Cal/Val @ TERN

Associate Professor Ben Sparrow

Program Lead – TERN Ecosystem Surveillance

TERN Australia Cal/Val Lead

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Acknowledgement of Country

We acknowledge the Traditional Owners of the lands and waters on which we work and gather knowledge throughout Australia and pay our respects to their Elders past and present.
We recognise Australia's first scientists and their enduring spiritual connection, sophisticated cultural practices, and innovation in caring for Country.
We commit to work alongside First Nations Peoples to enable a deeper understanding of Country, and it's sustainable management through right-way science, centred on listening, reciprocity, and respect.

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Ben Sparrow

- Run TERN’s extensive plot monitoring network
- Co-Lead TERN’s Dronescape (Extensive drone monitoring program)
- Leads standard protocol development (With Sally O’Neill)
- Coordinate Cal/Val within TERN
- Chair of Australian Committee for Earth Observation Quality Assurance (ACE-QA) A new committee including members from State and Territory Government departments and Australian Government departments and Research Infrastructures.

Randall Donohue

- Researcher at CSIRO
- Remote sensing and vegetation science
- Satellite-based mapping and modelling of
  - biomass/carbon
  - vegetation type, cover, structure, distribution
  - bushfire fuel characteristics
  - food production
  - vegetation condition/biodiversity

Sally O'Neill

- Expert in field methods
- Method Standardisation

Safety First

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The Campsite

- You'll have some familiarity
- Keep doors closed (no unwelcome friends)
- Shoes on outside
- Dining room
- Don't leave the immediate vicinity of the buildings without notifying one of the TERN team.
- Check in / check out
- Toilets/Showers
- Fires
- Charging things
- If You need help – Where we are?
- If you're unsure, or if you need help please ask.
- First aiders (= Where to find supplies)
- The river – CAUTION!

Theory Venue – The Hotel Renmark

- Bathrooms
- In case of evacuation
- Tea/ Coffee / Catering
- Dinner
- Lecture Notes
- Transport

In the Field

- Checking in and out when going into the field
- Groups – Which and Where
- When arriving at a site
  - Stay with the vehicles until after the Toolbox Talk.
  - Will identify risks, and what you should do
  - Where are first aid kits
  - Who is first aid qualified
  - Communications
- Follow directions in regards to vehicle use
- Risks associated with todays activities
- Doing Take 5's
- Care with Equipment
- Personal
  - Water (more in vehicles)
  - Snacks and lunch
  - Sunscreen and bug spray
  - HiVis Vests
- You should bring
  - Long sleeve shirts
  - Broad brim hats
  - Warm clothes
  - Rain Gear
  - Sunnies
  - Sturdy Boots & either long trousers or Gaiters
- Bathroom facilities (or lack thereof)

In the Field - Drones

- While the drone is in the air please direct all questions to one of our team members (not the pilot)
- Risks
  - Rotors
  - Batteries
  - Getting lost (RTH)
  - Collision avoidance
- The team will clearly identify when a mission is starting / stopping.

Legally Drones are considered Aircraft and the Operator a Pilot with the associated obligations

There will be plenty of opportunities to investigate the equipment (but please clear with the pilot first)

When in use there are requirements about how close you're allowed to be.

Any Safety Questions or concerns?

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Todays Sessions

1 – Theory, Definitions and Cal/Val Basics

2 – Ecological field methods for Cal/Val

3 – Field Sensors and platforms for Cal/Val

4 – How we use Cal/Val data – Some examples

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1 – Theory, Definitions and Cal/Val Basics

Or really Cal, Cal, Cal, Val

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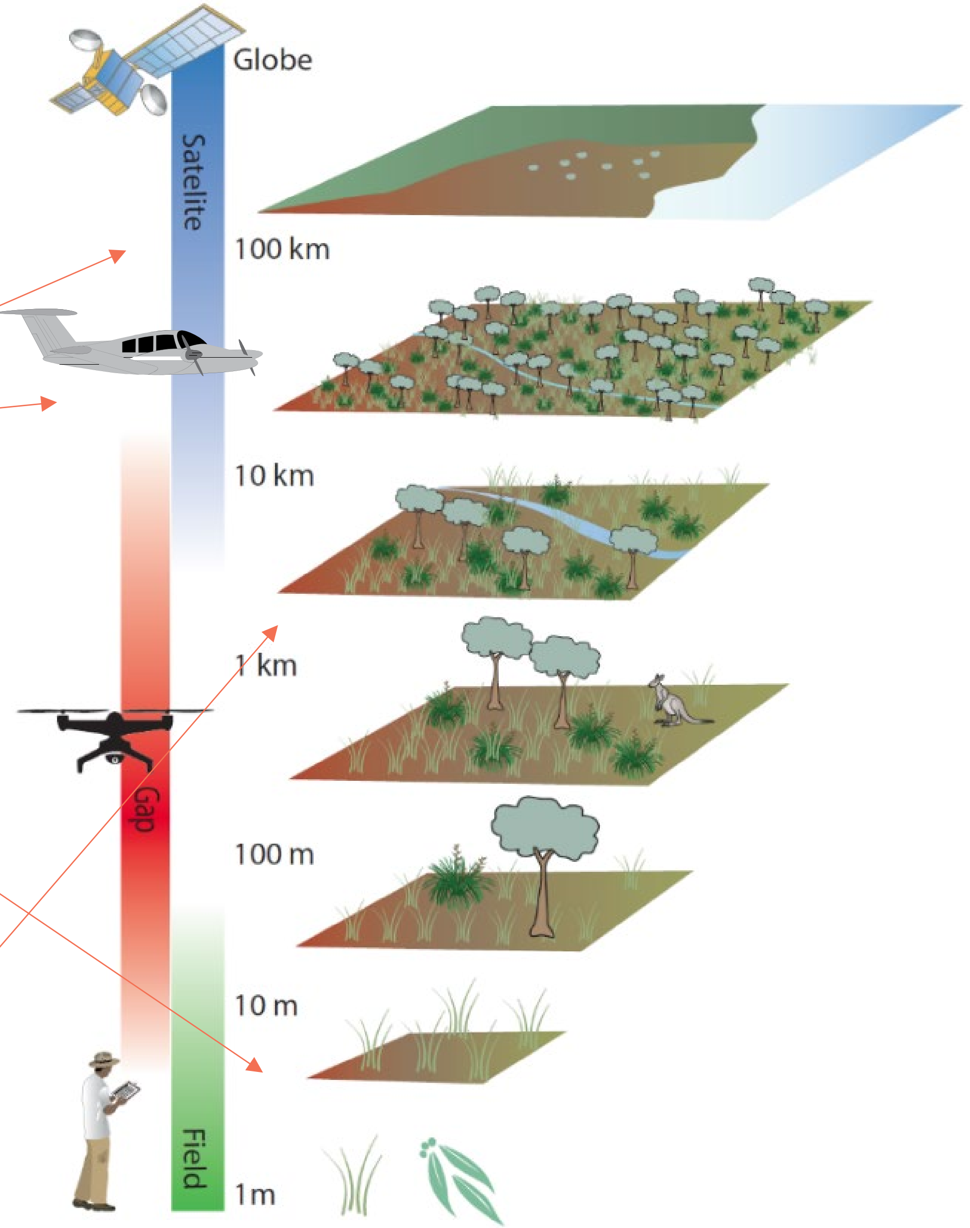
Scale

Our aim is to robustly relate imagery

To

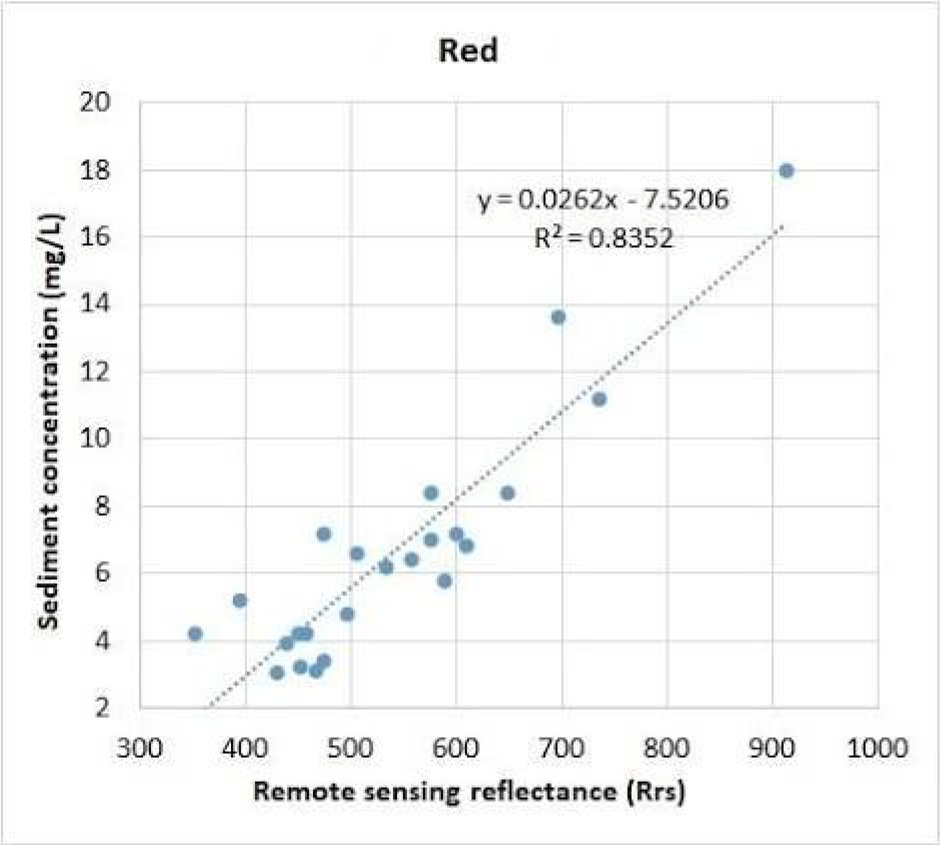
Field obtained information “Truth”

Sometimes using an intermediate product
(Remembering to propagate error)



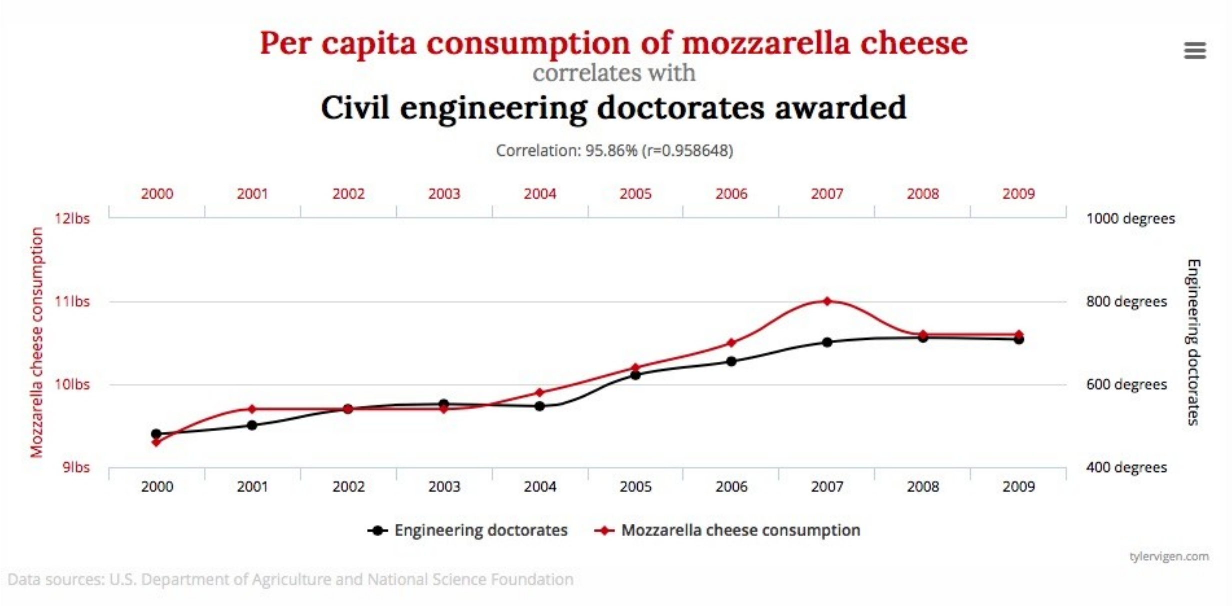
Remote Sensing is a Correlative Science

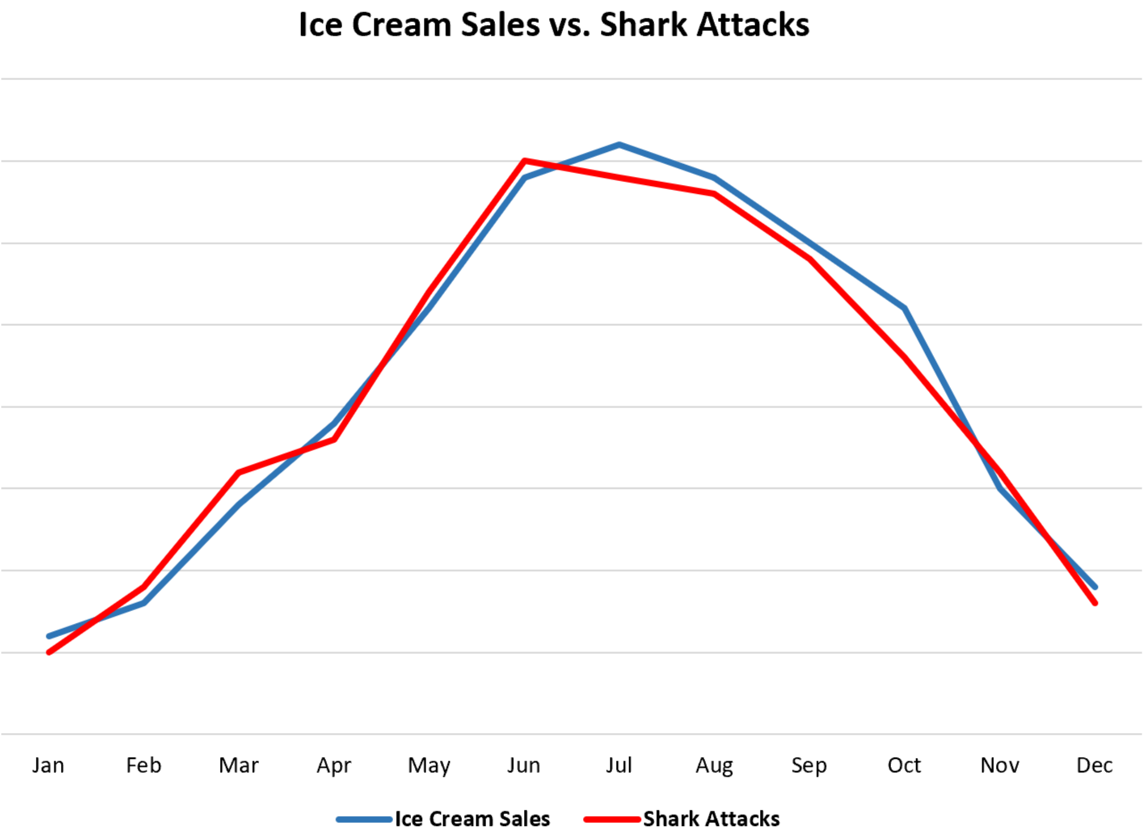
- Fundamentally your sensor is measuring reflectance (or emission) of light in various wavelengths that interact with features of interest in various ways.
- We then conduct some form if image analysis and correlate that to field measures.
- I.e. We're not measuring ground cover from satellite, but rather some product derived from reflectance that we hope will correlate strongly with our field measures
- We improve this process in three ways, and assess its accuracy in one key way….



https://doi.org/10.1590/2318-0331.241920180061

Correlation does not equal causation





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What do we mean by Cal/Val?

- Generally, we mean one of the following:
  - Sensor Calibration
  - Vicarious Calibration
  - Model Calibration (Development)
  - Model Validation (How accurate is my model compared to what we observe)

Sensor Calibration

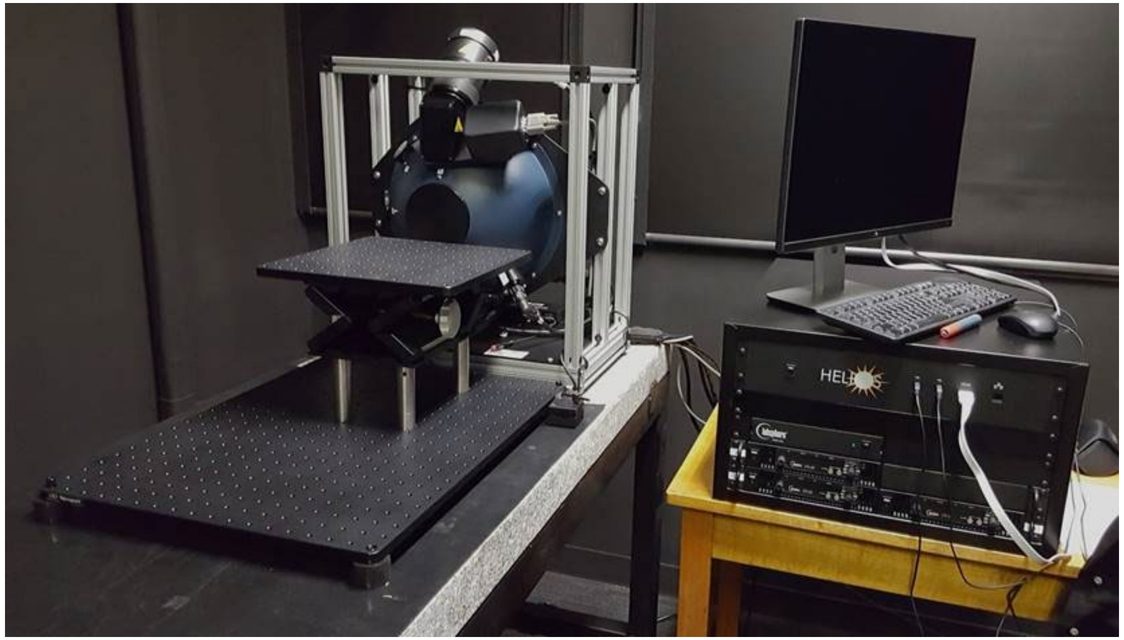
Quantifies:

Radiometric

Spectral

Geometric

response of a sensor



TerraLuma

- Most commonly you'd send your sensor off to get this done as a commercial service

OR

- It would be done for you before you're supplied with data
- Requires expensive specialised equipment and a specialist to use it.
- Not dealt with in detail in this course for that reason.

Vicarious Calibration

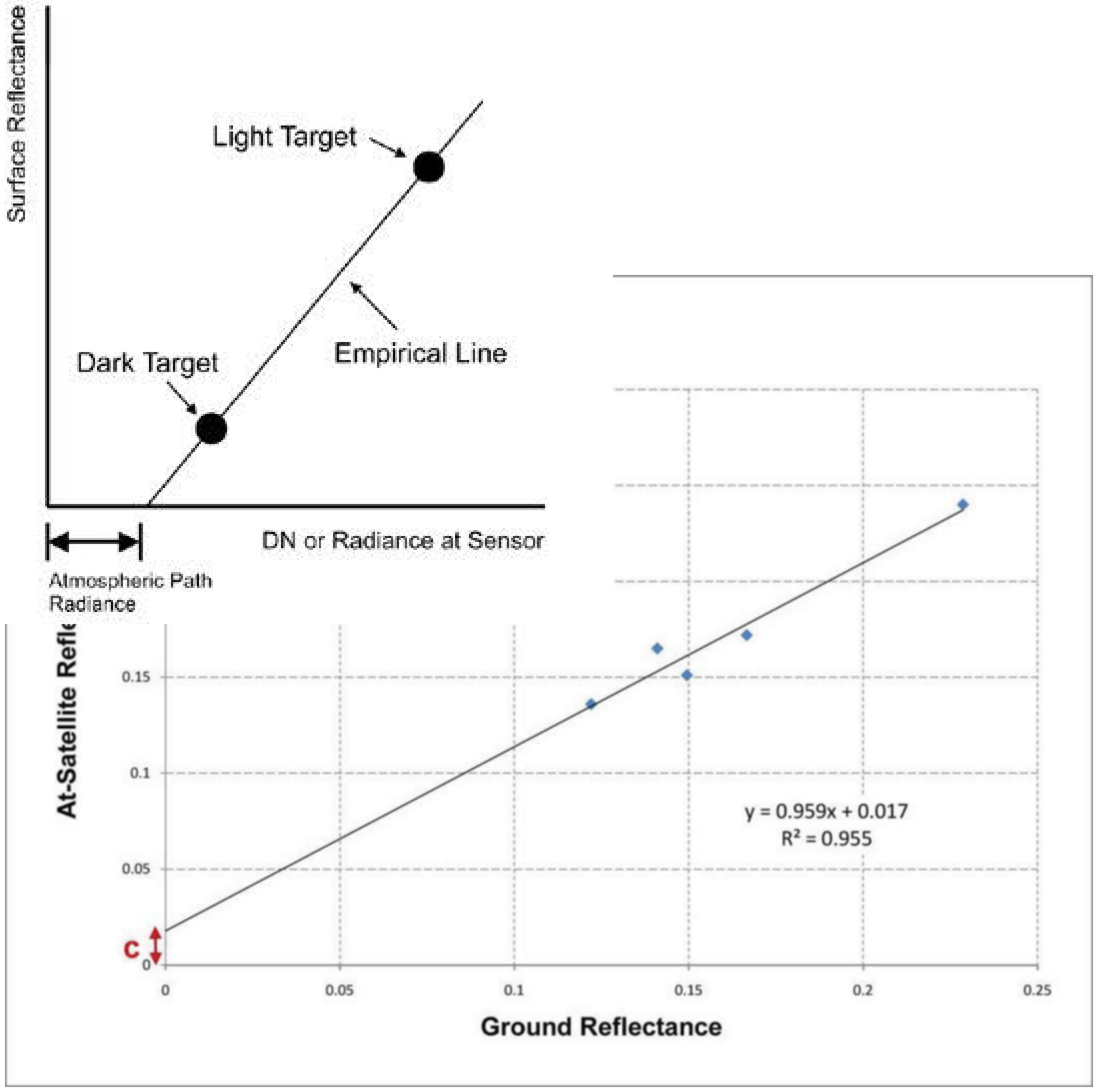
- A technique used to adjust and validate the accuracy of sensor data once it has been deployed
- 1 - Radiance – Sensors to detect the exact amount of EM radiation at the surface while a sensor is passing over.

- 2 – Reflectance – Uses a large invariant target (Natural or artificial). This target is measured with a radiometer while the satellite is passing over
- The reflectance from the radiometer is compared to the same pixel identified in the imagery.

- Commonly corrects for atmospheric effects.

- Primarily radiometric and Geometric

- Different models used to do this.



Remote Sensing model calibration

- Once data pre-processed (i.e. it’s analysis ready)
- Uses field collected data to develop/ train a model.
- We might use training areas in a supervised classification or
- We might try and attribute meaning to an unsupervised classification
- Or we might try and unmix data and correlate extreme pixels in the data with knowledge of field conditions
- Or we might try and correlate the reflectance of various field measures with endmembers in imagery.

Validation

- Field truth**
- We have measured something that we are interested in in the field.
- How well does our Image Analysis correlate with our field measures
- - Need to consider field measurement accuracy
- - The Case of Lidar V field structural metrics
- Correlations
- Quantifying Accuracy
- User and producer accuracy for mapping – Congalton and Green

CEOS validation levels

* From CEOS Website

	Validation Stages - Definition and Current State	Variable
0	No validation. Product accuracy has not been assessed. Product considered beta.	
1	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in situ or other suitable reference data.	**Fire Radiative Power**
2	Product accuracy is estimated over a significant (typically > 30) set of locations and time periods by comparison with reference in situ or other suitable reference data. Spatial and temporal consistency of the product, and its consistency with similar products, has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	**Snow Cover Extent** **SWE** **fAPAR** **Phenology** **Biomass** **Evapotranspiration**
3	Uncertainties in the product and its associated structure are well quantified over a significant (typically > 30) set of locations and time periods representing global conditions by comparison with reference in situ or other suitable reference data. Validation procedures follow community-agreed-upon good practices. Spatial and temporal consistency of the product, and its consistency with similar products, has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	**LAI** **LST & Emissivity** **Active Fire** **Burned Area** **Vegetation Indices**
4	Validation results for stage 3 are systematically updated when new product versions are released or as the interannual time series expands. When appropriate for the product, uncertainties in the product are quantified using fiducial reference measurements over a global network of sites and time periods (if available).	**Land Cover** **Albedo** **Soil Moisture**

Field "Truth"

- Measurement accuracy
- Measurement bias
- Measurement variability
- Are you measuring the same thing?
- Observer differences
- Observer Bias
- What can you control?

Lund Electronic Reports in Physical Geography
No. 1, October 1997
Department of Physical Geography
Lund University, Sweden
ISSN: 1402 - 9006

Reference: Lund eRep. Phys. Geogr., No. 1, Oct. 1997.
URL: http://www.natgeo.lu.se/Publikationer/Lerpg/1/1Article.htm

N.B. This is an experimental version on behalf of the LUFT-project

Ground-truths or Ground-lies?

Environmental sampling for remote sensing application exemplified by vegetation cover data

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0. Abstract

During time of fast development of computer and sensor technology, ground data sampling strategies have achieved diminished attention in many remote sensing studies. This paper discusses the importance of designing an appropriate sampling scheme of ground data collection for remote sensing applications. The difficulties of achieving a balance between the size and the error of the samples are identified. Different techniques of vegetation cover estimations are evaluated to illustrate parts of the proposed sampling design. The study indicates that traditional methods of ground data collection for remote sensing applications do not have to result in "ground lies". Determination of a reliable and appropriate sampling scheme for the ground data collection should be given a more attention when assuring accurate results in remote sensing studies.

Key words: ground data collection, ground truth, vegetation cover, remote sensing, sampling strategies

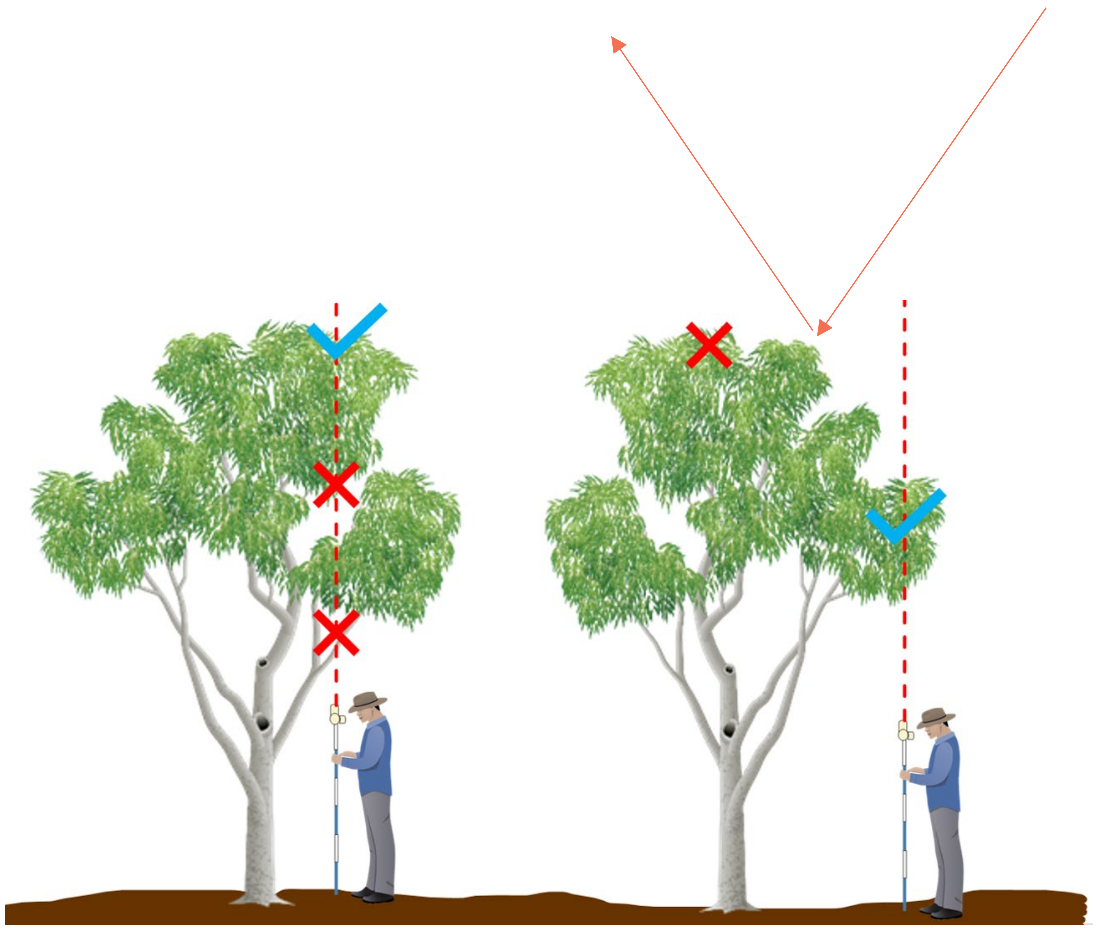
What do I need to validate?

- The product you are intending to create will in part inform what information you're likely to need in the field for validation.
- Seems self evident, but important to think through at the beginning or your project to ensure the maximum effectiveness of fieldwork.
- Does suitable data already exist?

Example: I'm using Lidar to try and quantify vegetation structure….. What are some RS Products that I might create?

What field measures will help me do that?

- What information can I collect in the field that I can relate to the products I'm creating?
- Regularly I'm collecting info in a different way to the sensor I'm using to create my products.
- "Think Like a Satellite"
  - E.g. Cover



Back to our example.....

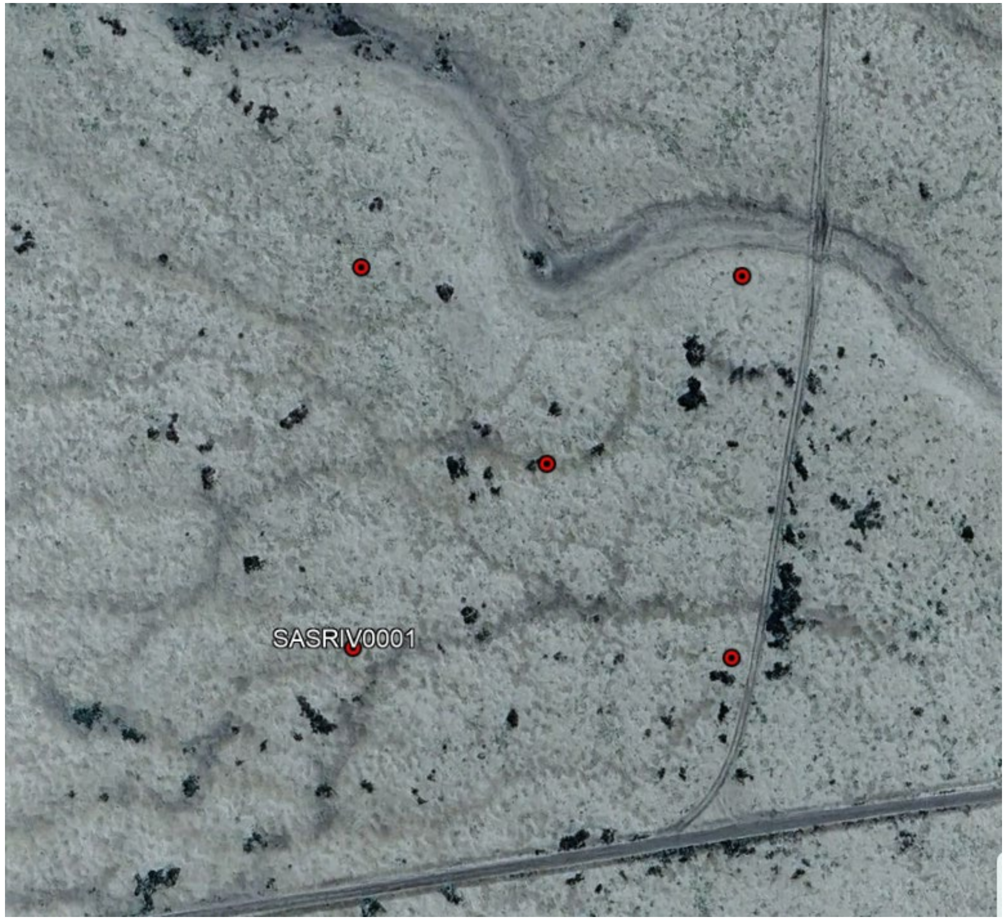
- What could we collect in the field that would be relevant to our Lidar Structural products?

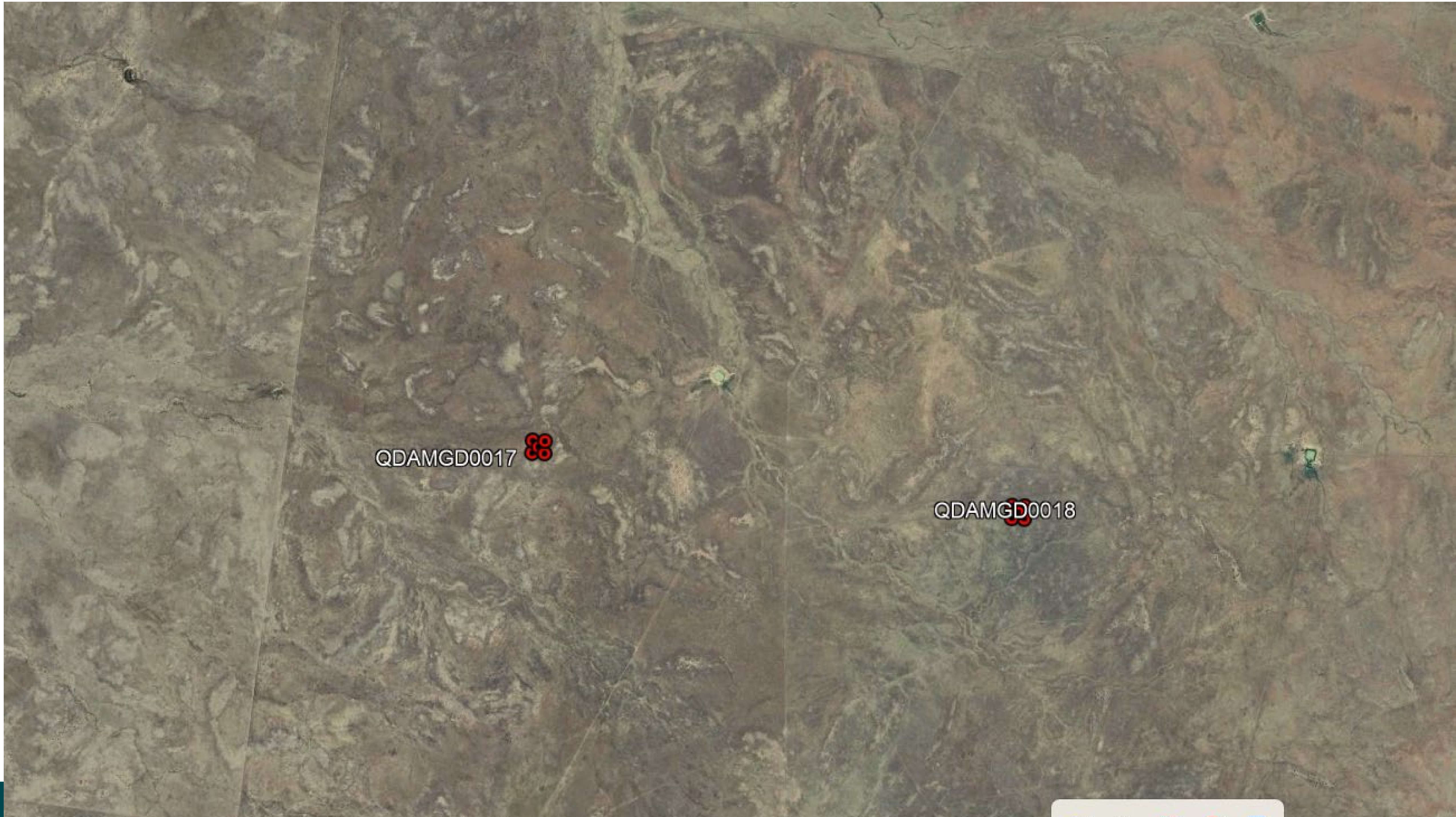
- What we collect
- What we do with what we collect...
- (e.g. we can't measure biomass)

Location, location, location!

- You're aiming to relate your field measures to your imagery products – to do that you need to know where your field measures are!
  How well you need to know that relates to:
  - The spatial resolution of your imagery
  - The size of your field site (or point sample)
  - The accuracy that you aspire to.

Homogeneity

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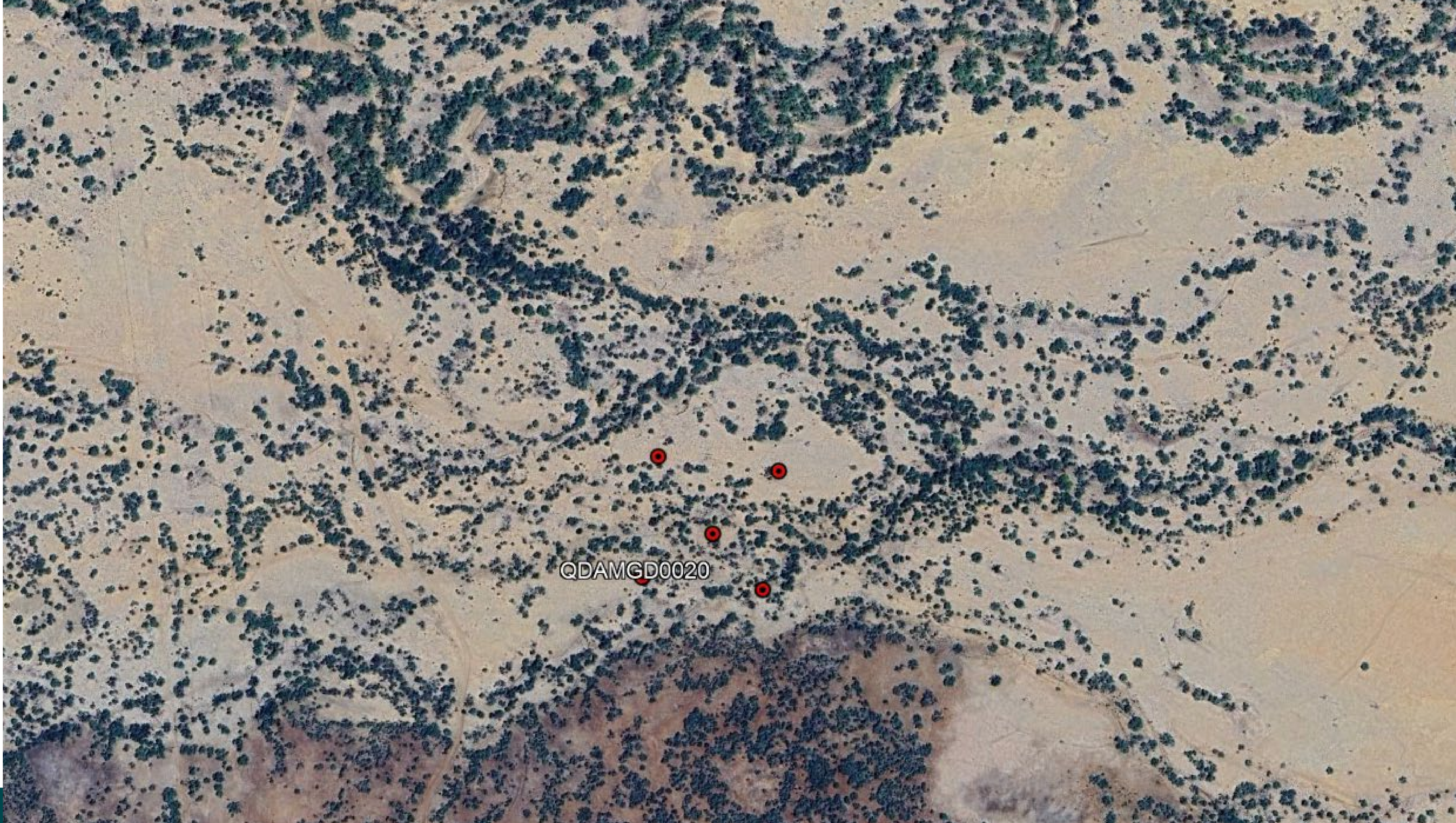
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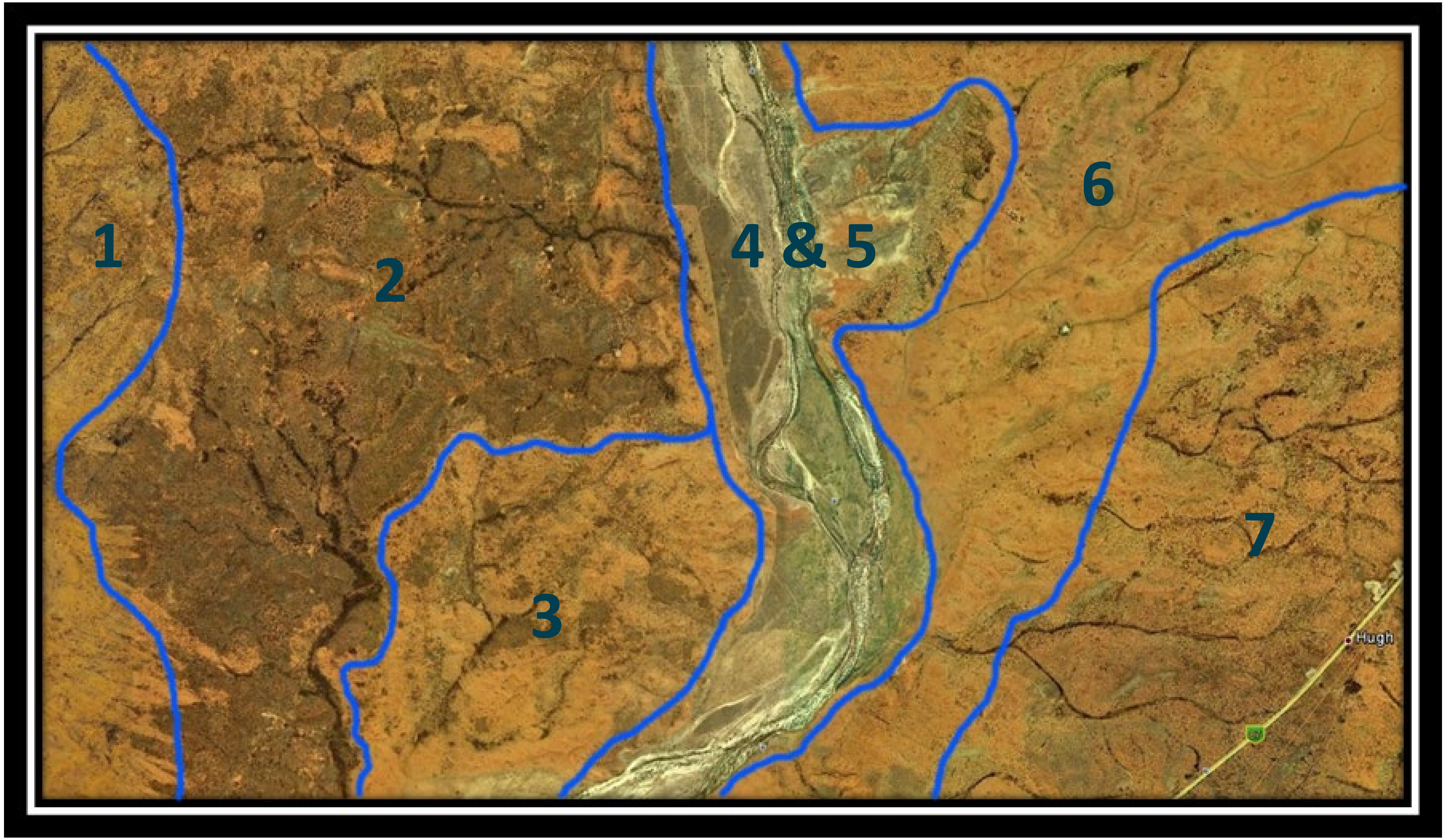
Locating the Site



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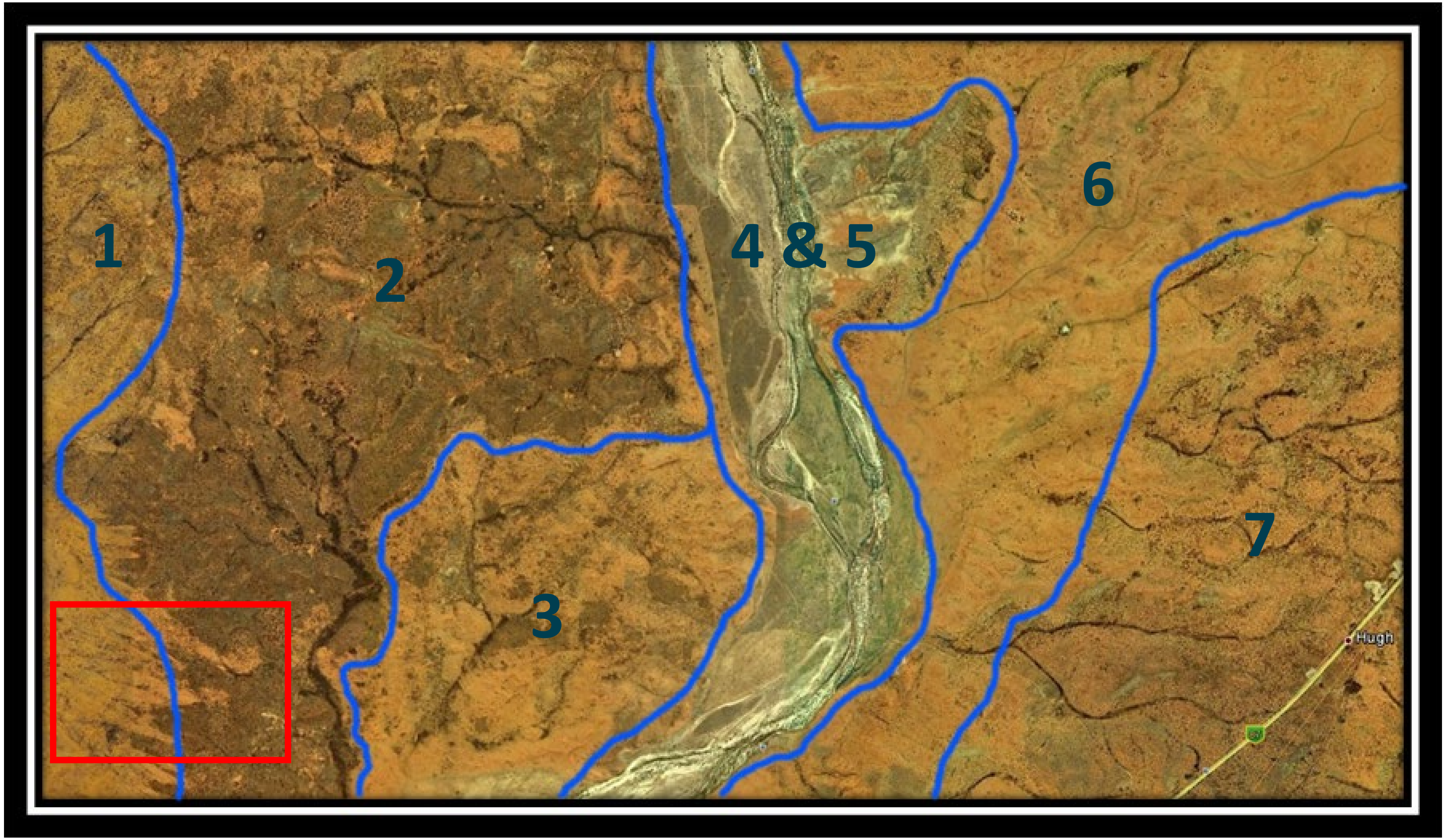
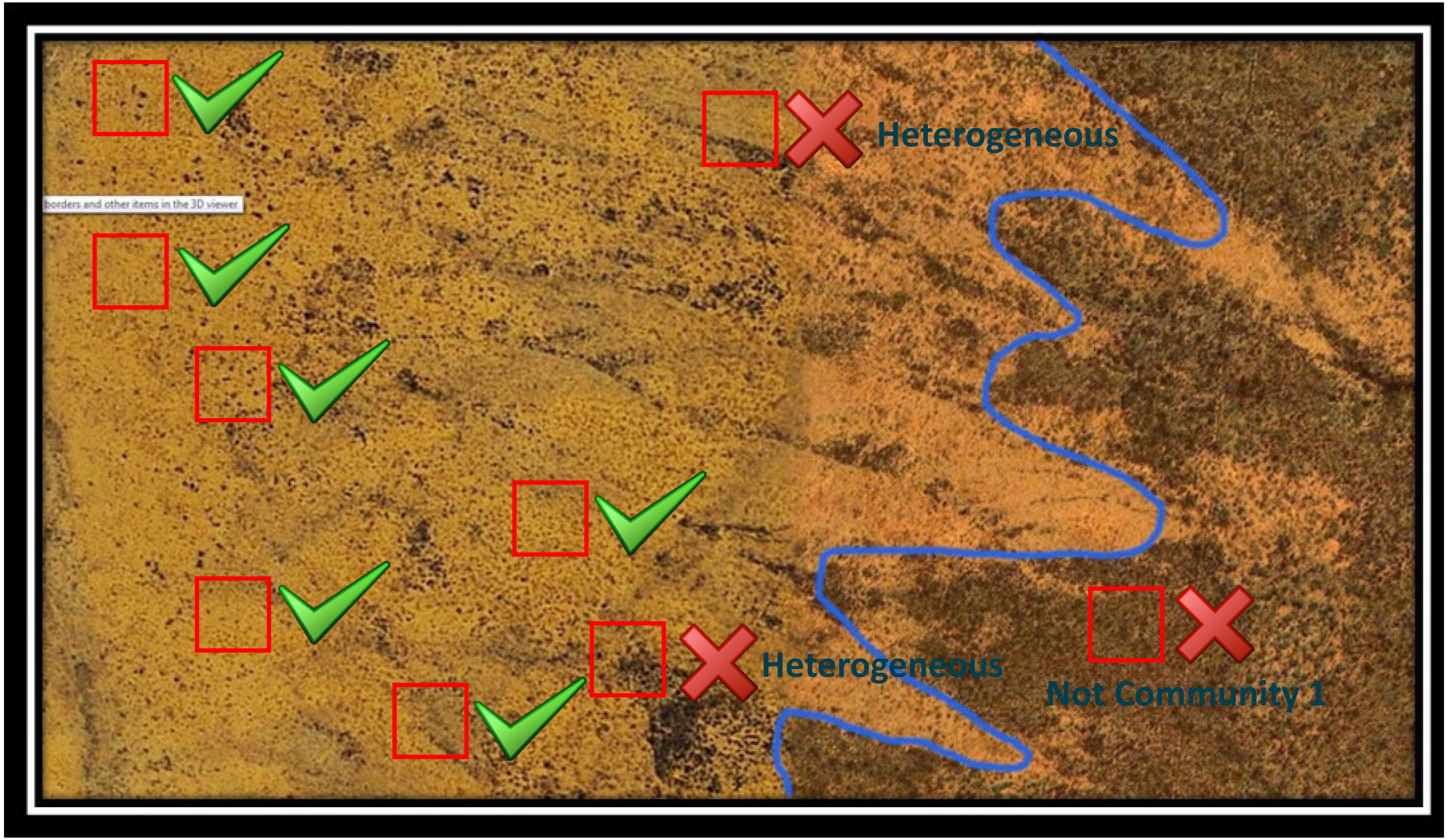
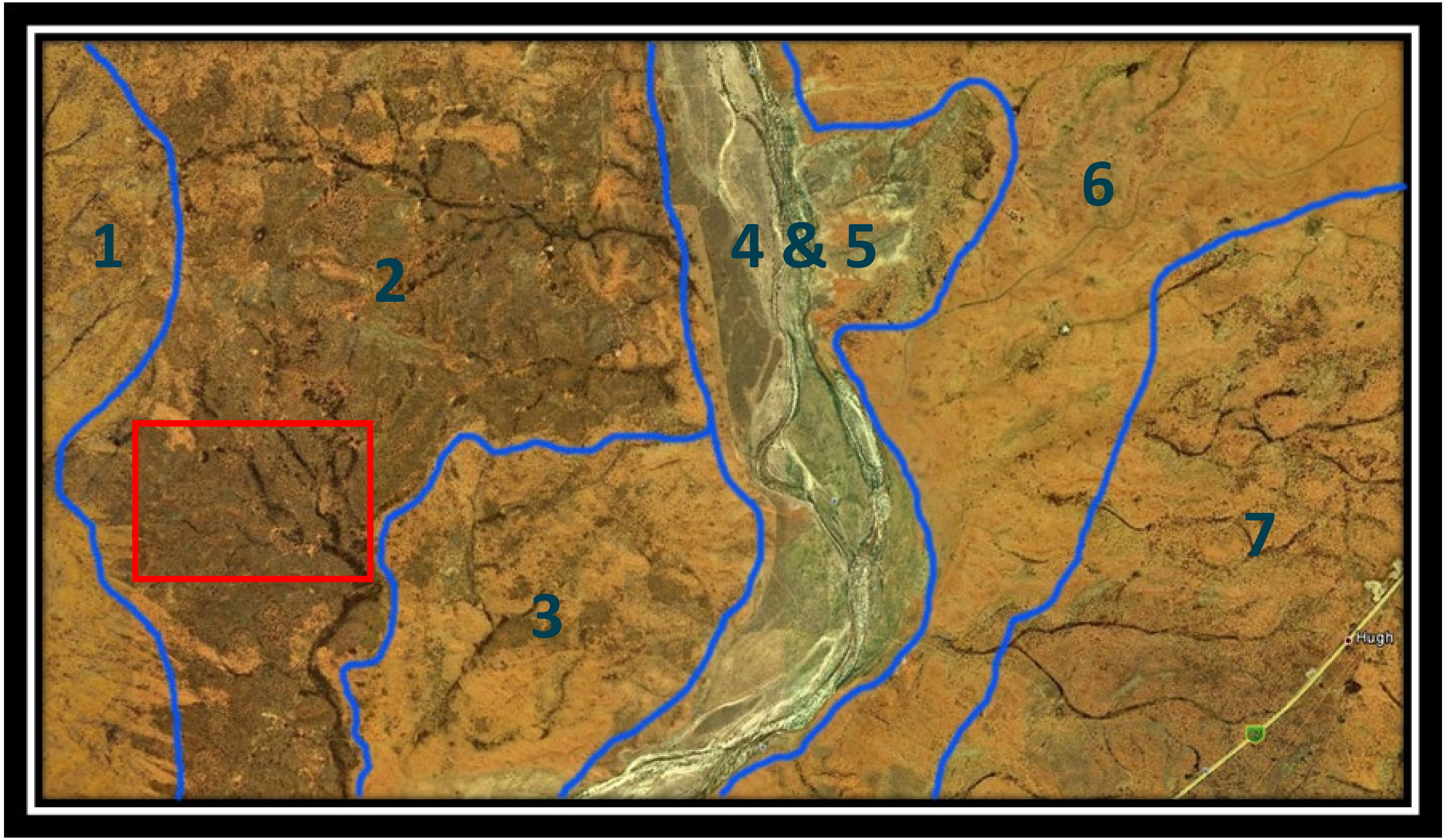
Locating the Site – Community 1



Locating Plots – Community 1



Locating the Site – Community 2



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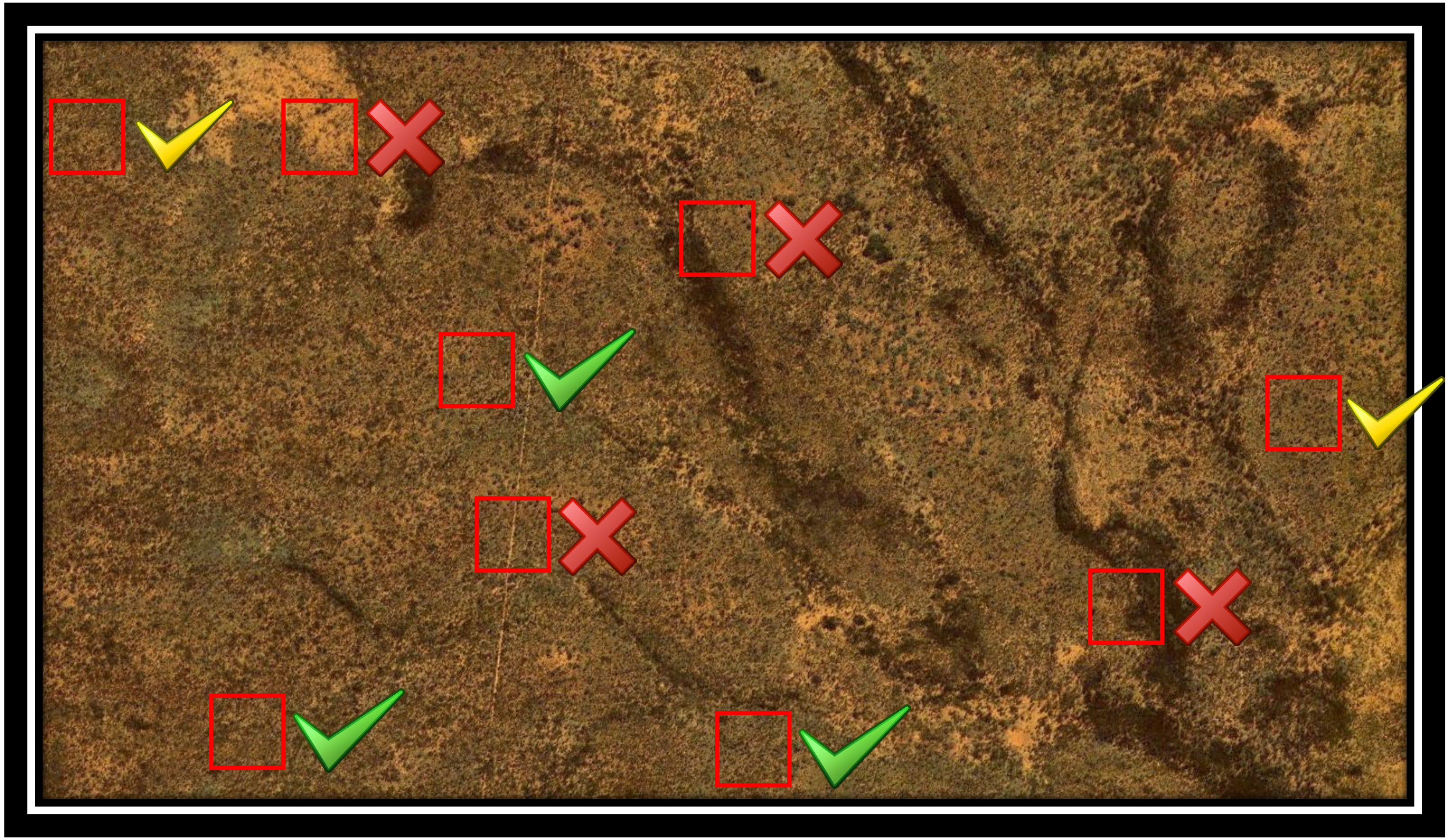
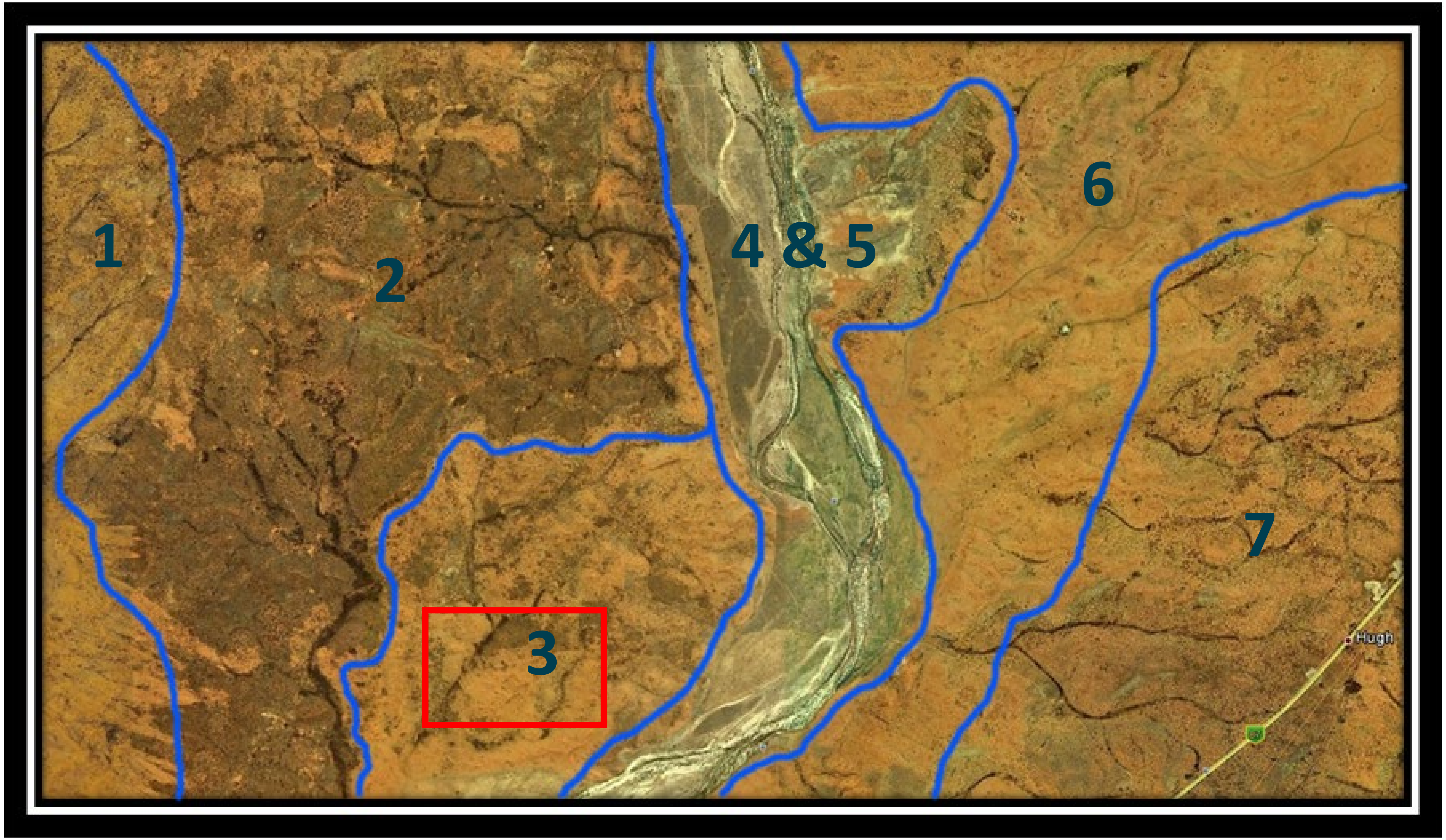
Locating Plots – Community 2



Locating the Site – Community 3



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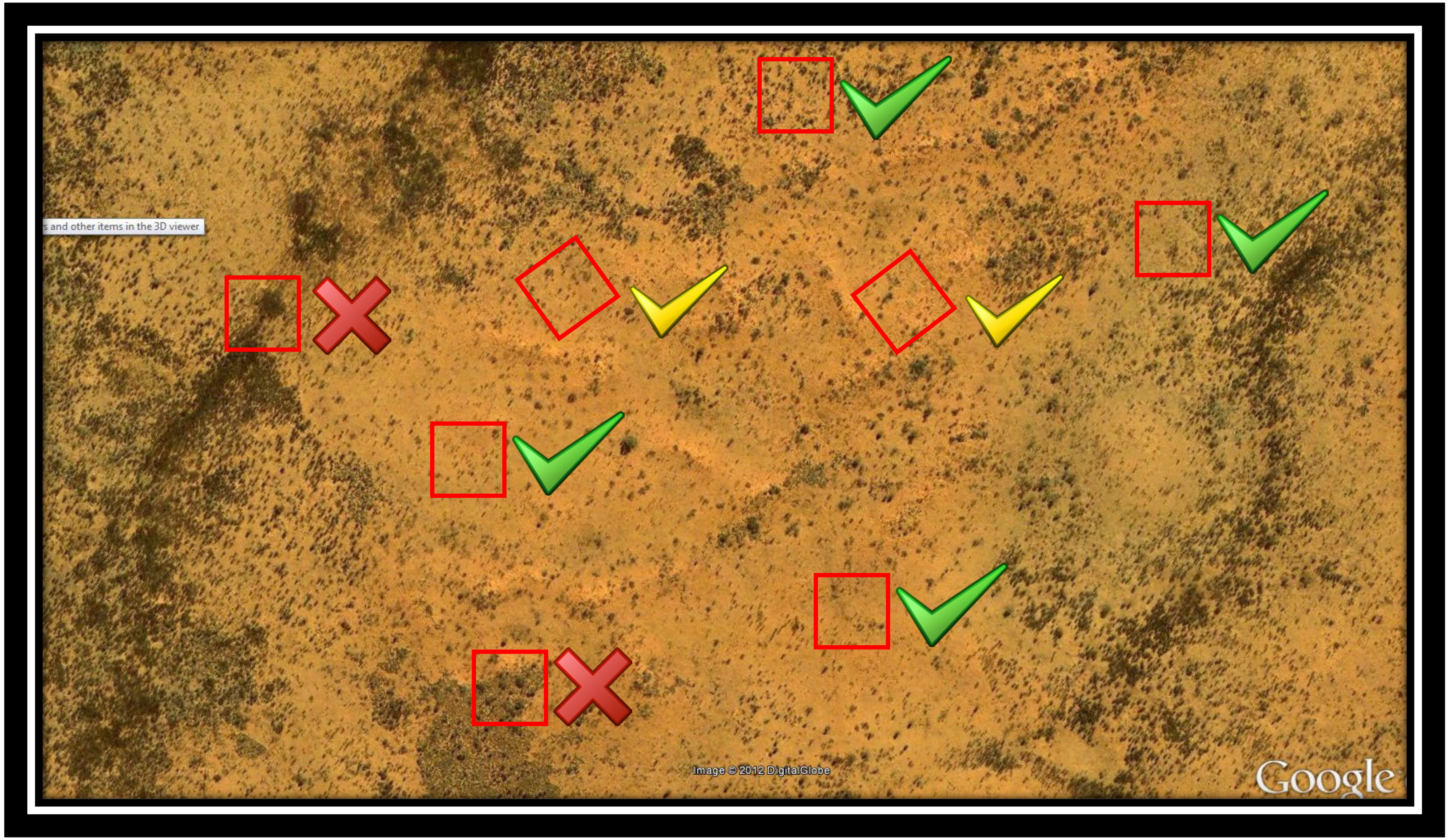
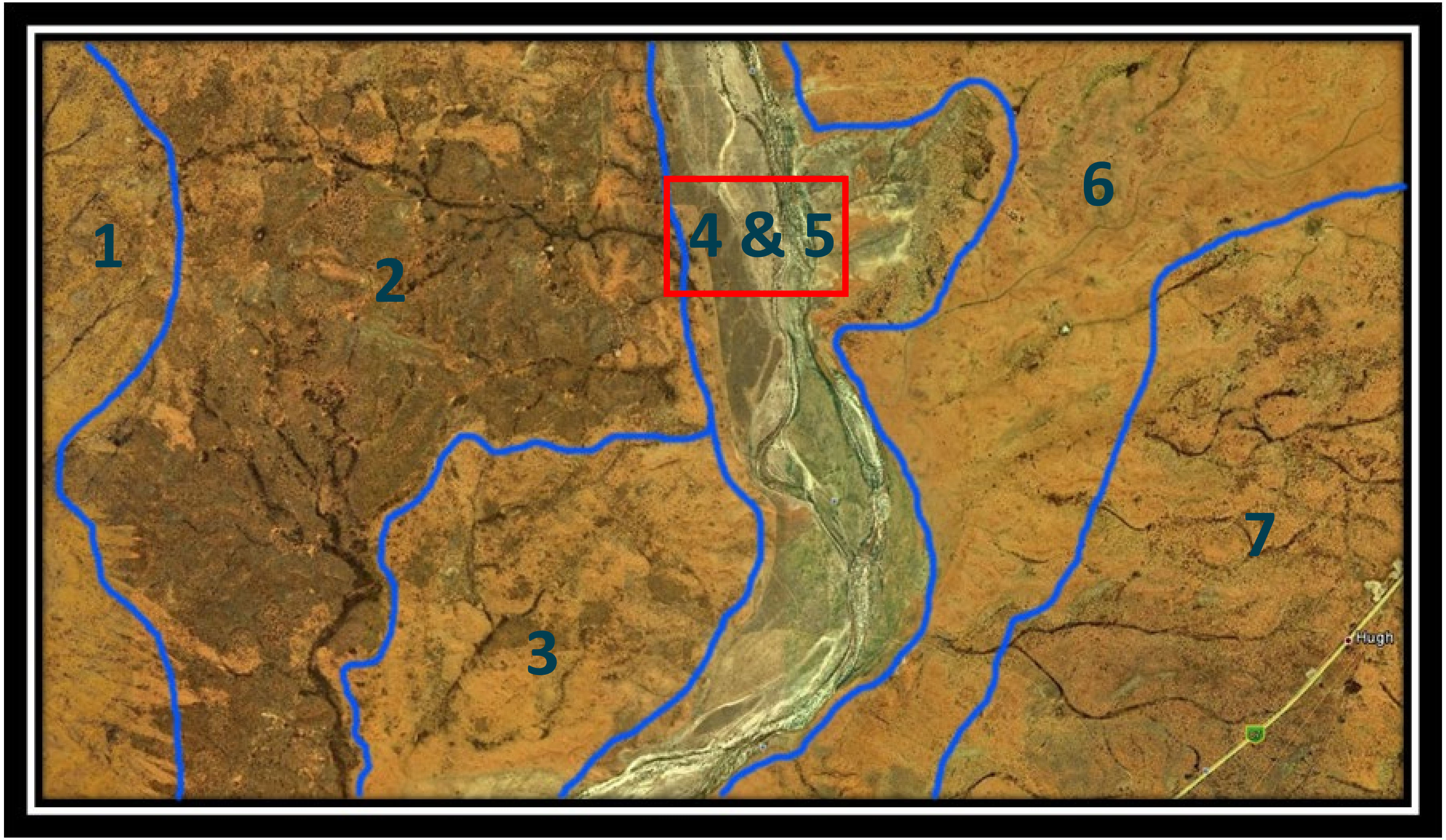
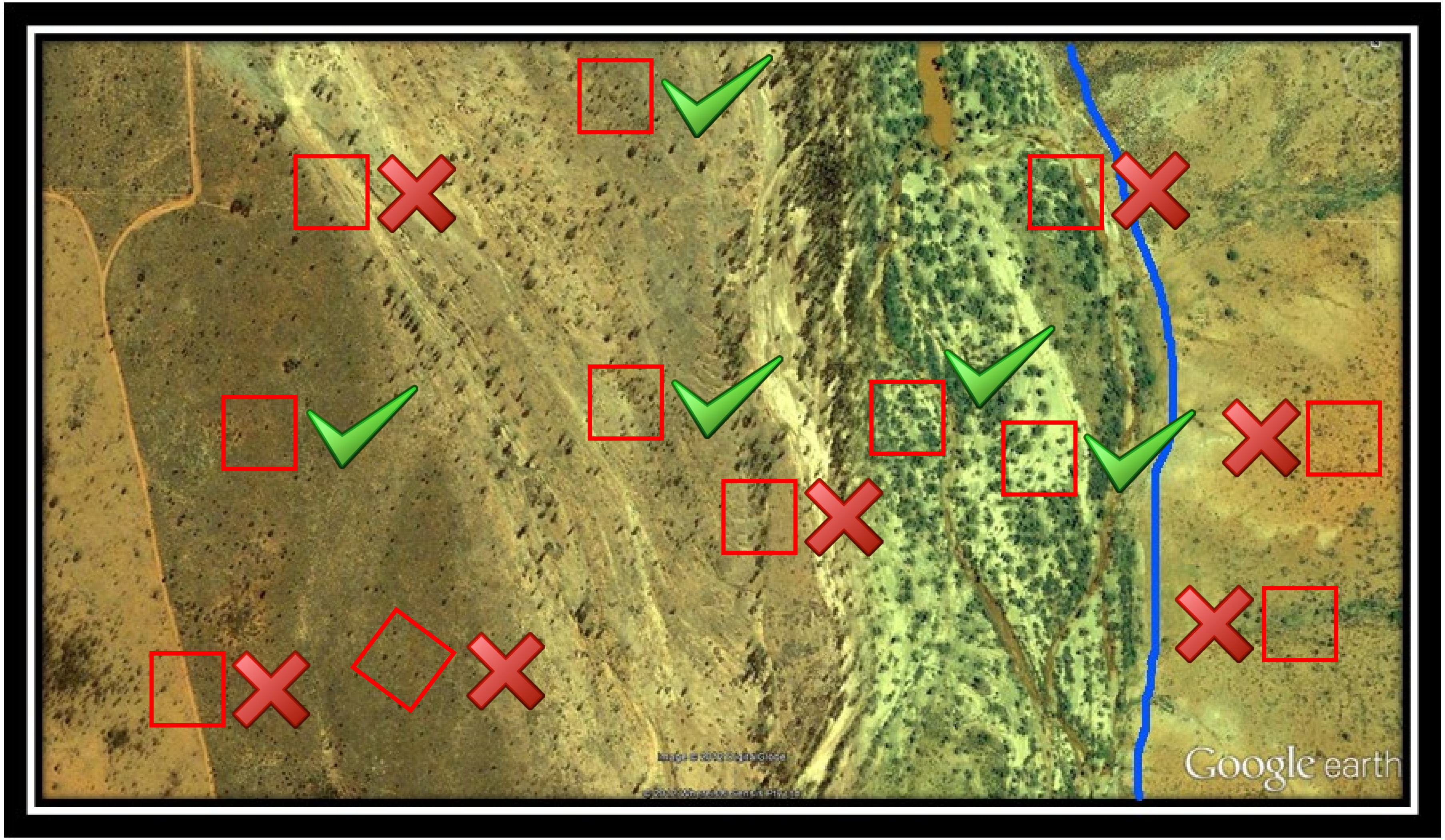
Locating Plots - Community 3



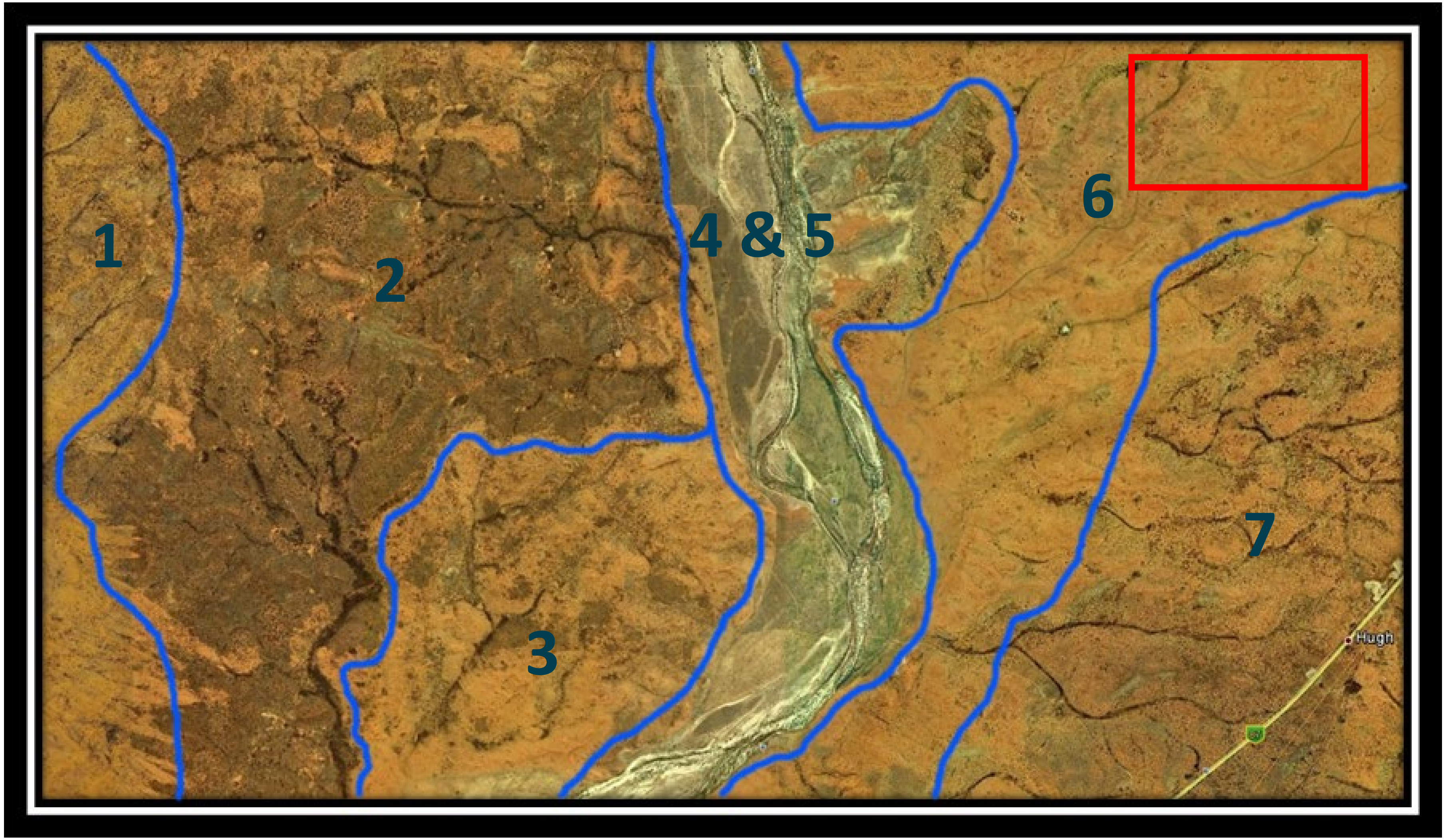
Locating the Site – Community 4 & 5



Locating Plots - Community 4 & 5

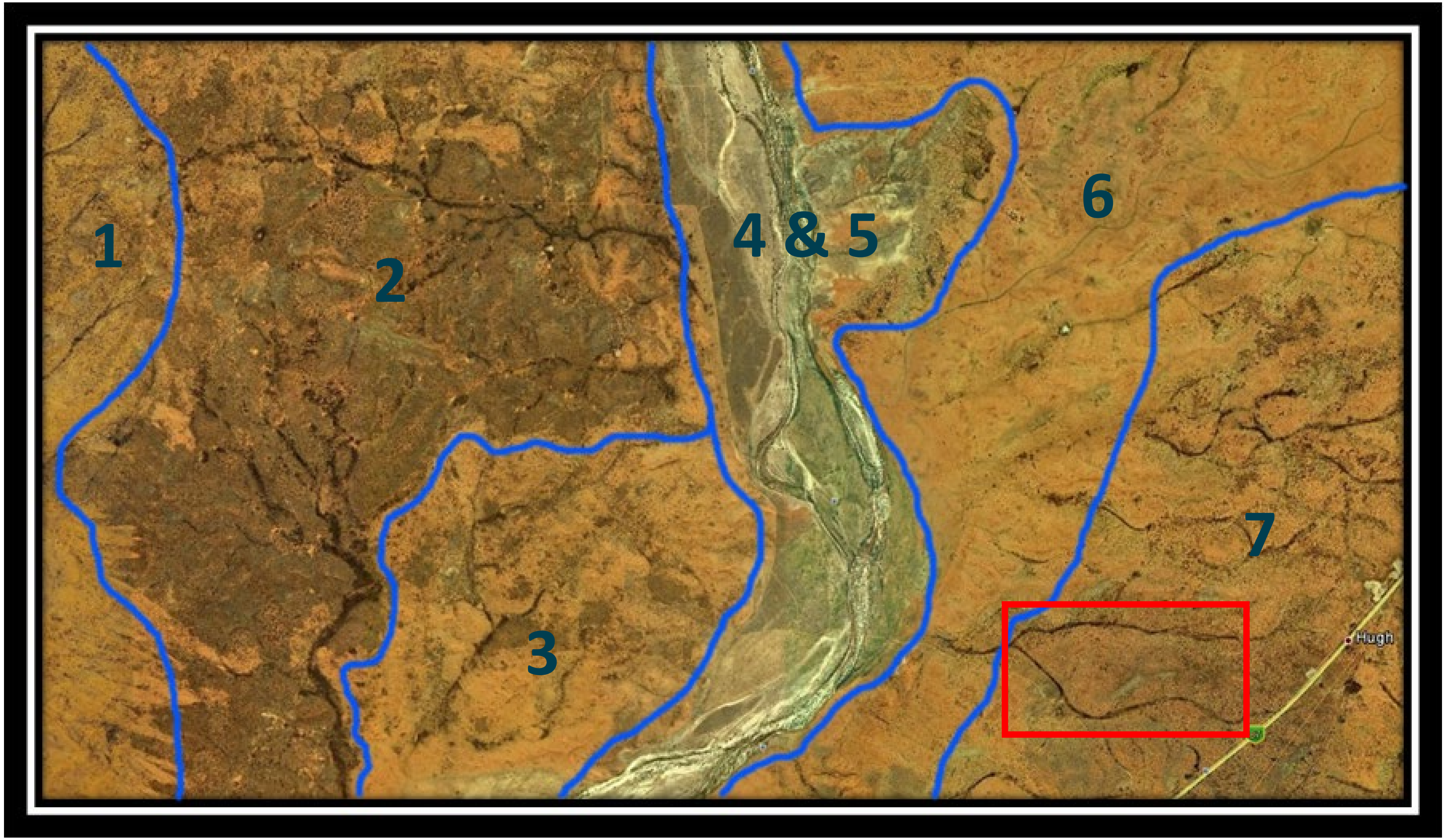


Locating the Site – Community 6



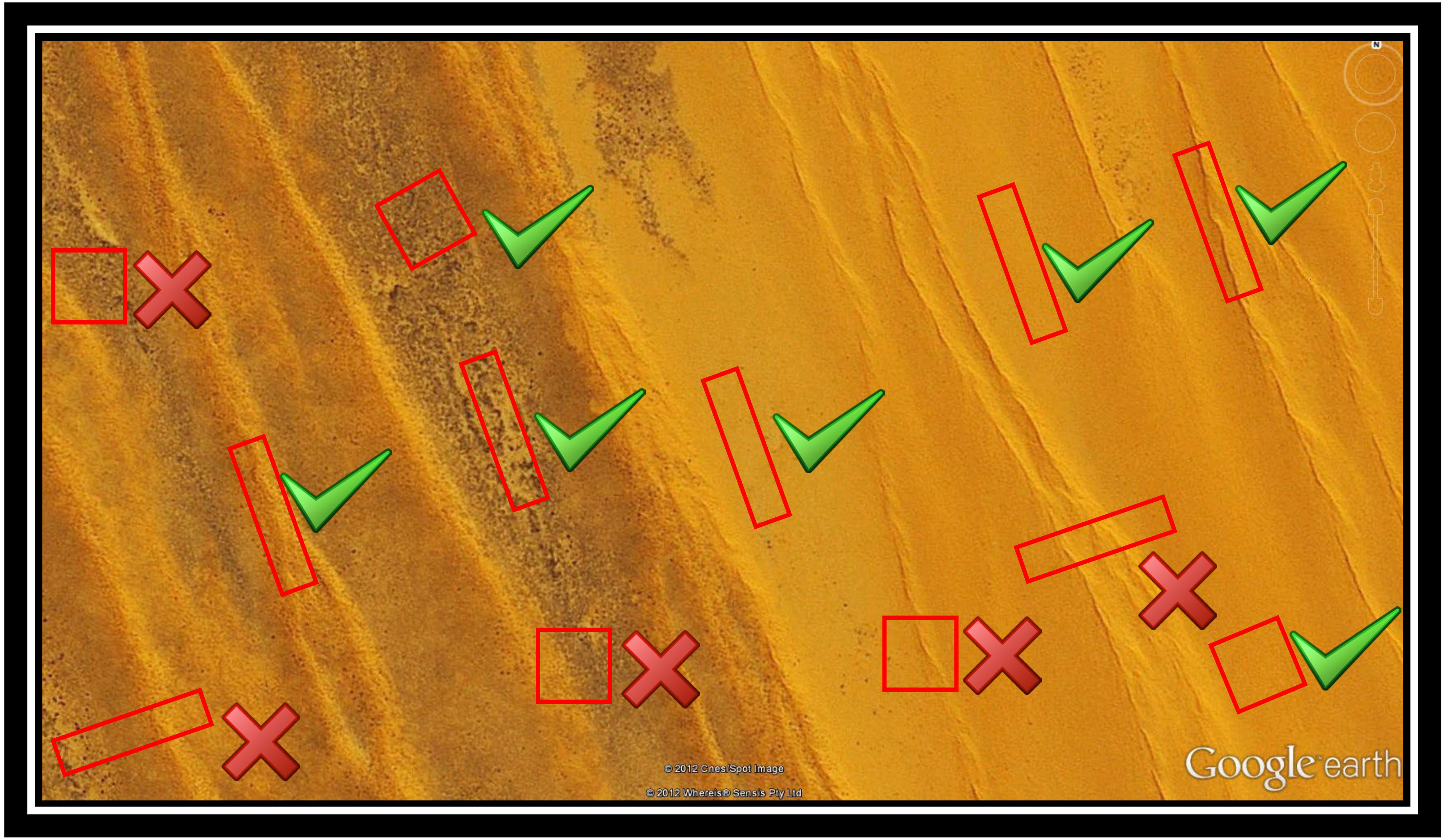
Locating Plots – Community 6

Locating the Site – Community 7



Locating Plots – Community 7

Exceptions



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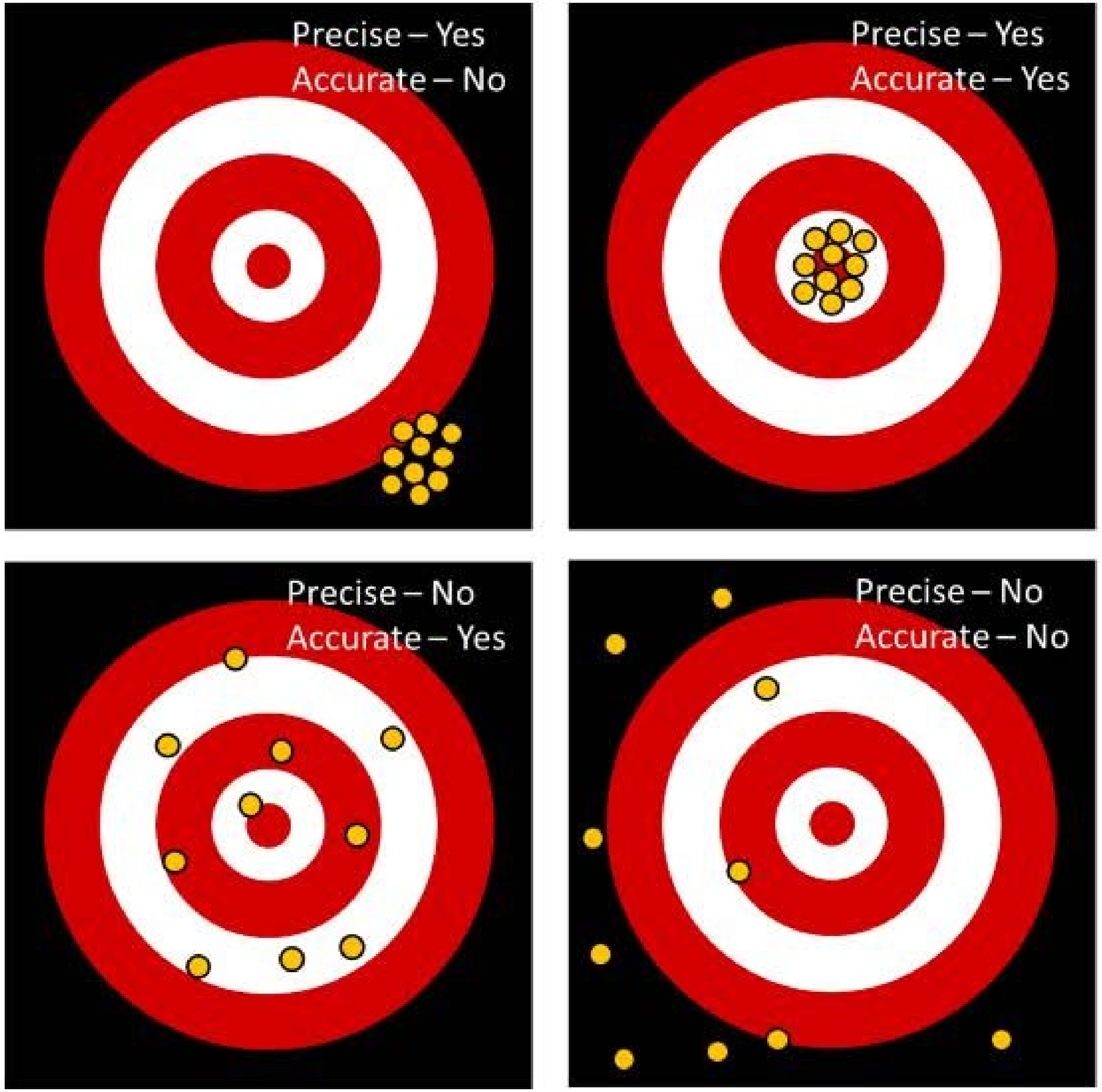
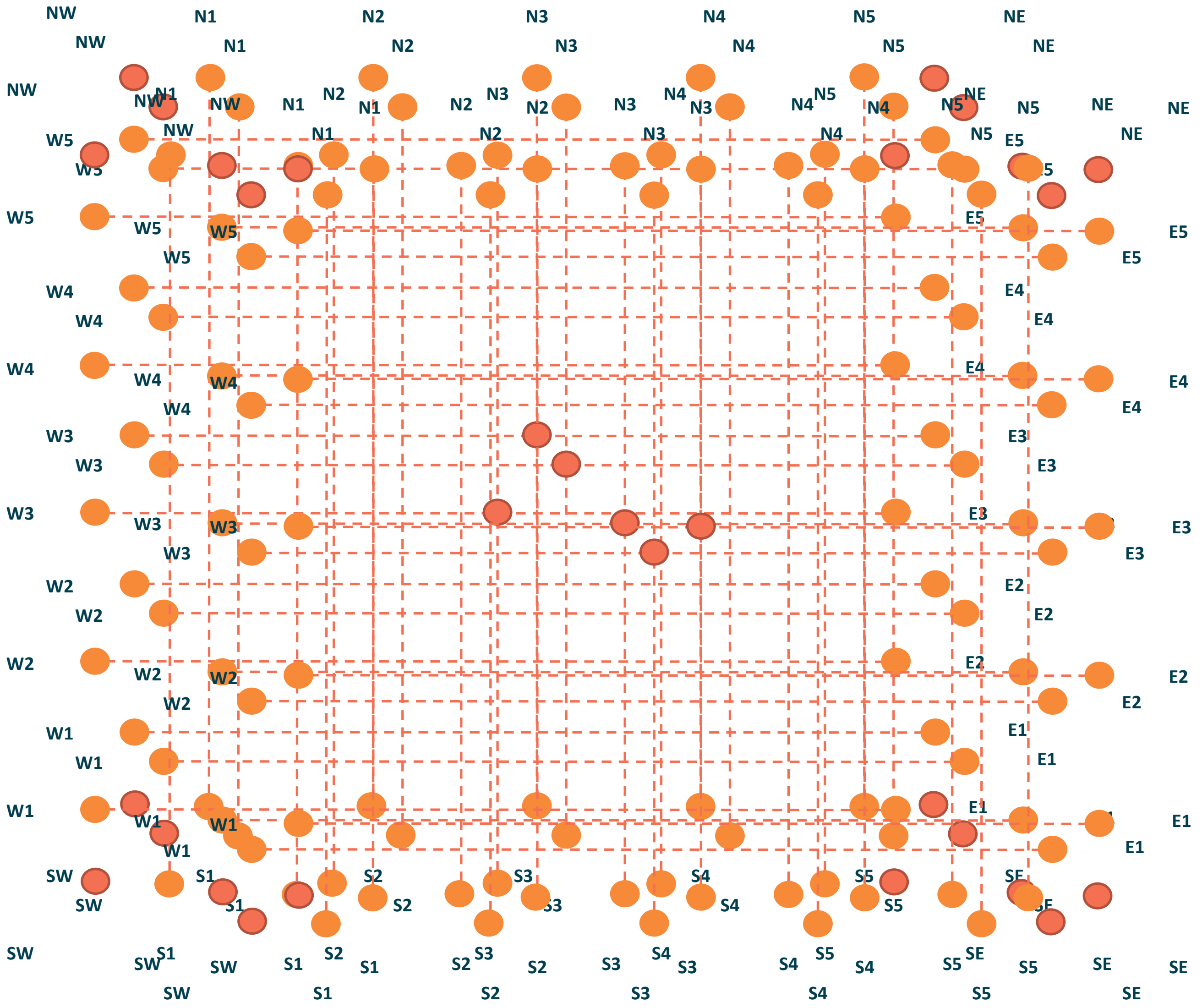
Google earth

Accurate and Precise

- Do you need relative accuracy or absolute accuracy?
- Often you'll want to locate with DGPS, but how that happens (and What cost) relates to how accurate you want things to be.



Location



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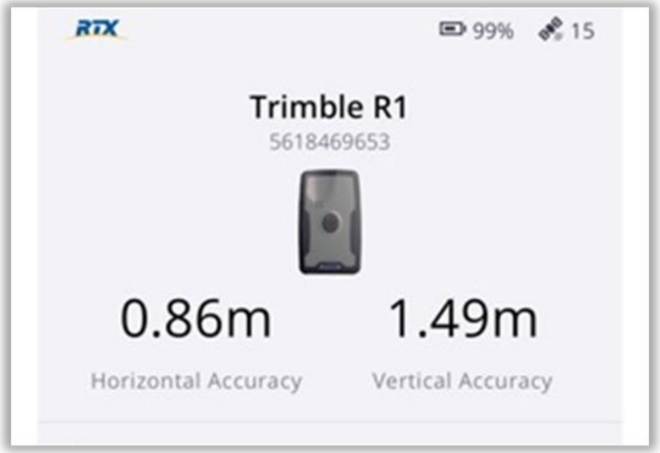
GPS accuracy

- **Open sky:** 3–5 m Strong satellite lock, minimal obstruction.
- **Suburban streets / light tree cover:** 5–10 m Mild obstruction reduces satellite geometry.
- **Dense city ("urban canyon"):** 10–30+ m Multipath reflections off buildings cause large errors. Dense canopy
- **Indoors / underground:** Very poor Usually falls back to Wi-Fi or cell-tower positioning (15–40 m or worse).

- Often GPS can be appropriate for medium to coarse resolution imagery, but you'll probably want to consider DGPS for higher accuracy in medium to very high-resolution imagery.

DGPS

- Most commonly receives a correction factor from a known reference station via a communications satellite
- Common to get sub-metre accuracy
- Sub decimetre possible in some conditions
- Easy to use.



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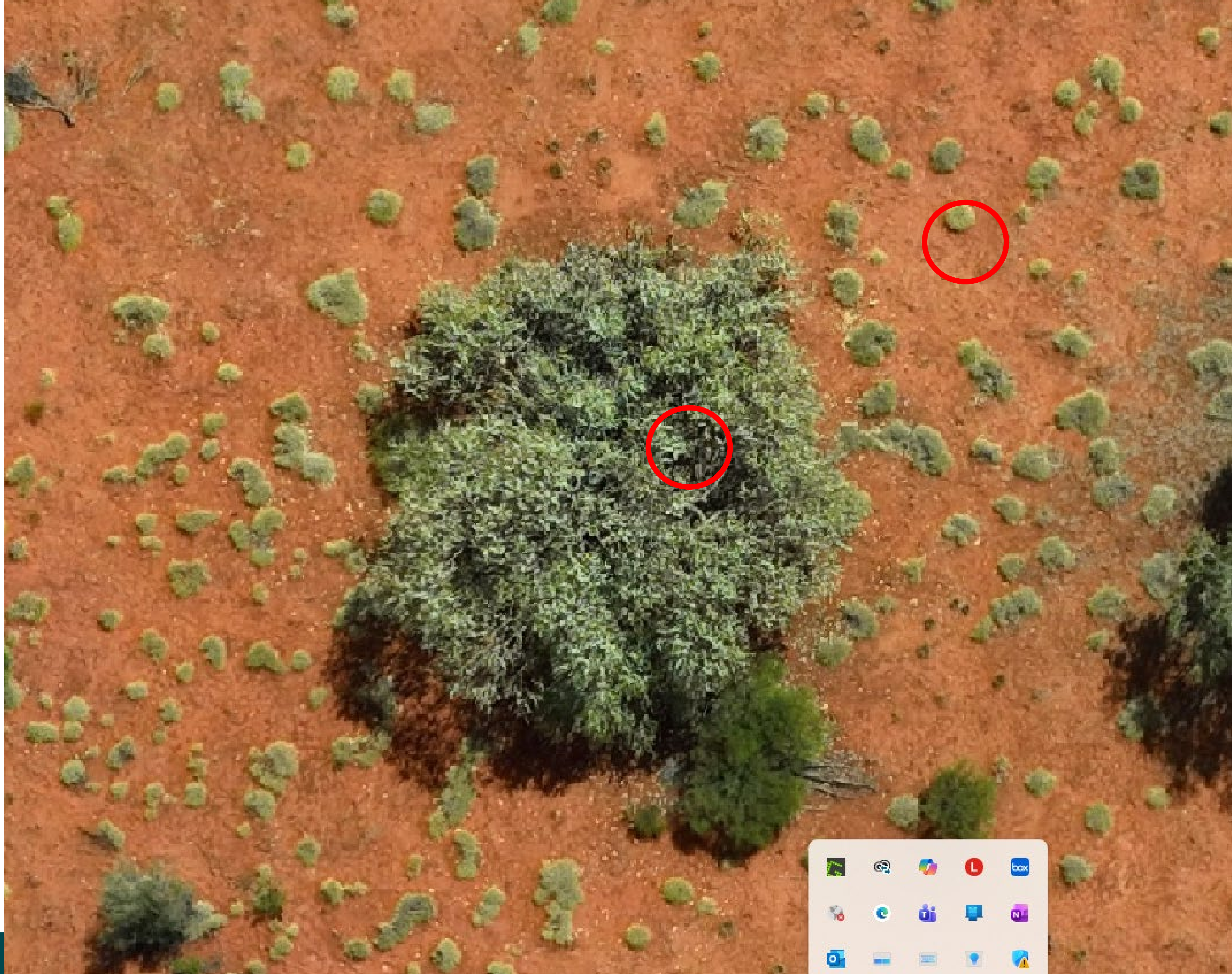
RTK

- An RTK system is a **GNSS positioning technique** that uses **real-time correction data from a known reference station** to allow a mobile receiver (the rover) to compute its position with **1–3 cm accuracy**.
- Often used for extreme accuracy applications
- Enables super accurate drone collection
- Does require the base station to be set up over a location that is known accurately.
- It “transfers” that accuracy to the “rover” (often Drone)
- We will do this in the coming days.
- Can be used without the known point for relative accuracy.

Points

You need to consider GPS quality compared to what you're looking at.
- In this example (the circle shows gps accuracy) it's probably useful training for the acacia, but not for the triodia



Plots

- Often for coarser resolution imagery you'll want to aggregate a number of field measures to inform on a plot. (we'll use cover as an example)
- E.g. Our plot 100 x 100 (3x3 landsat pixels
- Given you'll "cookie cut" your imagery it's sensible to define your plot with DGPS
- Aligning your plots to the map grid makes validation so much easier for you.
- * Unless there is a good reason not to – Put your plot in a homogeneous area.
- Consider if you're plots are independent samples (don't locate right next to each other)

What is an appropriate plot size

- field validation plot should be at least 2 to 3 times the satellite's ground sampling distance (GSD)

Satellite / Sensor Category	Spatial Resolution (Ground Pixel Size)	Recommended Minimum Validation Plot Size	Core Application / Context
High Resolution (e.g., PlanetScope, SkySat, WorldView)	0.5 m – 3 m	6 m × 6 m to 9 m × 9 m	Precision agriculture, urban mapping, infrastructure monitoring
Medium-High Resolution (e.g., Sentinel-2 MultiSpectral Instrument)	10 m – 20 m	30 m × 30 m to 60 m × 60 m	Crop type mapping, forest canopy cover, water quality
Medium Resolution (e.g., Landsat 8/9 OLI, Sentinel-2 60m bands)	30 m – 60 m	90 m × 90 m to 180 m × 180 m	Regional land cover change, wildfire burn severity, biomass estimation
Coarse Resolution (e.g., MODIS, Sentinel-3 OLCI)	250 m – 500 m	750 m × 750 m to 1.5 km × 1.5 km	Continental vegetation indices (NDVI), global climate modeling

Consider Timing

- Ideally as close as possible to the time of image acquisition
- Sensitivity depends on what your measuring – How temporally variable is it?
- Consider seasonality of the environment you're in (as well as disturbances such as fire, flood, drought etc)
- If calibrating using solar irradiance / reflectance instruments, you'll want to sample them at the same time/day as the satellite overpass….. These measures are susceptible to atmospheric changes.

Method Considerations

- Does the method need to be used over large areas?
- Does it need to be used with other data?
- Does it need to be used by multiple people?
- Multiple skill levels?
- Over an extended period of time?
- Do standard methods already exist?
- Don’t invent something new if one already exists
- Maximises benefit for everyone

Where to find methods?

- EMSA
- TERN Website
- Good practice guidelines (green book)
- CEOS
- Links

Measure the right things

- Do you need to measure a proxy?
  - E.g. Only way to *Measure* biomass is to cut everything in your plot down and weigh it…. But that's not feasible
  - Most likely you'll need to measure DBH and use Allometric equations to calculate biomass and relate this to biomass from your analysis

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

Accurate

- Will it collect information of suitable accuracy for your application?
- E.g. it's pointless collecting cover data that accurate to 20% if your aim is to detect 5% change in cover.

Ensure your field method is accurate enough to achieve your aims.

Some Change is Massive....

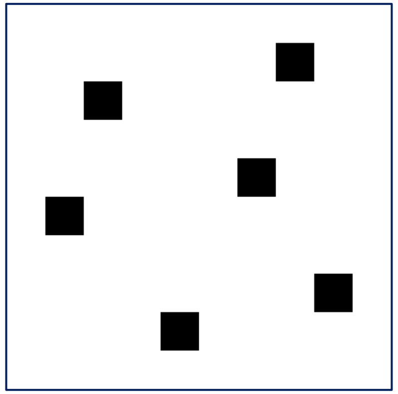
... and some change is subtle...

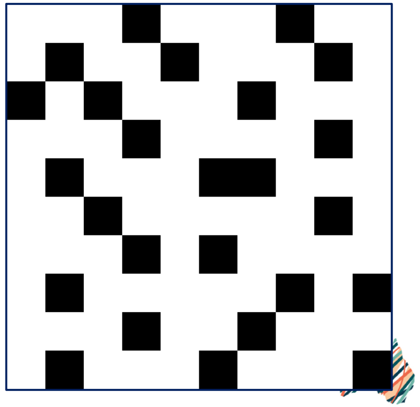
... Need to accurately measure change and understand accuracy!

Objective Measures

- … to prove that change is occurring, and quantify that change.

Score	Modified Score	Description
N	0.1	Not many, 1-10 individuals
T	0.5	Sparsely or very sparsely present; cover very small (less than 5%)
1	1	Plentiful but of small cover (less than 5%)
2	2	Any number of individuals covering 5-25% of the area
3	3	Any number of individuals covering 25-50% of the area
4	4	Any number of individuals covering 50-75% of the area
5	5	Covering more than 75% of the area





Consider openly available data

- Is their suitable FAIR data you could use?
- ACE-QA/DCCEEW/TERN project
- If not, and you collect according to a standard then maybe you'd be happy to submit your data for others to use?