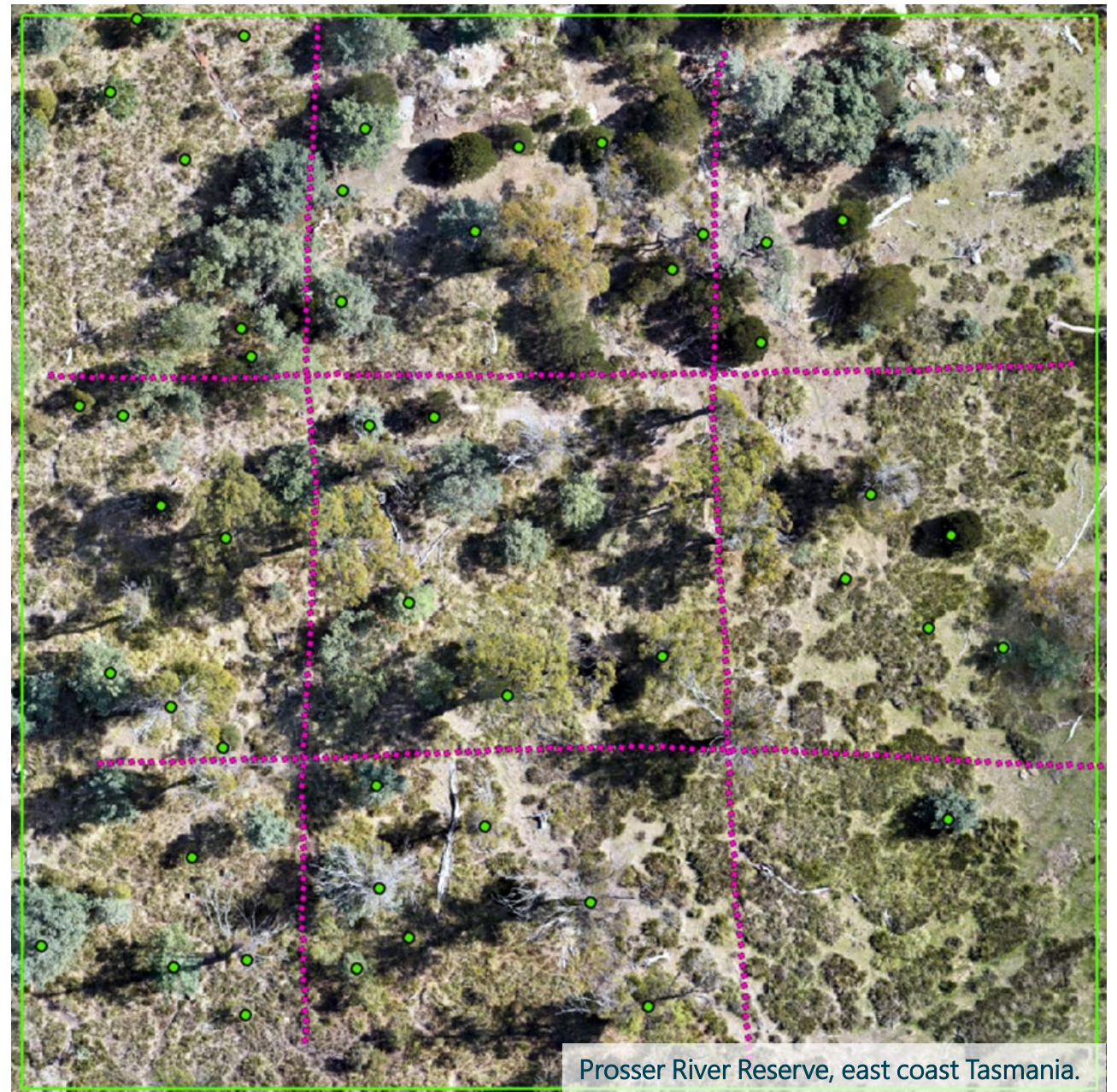




Bon Bon Station Reserve, South Australia

- Hashtag: four 100 metre transects collecting field points at 1-metre intervals for: substrate, broad taxonomic group, growth form, life stage, phenology, canopy cover, photosynthetic vs non-photosynthetic, health.
- High precision spatial field data will train remote sensing and AI workflows and validate remotely sensed biodiversity products
- Builds upon current established vegetation monitoring methods (Australian Soil and Land Survey Field Handbook and the EMSA cover module)

Validation with Field Data



Prosser River Reserve, east coast Tasmania.

Validation with Field Data