Manaaki Whenua
Landcare Research

MANAAKI WHENUA – LANDCARE RESEARCH

Directing predator control from space: using satellites to detect beech flowering

Ben Jolly, John Dymond, James Shepherd, Terry Greene, and Jan Schindler

The problem

Stoats and rats are eating our native fauna

https://www.doc.govt.nz/nature/pests-and-threats/animal-pests/

The problem

- Beech trees flower and produce seeds every year, however the intensity of flowering and volume of seed changes year-on-year and from place-to-place

- Highly productive 'mast' years produce lots of flowers and seed which cause explosions in rodent and then mustelid (e.g. stoat) populations

- When the seed is gone, they all switch to native birds and animals

The Department of Conservation needs to control predator populations in areas of heavy beech masting to protect native species

The problem

- There are ~4.1 million ha of forest in Aotearoa where beech trees are present

- A map of flowering intensity over areas of beech forest would provide helpful information on where to start planning predator control efforts

The Department of Conservation needs to know <u>if</u>, and <u>where</u>, heavy masting is happening

The idea

- If we can produce a map quickly, we can get information to DOC at the end of Spring – well in advance of seed fall in late Autumn

Flowering is very visible from the ground as a red/rust colour, surely this should be visible from space…..

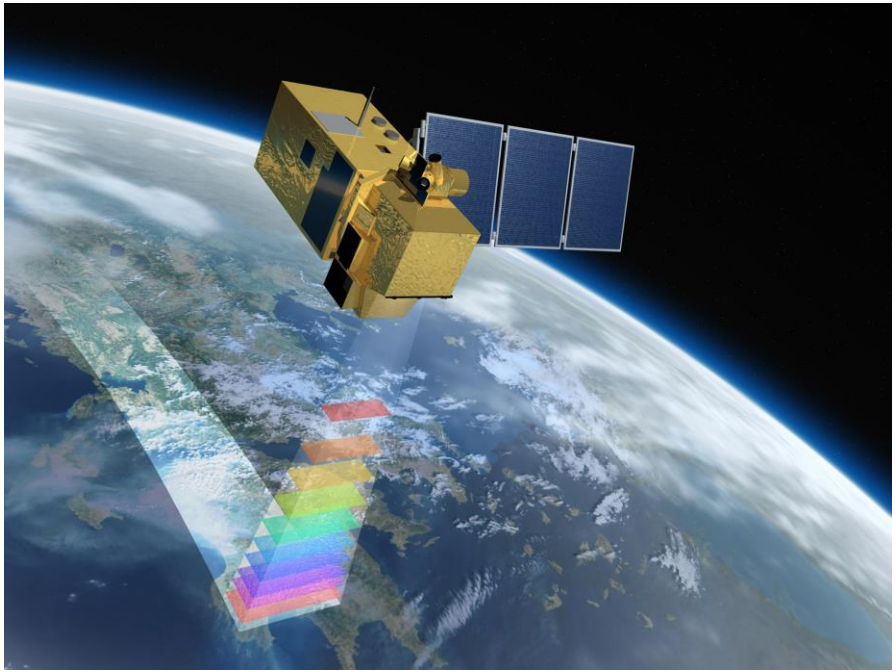
Photos courtesy of DOC staff

The idea

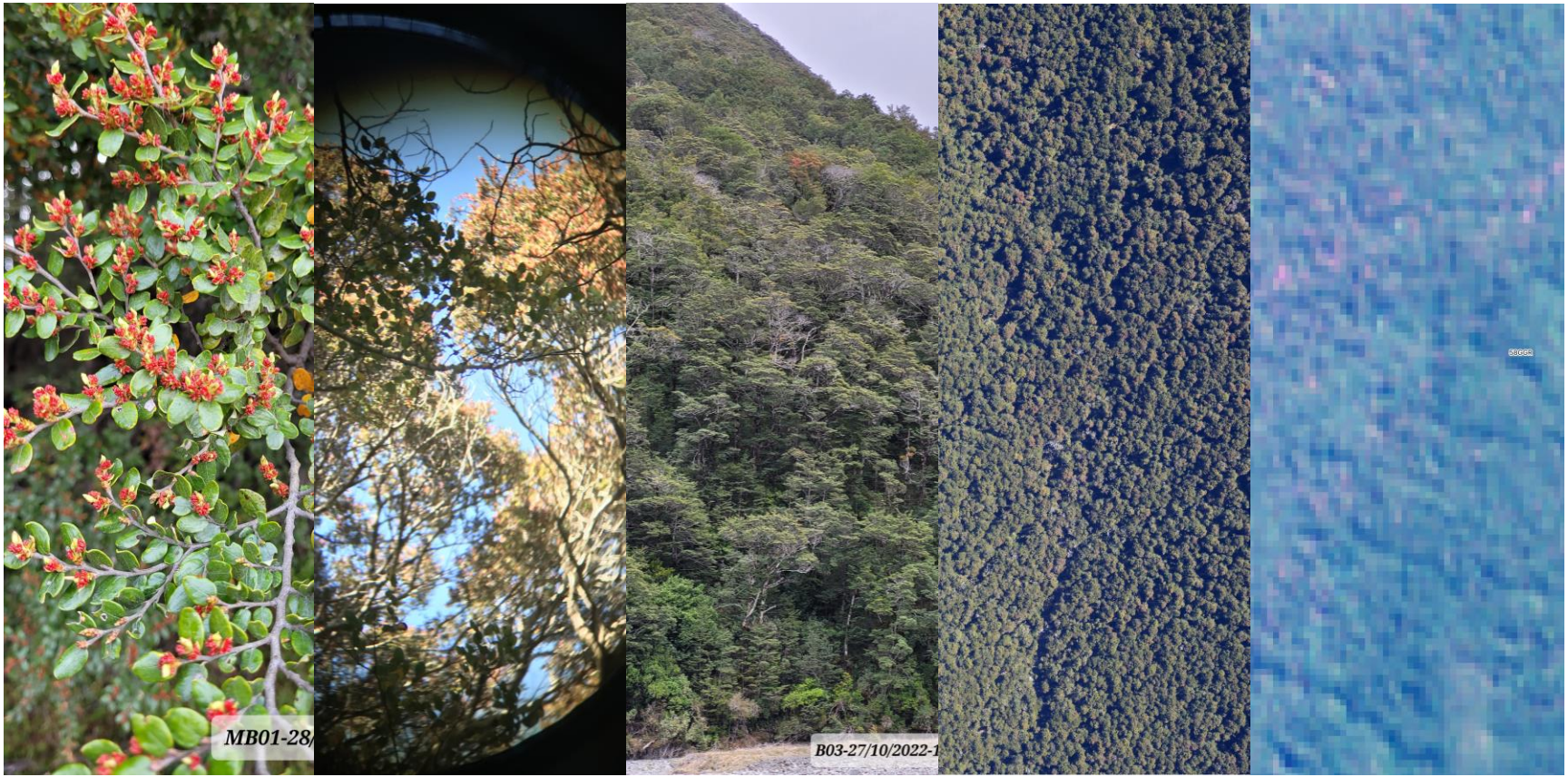
- Sentinel 2a & 2b are satellites with multi-spectral imaging sensors
- 5 daily repeats (national), more in some areas (overlapping passes)
- Data since 2016
- Pixels 10 m x 10 m

- We process/archive all S2 for NZ
- This study used all available images
- Processing only possible on HPC (50,000 core hours and counting)

NeSI
New Zealand eScience Infrastructure



The idea



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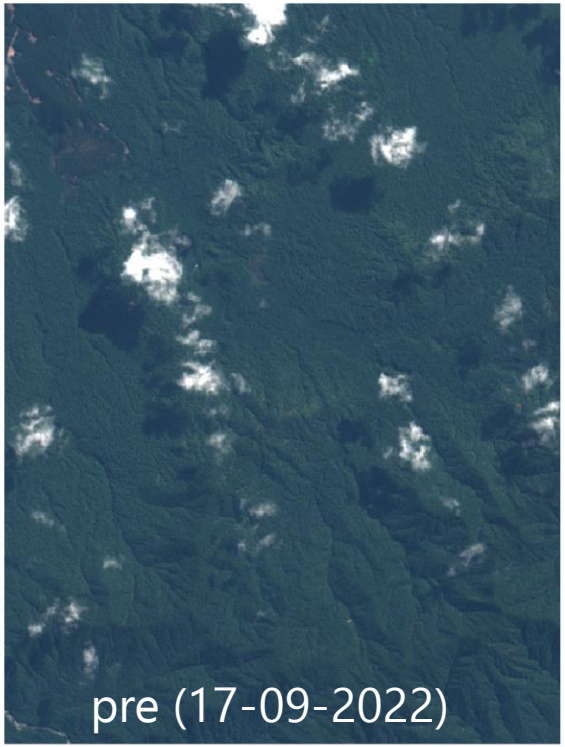
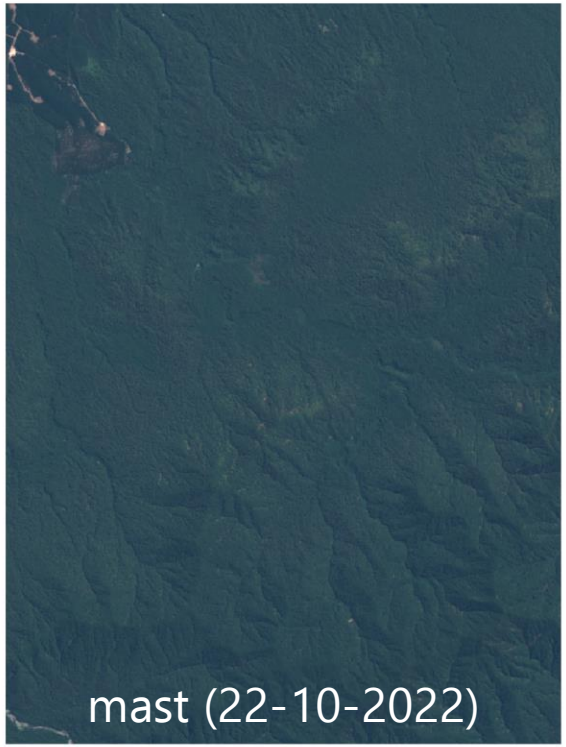
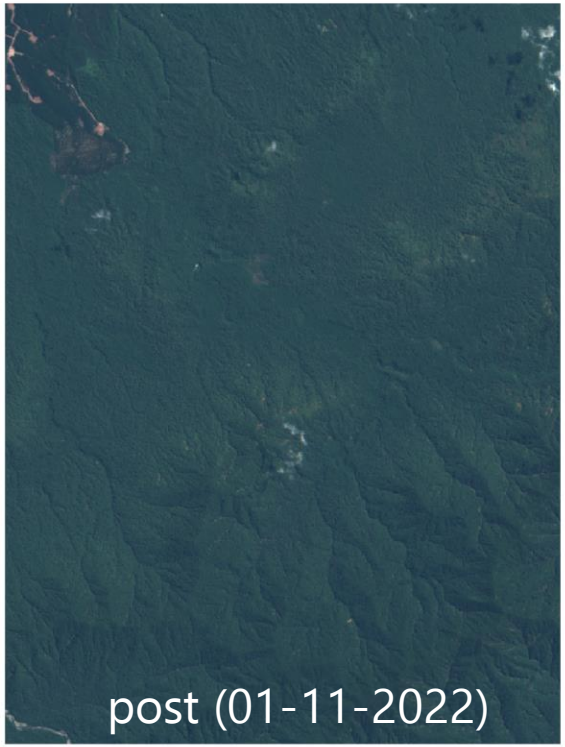
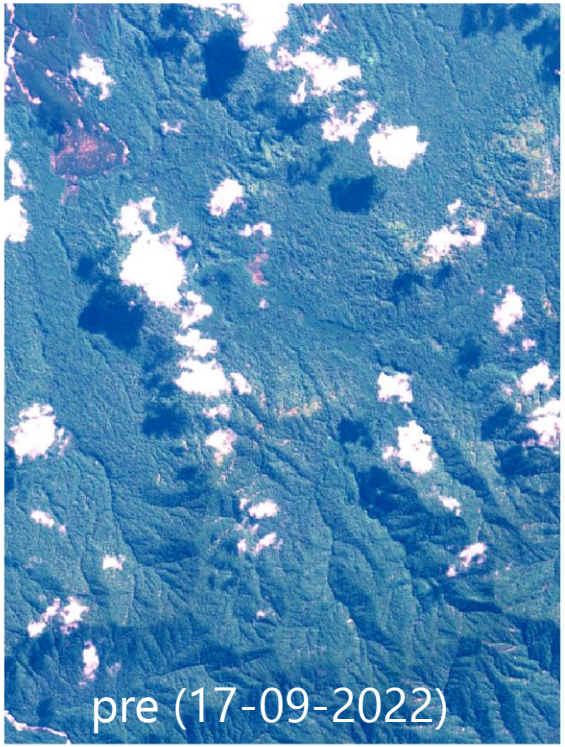
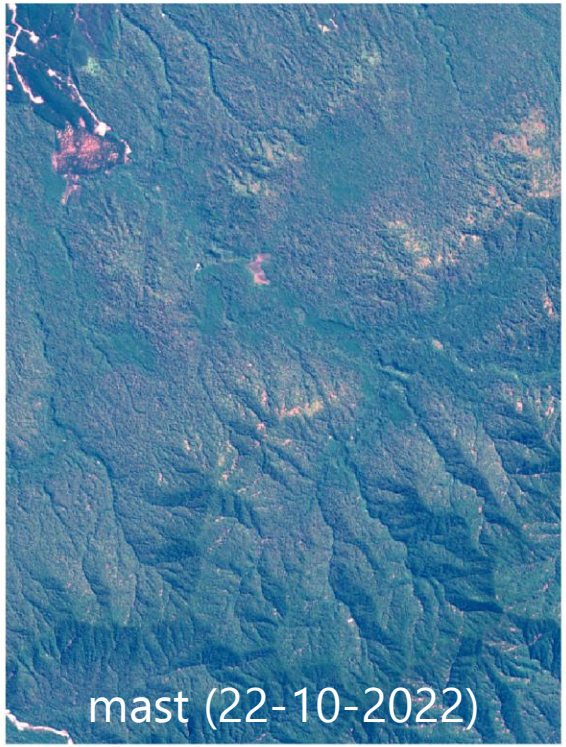


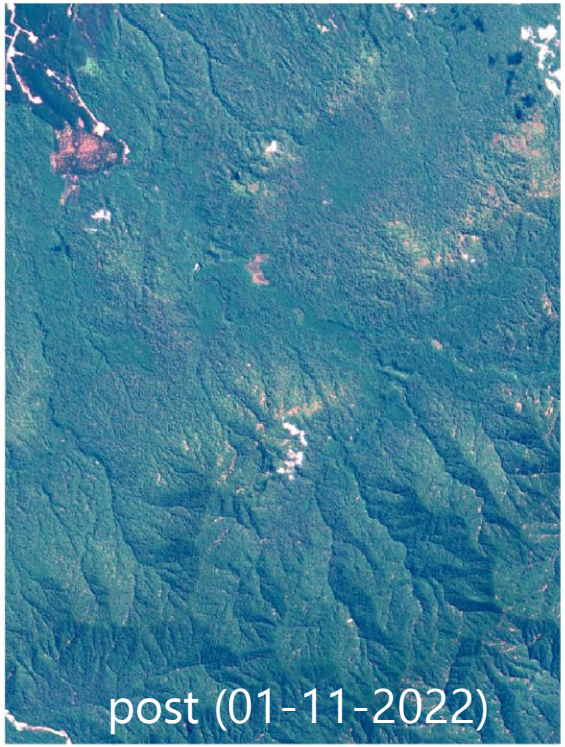




The reality







Methodology

- Beech flowering is not consistent year-on-year
- We have access to temporal satellite data, so we can model a 'typical' (non-masting) year, then calculate the difference for each year to detect heavy flowering as it happens
- To do this, we use an index:

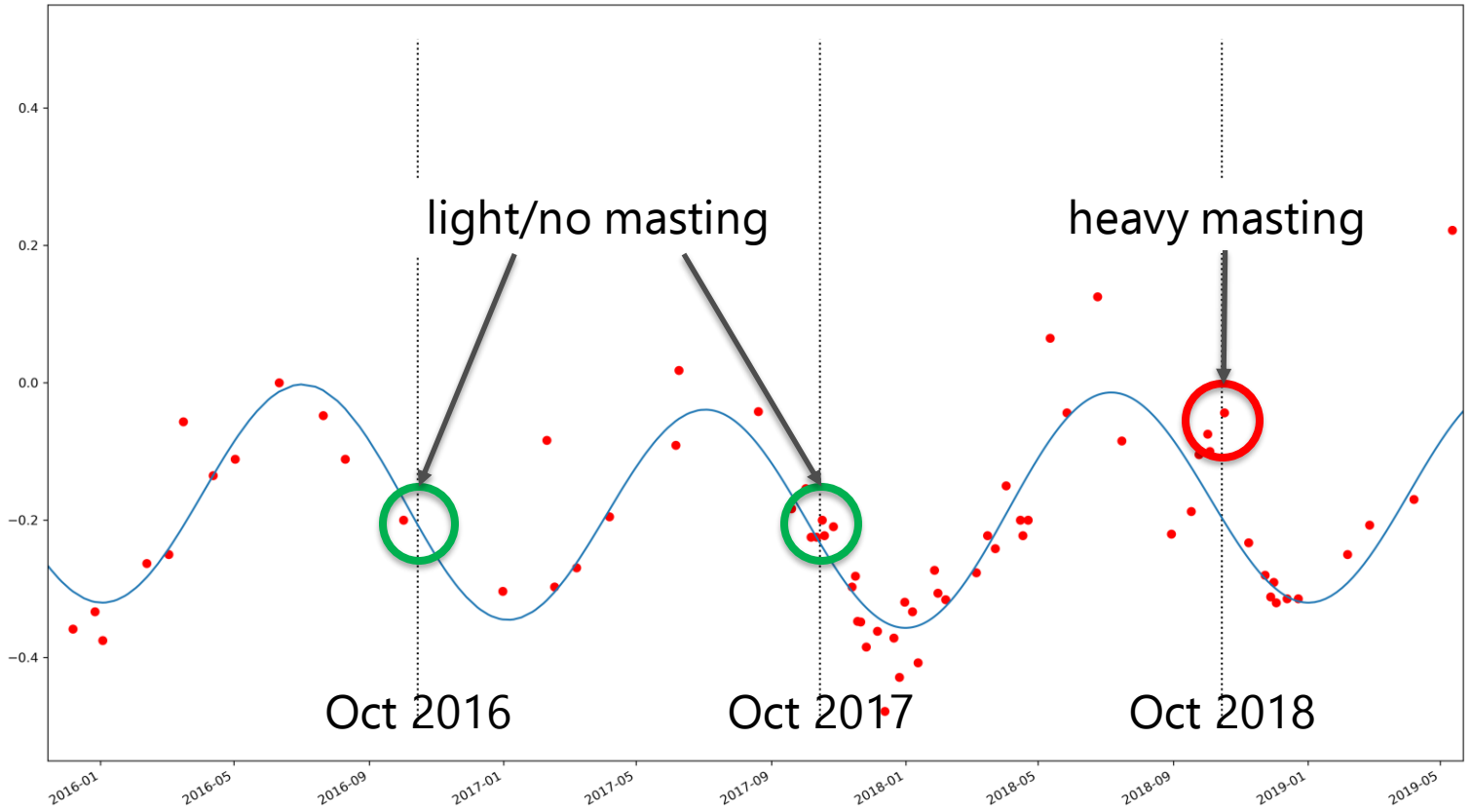
$$NDYI = \frac{R - G}{R + G}$$

- … and a model:

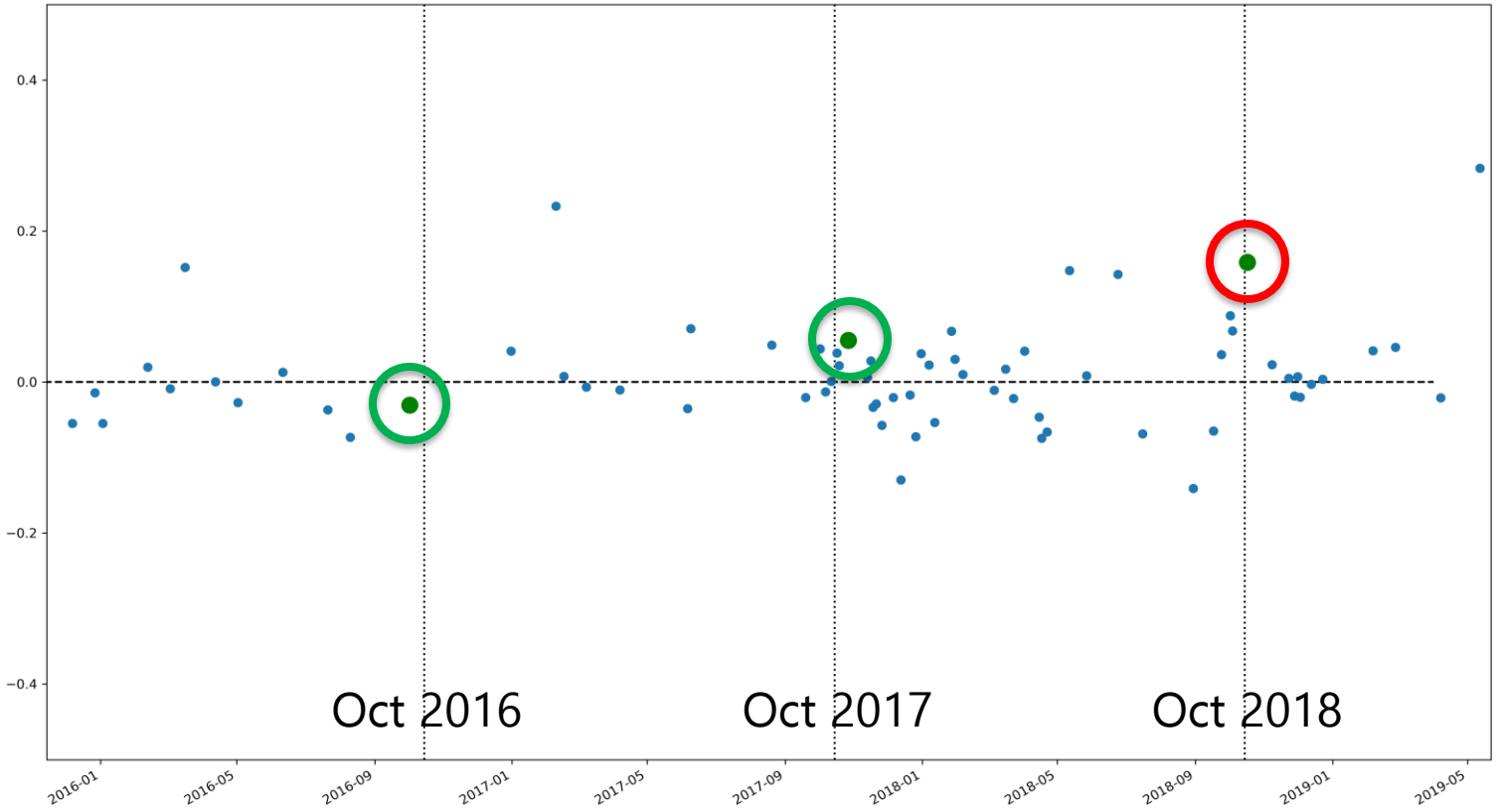
$$\mathrm{NDYI}_{mod}(i,j,x) = c_{i,j} + a_{1,i,j}sin(2\pi\frac{x}{T_{yr}}) + a_{2,i,j}cos(2\pi\frac{x}{T_{yr}}) + a_{3,i,j}sin(2\pi\frac{x}{T_{all}}) + a_{4,i,j}cos(2\pi\frac{x}{T_{all}})$$

- … per pixel (410,000,000+)

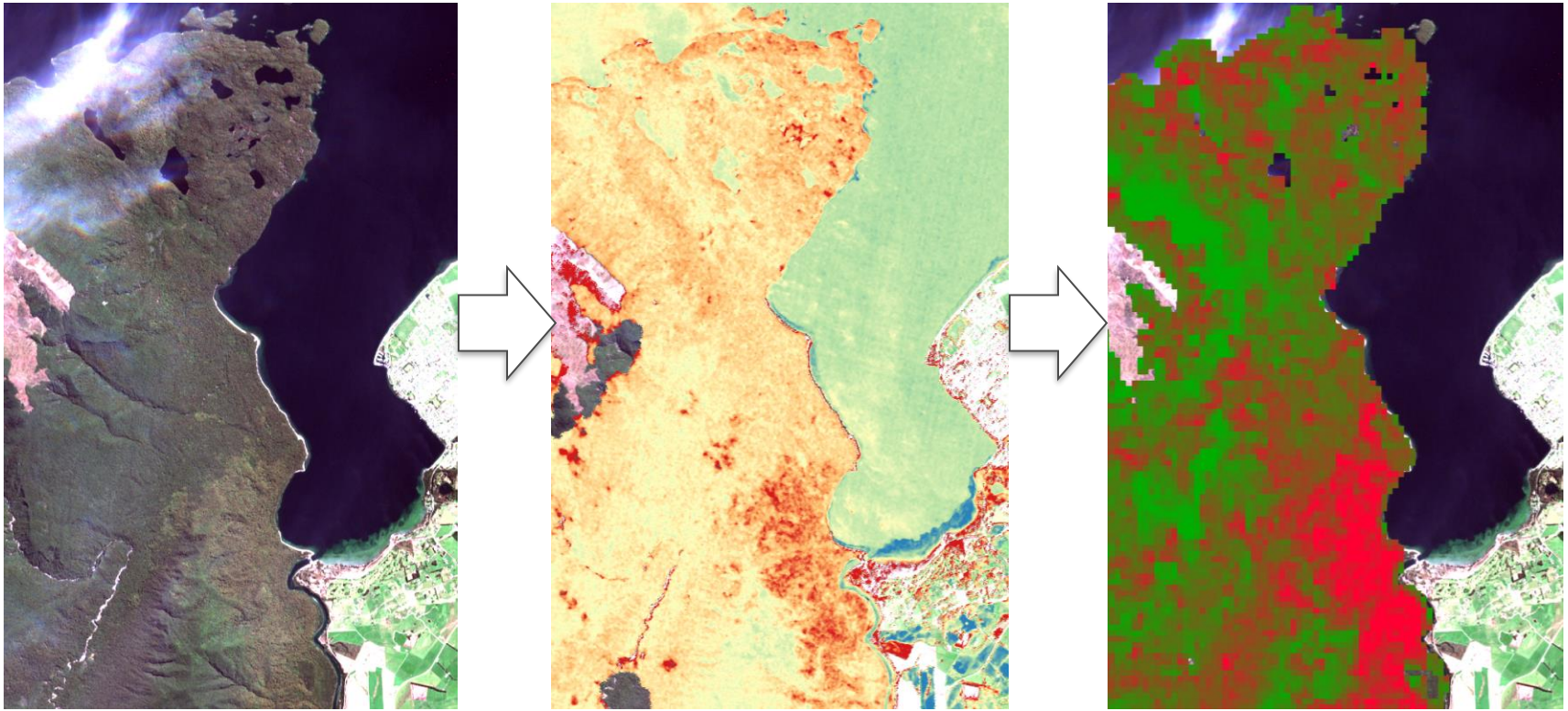
Methodology – Te Anau



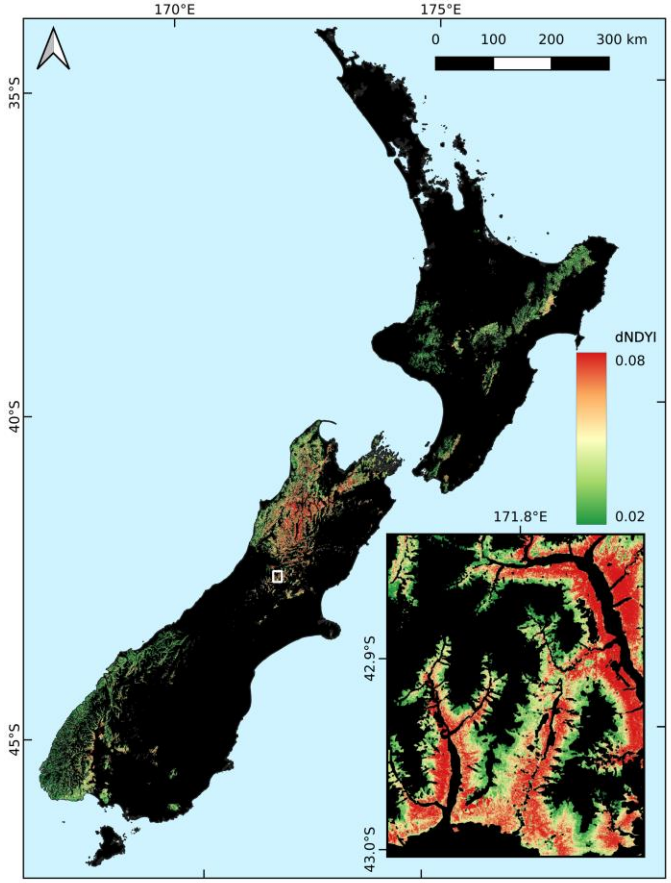
Results – Te Anau



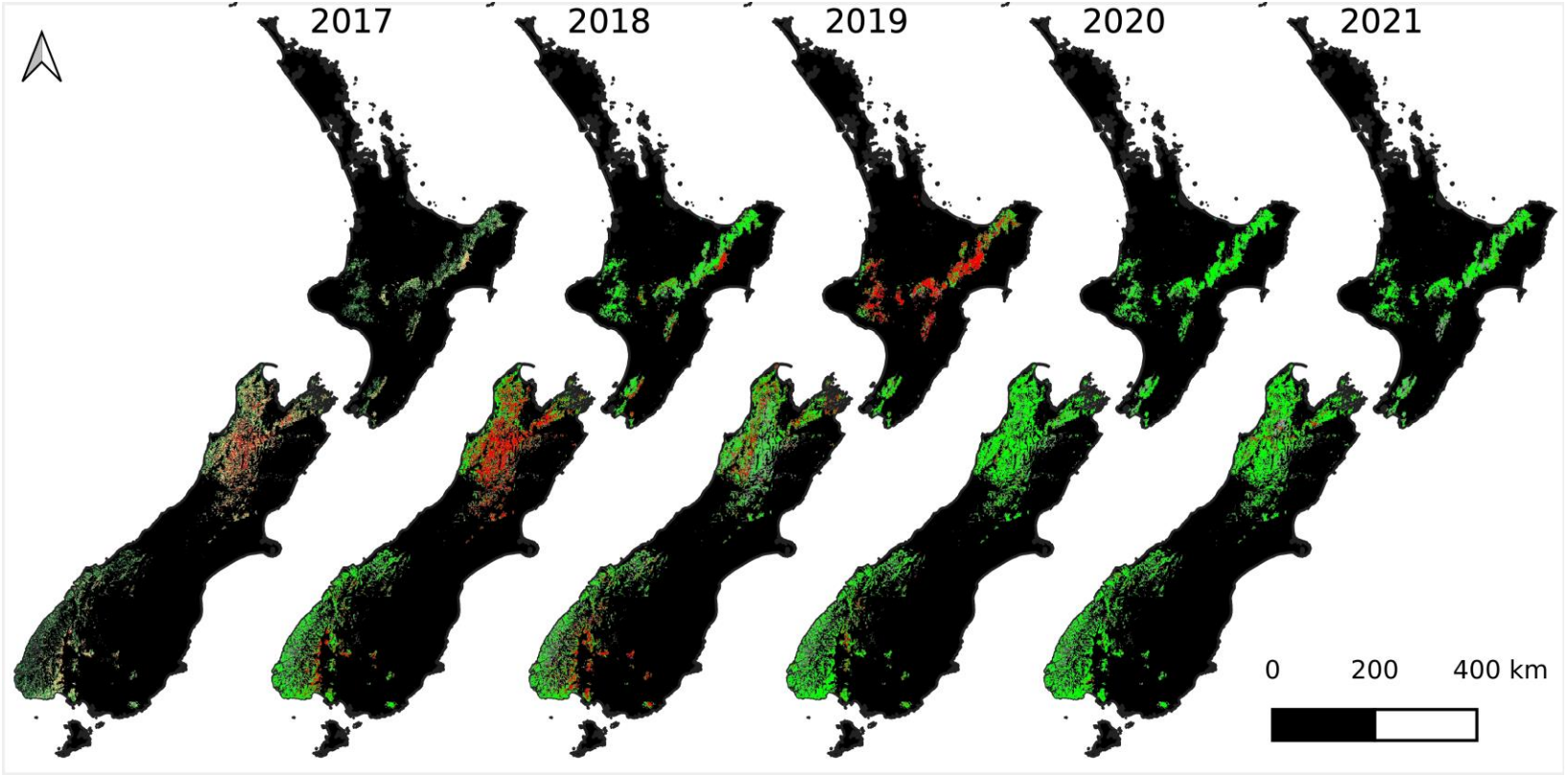
Results – Te Anau



Results – National (2018)



Results – National



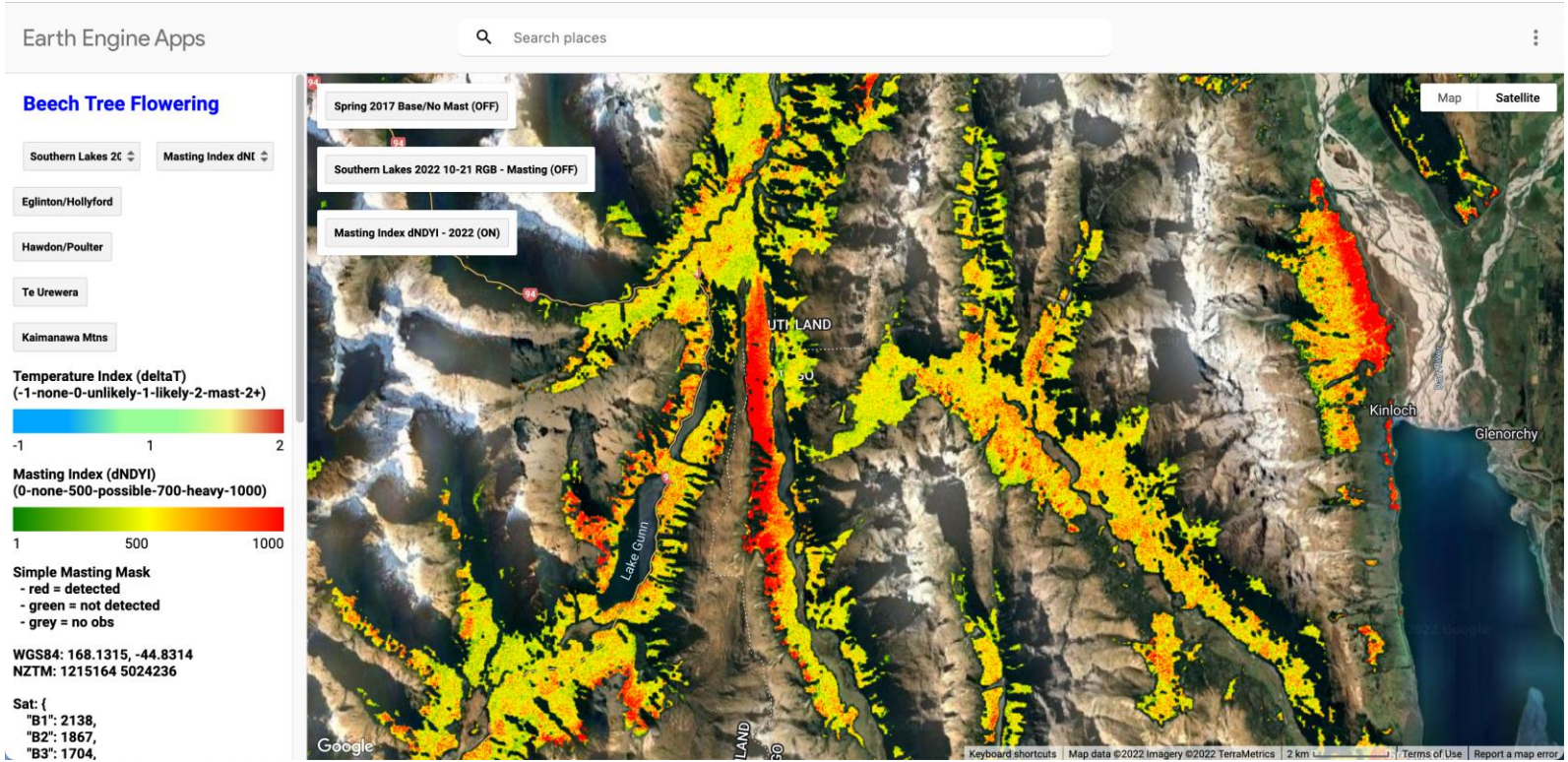
Results – Accuracy

- Accuracy assessment vs manual image interpretation:
  - Overall accuracy
    90.8%
  - Precision (detected flowering was actually flowering)
    90.4%
  - Recall (successfully detected flowering)
    84.4%

Our method slightly under-estimates flowering but we are confident in the detected flowering areas found

		Reference Flowering		
		Detected	Not Det.	**Precision**
Mapped flowering	Detected	0.316	0.034	0.904
	Not Det.	0.059	0.592	0.910
	Recall	0.844	0.946	
	F1-Score	0.873	0.928	

Results – Delivery



Lessons

- Remote sensing is much easier if you already know what you're looking at
- If you want a national map, do not train a model or develop an algorithm using one area, not even once
- A lower accuracy map at national scale can be more valuable than a highly-tuned one for a couple of valleys
- Ground data is invaluable, just so long as you actually know where it is

Pretty maps are easy, pretty accurate maps are much harder

Quick Acknowledgement

- What we did wouldn't have been possible without NeSI
- Our satellite and lidar archives would cost significantly more than our NeSI investment just to store on the cloud
- NeSI Support are hands-down the best science compute support group we've come across
- The NeSI Infrastructure team are dedicated and know what they're doing
- The NeSI Consultancy team are genuinely helpful wizards
- Together they save MWLR at least 3 hard-to-fill FTEs

NeSI
New Zealand eScience Infrastructure

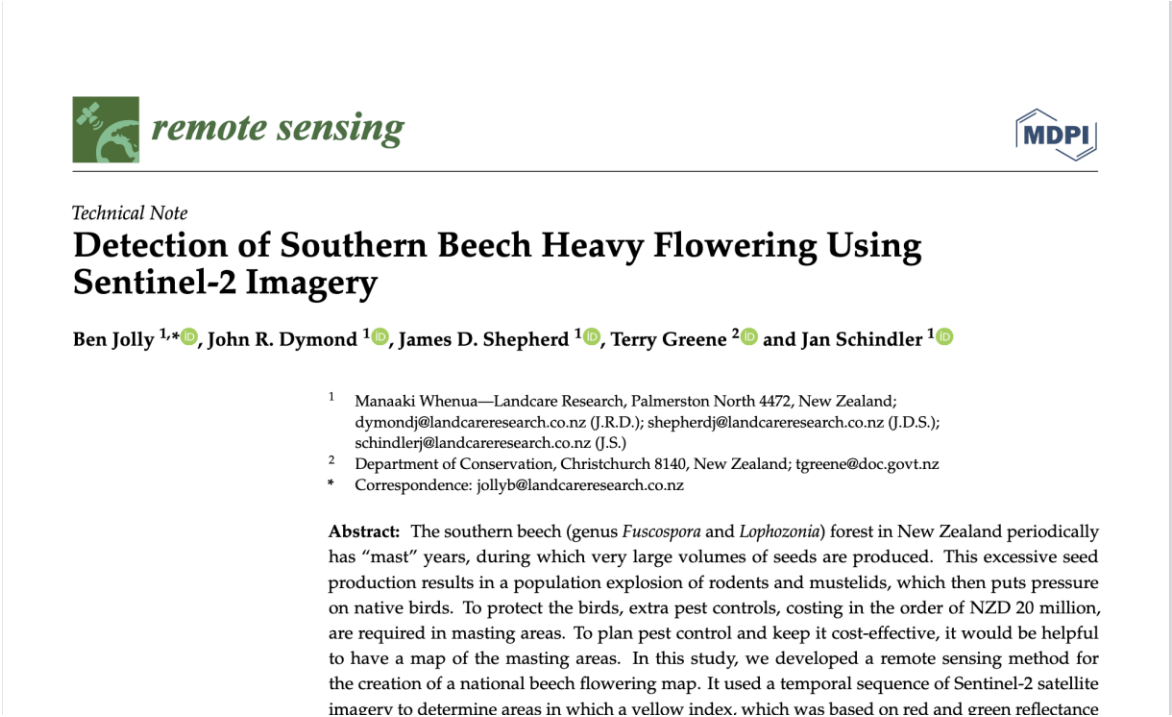
Conclusions

- Heavy beech flowering is detectable using satellite imagery
- The window of detection looks to be short (a couple of weeks) which can present difficulties with cloud
- But, if we can see it, we can map it
- This is now 'in production', feeding into DOC's planning for predator control efforts. We plan to run it again this Spring

This work was made possible by the Advanced Remote Sensing of Aotearoa MBIE Endeavour programme

Thank you

- For more information, see: doi.org/10.3390/rs14071573 || mwlr.nz/masting-paper



remote sensing

MDPI

Technical Note

Detection of Southern Beech Heavy Flowering Using Sentinel-2 Imagery

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Abstract: The southern beech (genus *Fuscospora* and *Lophozonia*) forest in New Zealand periodically has "mast" years, during which very large volumes of seeds are produced. This excessive seed production results in a population explosion of rodents and mustelids, which then puts pressure on native birds. To protect the birds, extra pest controls, costing in the order of NZD 20 million, are required in masting areas. To plan pest control and keep it cost-effective, it would be helpful to have a map of the masting areas. In this study, we developed a remote sensing method for the creation of a national beech flowering map. It used a temporal sequence of Sentinel-2 satellite imagery to determine areas in which a yellow index, which was based on red and green reflectance