



Australian  
National  
University

# 3D Forest Monitoring

*Drone Photography,  
Photogrammetry,  
and Python*

Zac Hatfield Dodds

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# Outline

1. CONTEXT – who, what, where, why...
2. RAW DATA – aerial images
3. POINTCLOUDS – photogrammetry tips
4. ANALYSIS – data to information with Python
5. QUESTIONS!



# CONTEXT

Where are these trees and why is anyone measuring them?



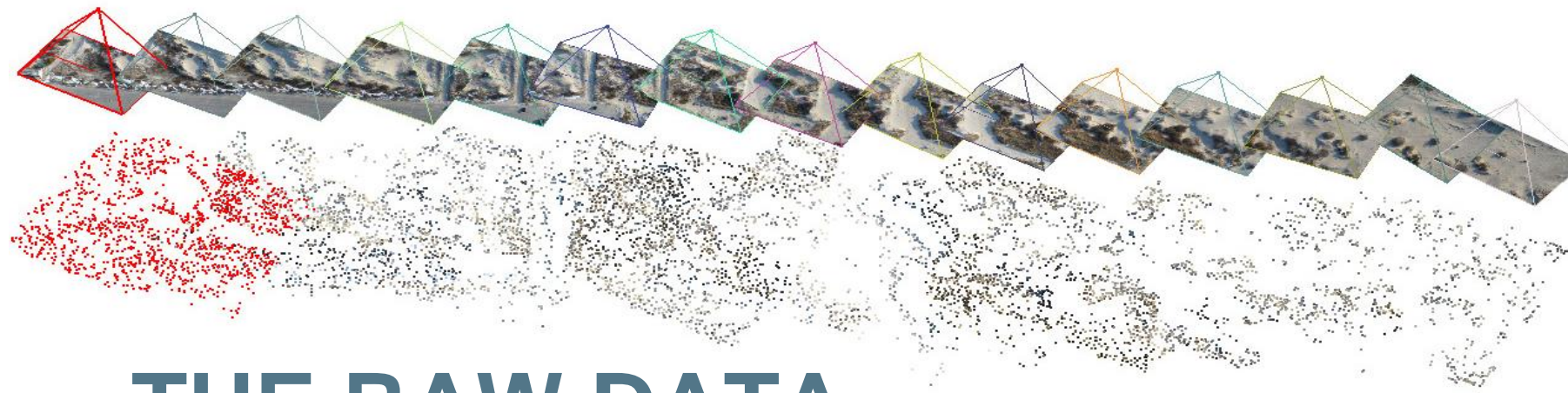
# National Arboretum Research Forest

- Joint project of ANU, CSIRO, ACT gov.
- Research forests for biology & ecology
- Testing and calibration site for RS tech
- Plan: collect *all* the data we'll want in 30 years

# Show me the drones!

- Citizen science: awesome, but doesn't scale
- PESA: pretty cool, but it doesn't fly
- LIDAR: very cool, but either
  - terrestrial: carried by hand, slow, expensive
  - aerial: low-res, very very expensive

Challenge: individually measure every tree in a forest, fast and cheap enough for weekly data



# THE RAW DATA

Flight patterns for lots of overlapping images

# Photogrammetry 101

- We can construct a 3D scene from 2D images
- Best results if we have:
  - Many images
  - Known location and angle
  - High overlap
- Output is a ‘point cloud’
  - List of RGB pixels with XYZ coordinates
  - Imagine LIDAR, + colour, - precision

# High-overlap Flight Patterns

- Grid patterns: classic cause they work
- Need  $\sim 1/3$  image overlap on each side
- Think about vertical surfaces
  
- ‘Orbiting’ a feature of interest works too



# Other considerations

- Camera shutter speed – blur is bad
- Sacrifice resolution for clarity
- Some software can use video
- Not all GPS tags are good enough
  - Supplement EXIF with a flight log



# PROCESSING TO POINTCLOUDS

2D is so twentieth century...



# Software Options

- FOSS:
  - Libre, affordable, cross-platform, ...and lagging
  - VisualSFM is my favorite
  - CMP-MVS also looks good
- Proprietary / commercial:
  - Typically black-boxed, Windows-only
  - You *do* get what you pay for
  - My lab has a noncommercial license for Pix4D

# Generic tips for vegetation

(SFM algorithms are not designed for trees)

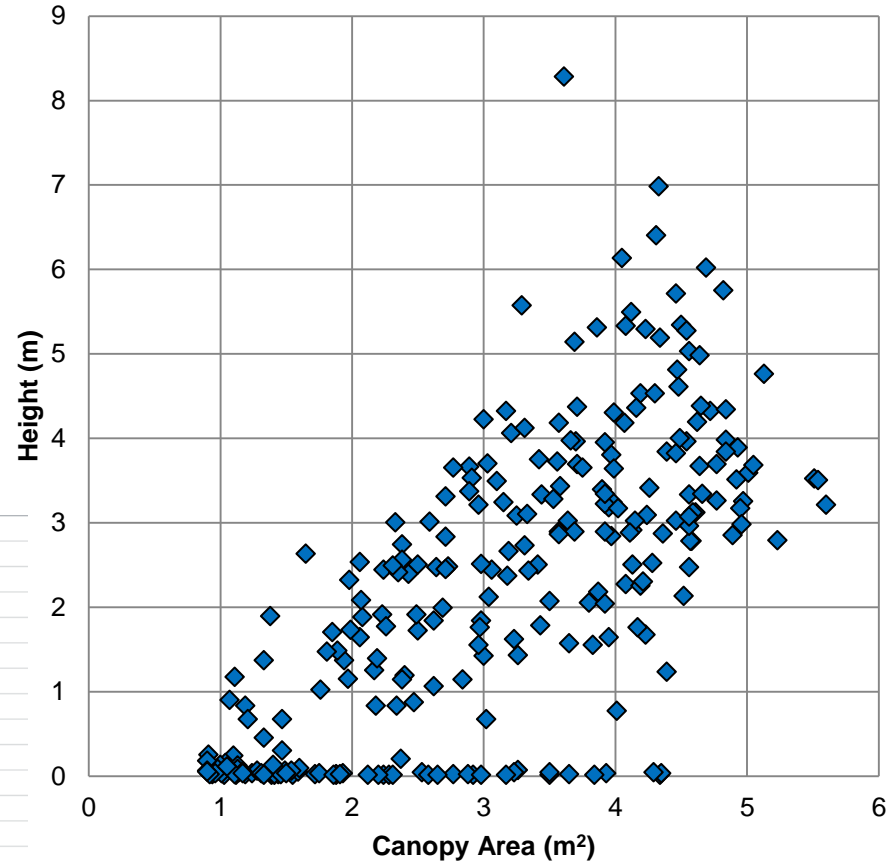
- Downscale images for feature matching
- Full-scale for point densification
- Use maximum point density
- Match few images (default 3; use 2 instead)



# ANALYSIS

Reducing data to information with Python & *forestutils*

latitude	longitude	UTM_X	UTM_Y	UTM_zone	height	area	base_alt	red	green	blue	point_count
12.54093	-79.3993	6091367	6091409	55	4.5	3.01	35.46	50	48	29	21649
12.54034	-79.3982	6091450	6091326	55	5.53	5.53	30.21	50	46	28	29952
12.54065	-79.3977	6091498	6091342	55	6.88	10.64	27.46	43	39	25	54844
12.54033	-79.3982	6091445	6091326	55	6.28	10.71	30.44	45	42	28	54559
12.54045	-79.3988	6091403	6091351	55	4.76	6.33	33.27	46	46	27	41819
12.54058	-79.3994	6091354	6091379	55	5.78	6.21	34.92	46	48	26	43979
12.5411	-79.3985	6091440	6091404	55	6.18	7.85	31.26	40	39	23	47434
12.54159	-79.3998	6091344	6091483	55	2.83	2.09	39.69	41	41	23	9555
12.54075	-79.3994	6091361	6091394	55	4.17	2.75	35.41	61	61	30	20663
12.5403	-79.399	6091383	6091342	55	5.93	4.6	32.15	58	54	36	22979
12.54041	-79.4001	6091292	6091381	55	2.19	3.05	33.84	95	103	93	14007
12.54094	-79.3976	6091506	6091369	55	3.92	0.02	26.15	3	4	3	61
12.5414	-79.3983	6091462	6091427	55	5.33	5.01	30.05	38	37	23	29584
12.54108	-79.3976	6091509	6091382	55	6.14	6.34	25.93	52	47	32	32180



# From data to information

- 3D models make *fantastic* tech demos
  - Especially when getting sensor platforms funded
- Less clear what the scientific use is
  - Not LIDAR; can't measure eg DBH directly (yet)
- We want lower detail, lower dimension data
  - How about measuring each tree?
  - Location, height, canopy area, colour

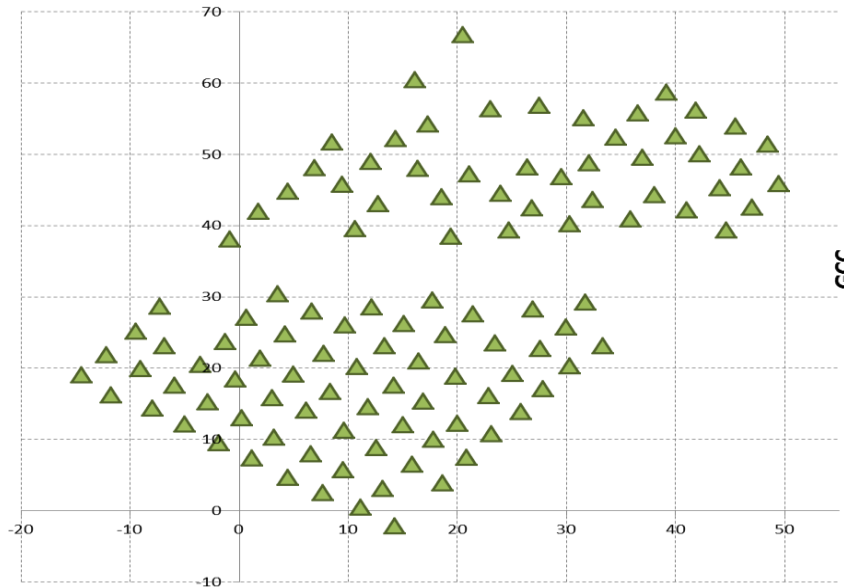
# Python Package: *forestutils*

- <https://pypi.python.org/pypi/forestutils>
- Combines and de-densifies point clouds
- Identifies and measures trees
  - before canopy closure
- GPL3+ and contributions welcome!

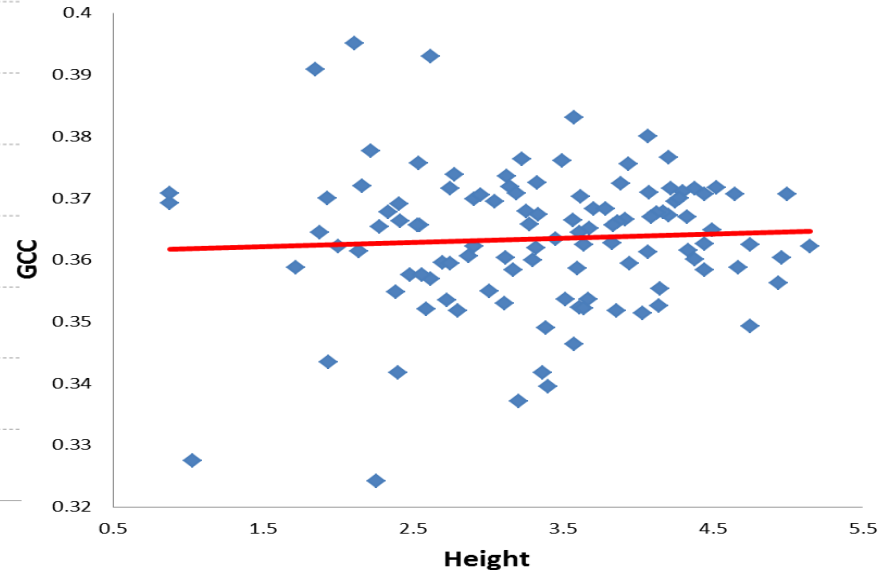
# Sample Outputs:

Attributes for analysis:

**XY Position**



**height and GCC**







Surely I didn't mention everything...

**QUESTIONS?**