Autonomous Forest Health Monitoring

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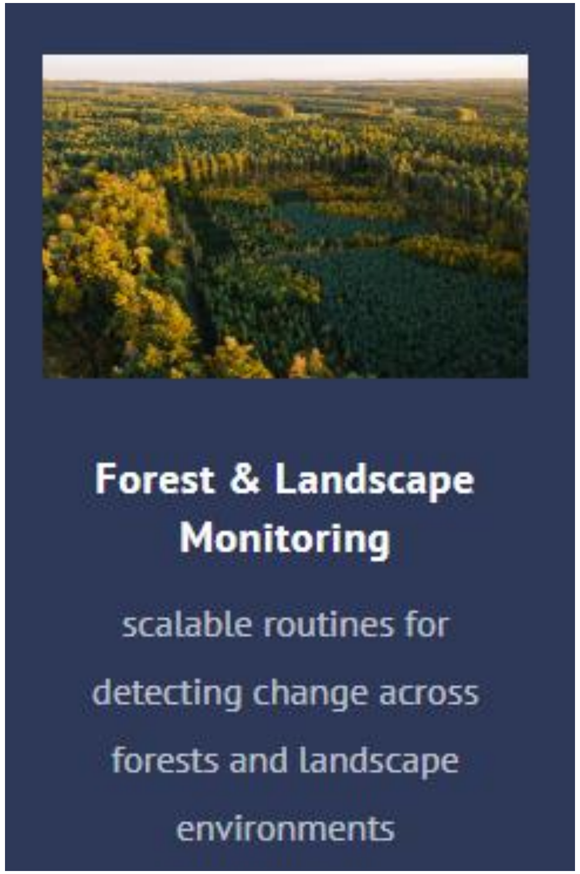
Purpose of presentation

- Overview of project
- Development of an alerts framework
- Prototype monitoring system
- Further work



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Goals: ‘Tip and queue’ forest health surveillance

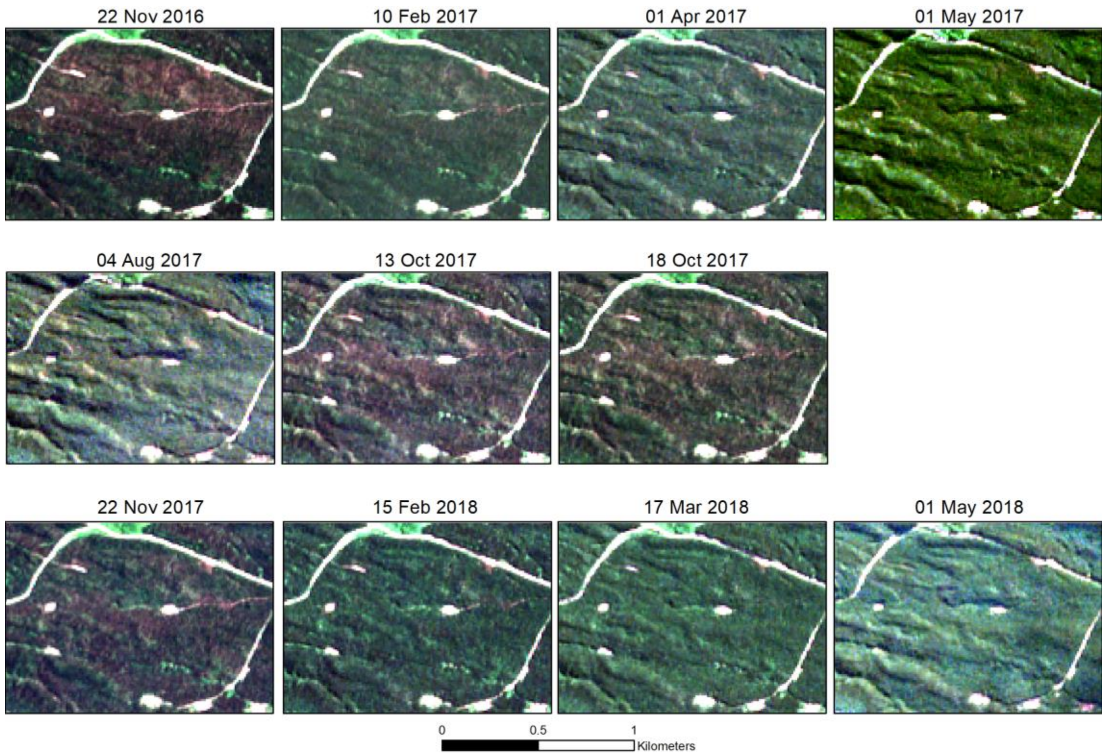
Why remote sensing?

- Existing monitoring methods
- Reports
- Forest Health Database
- Nearly all roadside observations

Monitor the whole planted forest estate for pathogen outbreaks

Test to see if free imagery like Sentinel can detect outbreaks

- Confirm: VHR, field visit or from expert interpretation
- Establish a baseline so we can track progression
- Build a prototype alerts framework to track outbreaks
- Scale it…



Contains Copernicus Sentinel-2 2016 to 2018

Phase 1

Key findings 2020-2022

- Individual crown expression was visible in VHR imagery in September/October. This was digitized by Scion over several sites
- Using atmospherically corrected Sentinel-2 scene, corresponding canopy discoloration was clear
- A single satellite scene didn’t provide enough evidence of RNC
- Using a time series of multiple images prior to the peak expression allows the point at which the imagery can pick up the change in canopy to be pinpointed
- Increased RNC expression corresponded to decline in vegetation indices like the Red/Green index

MAXAR WorldView, Contains Copernicus Sentinel-2 2016 to 2021

Phase 1

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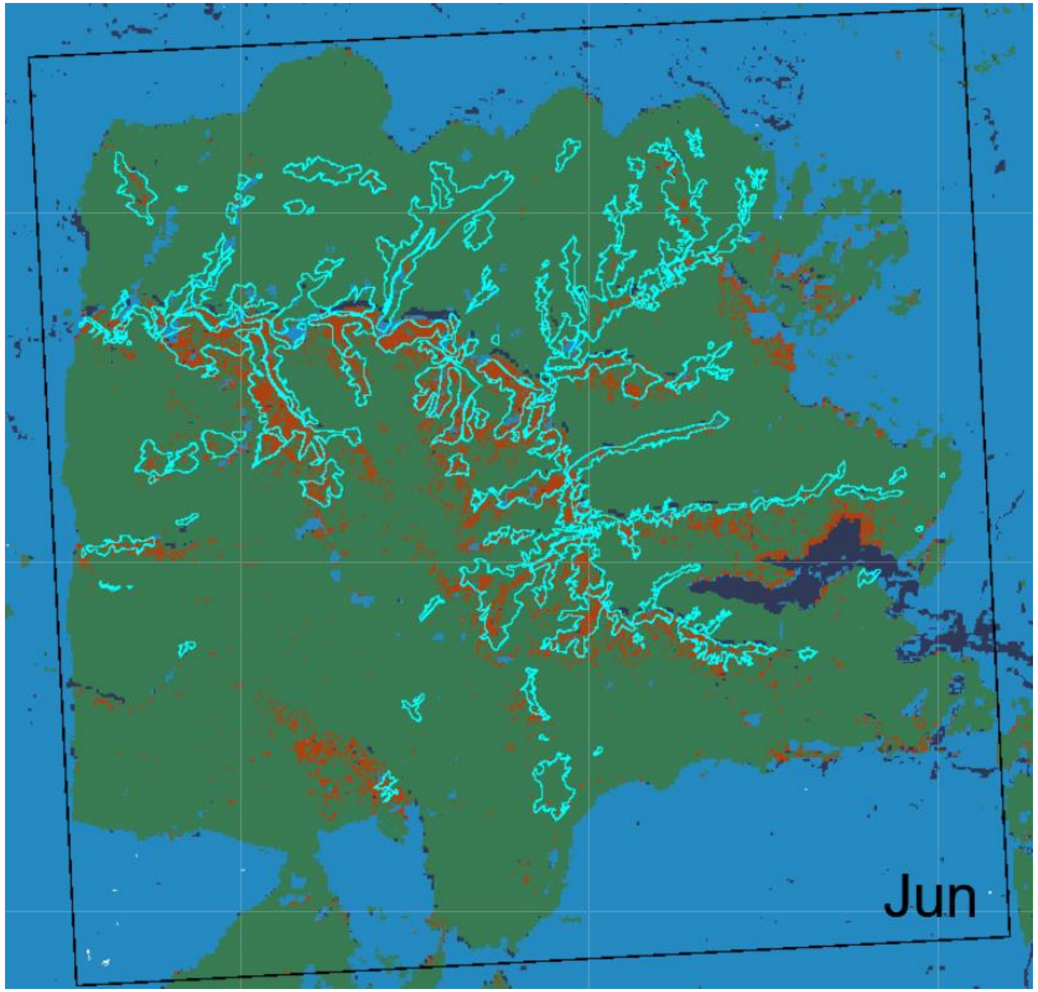
Phase 1

First regional results

A random forest classification was used to detect RNC expression from monthly composite imagery

This worked well but it was slow and computational expensive:

- Required lots of image pre-processing to get single monthly cloud free result to classify
- Often composite images had to be used – completely cloud free regional images are rare in NZ
- Needed our own underlying forest/non-forest classification
- Many training samples required, difficult to get consistency in the forest area classified between runs



Contains Copernicus Sentinel-2 2021 (modified)

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Phase 2

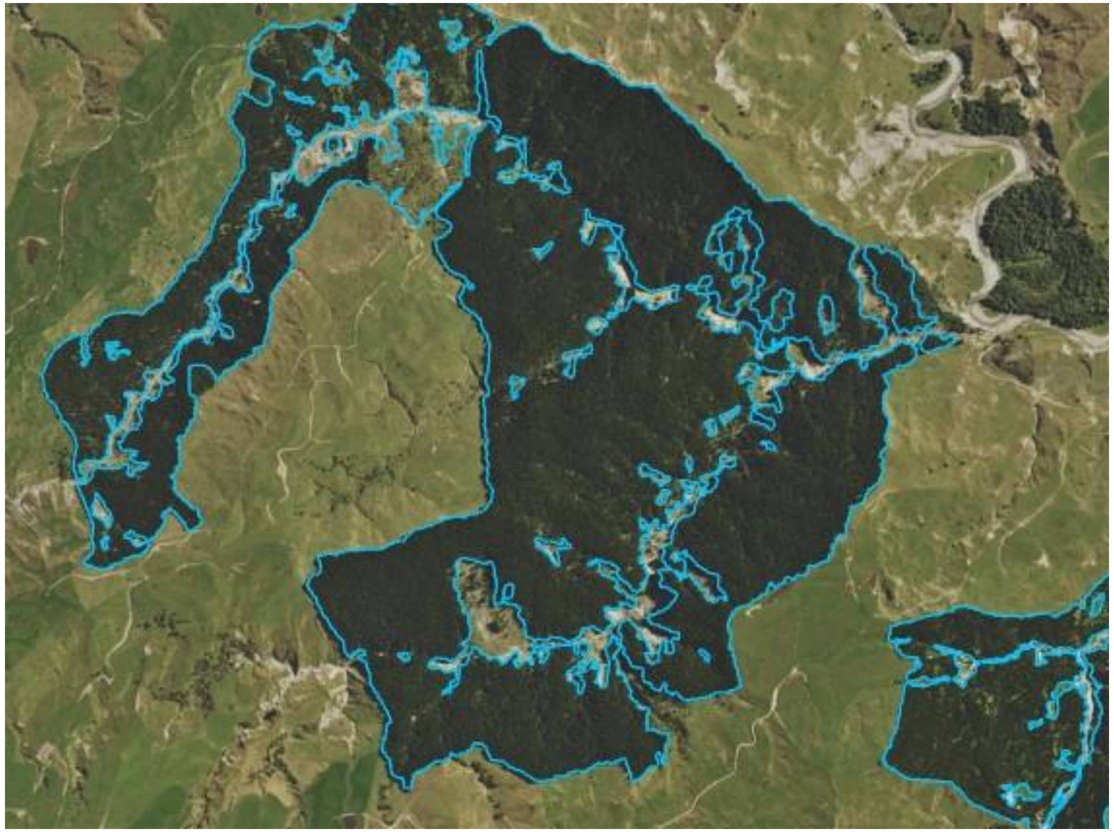
Phase 2: 2022-23

Introducing Scion's Digital Forest Project boundaries

While this RNC detection model was being developed, the Scion team was working on the Digital Forest project - a cutting-edge deep learning model that extracts accurate exotic plantation boundaries from aerial imagery

This provided an accurate and consistent snapshot of the exotic forest extent within the East Coast region, which could be updated using harvest detection

The Digital Forest Project has the eventual goal mapping all planted forests across New Zealand, with Hawkes Bay nearing completion, allowing the extent monitored to be increased



Sourced from the LINZ data service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand. Boundaries from Scion SmartForest project

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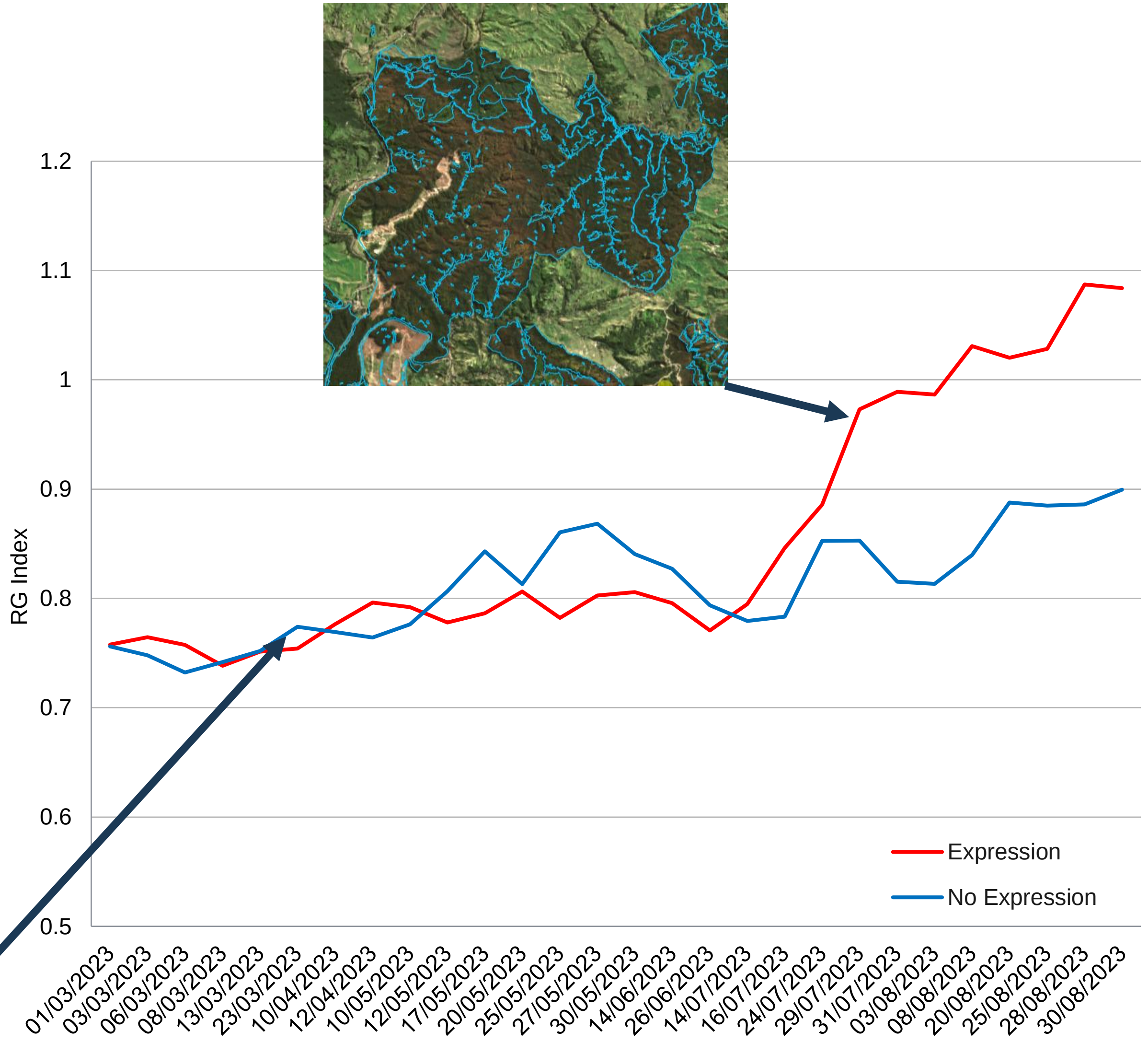
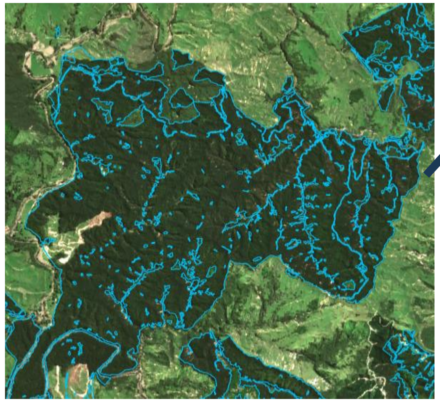
Harnessing timeseries for detection

By using these boundaries as a baseline, our own forest/non forest classification was no longer needed – detection could be restricted to just the areas delineated by the AI model, making results more consistent, comparable and reducing false positives

The extent of the 2023 disease expression also suggested that using a classification approach may not be required, as the reviewing the previously classified areas showed that the ratio of red and green reflectance, which was a critical variable for the classifier, could be used to separate expression sites by itself





Data Source: Copernicus Sentinel-2 2023

Phase 2

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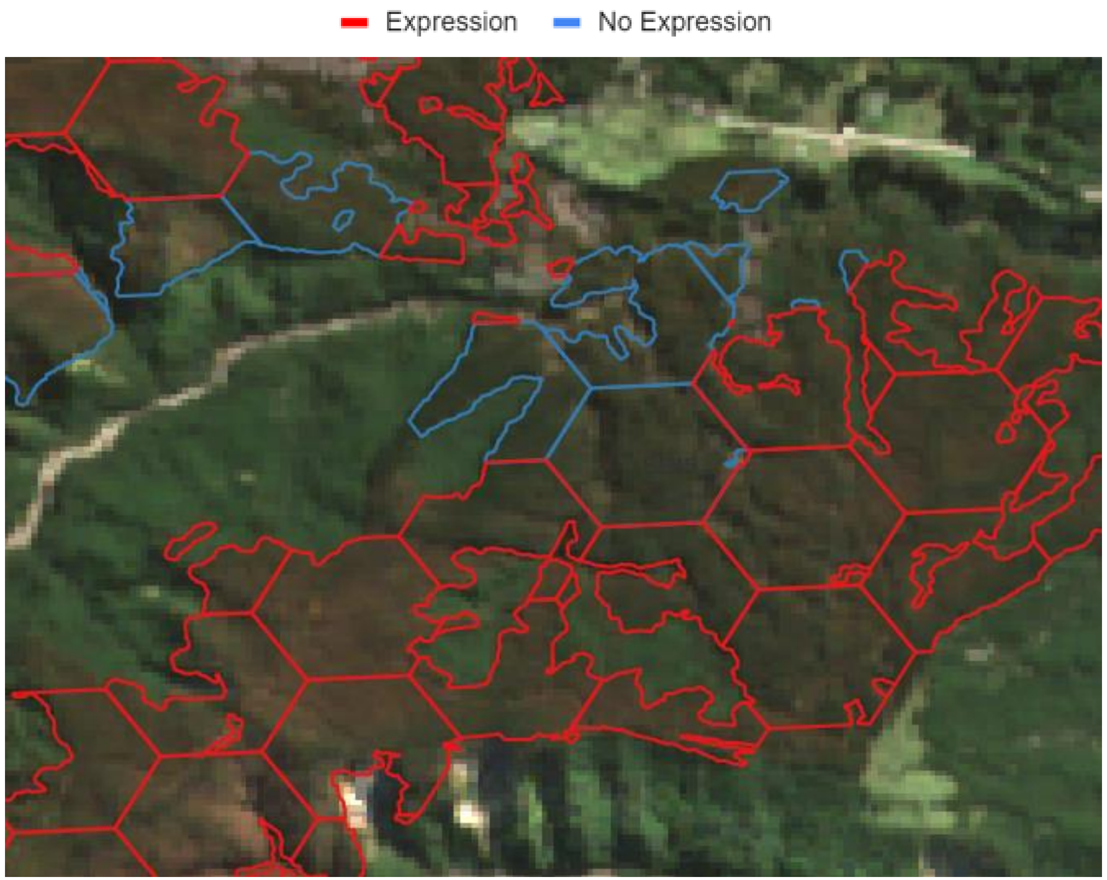
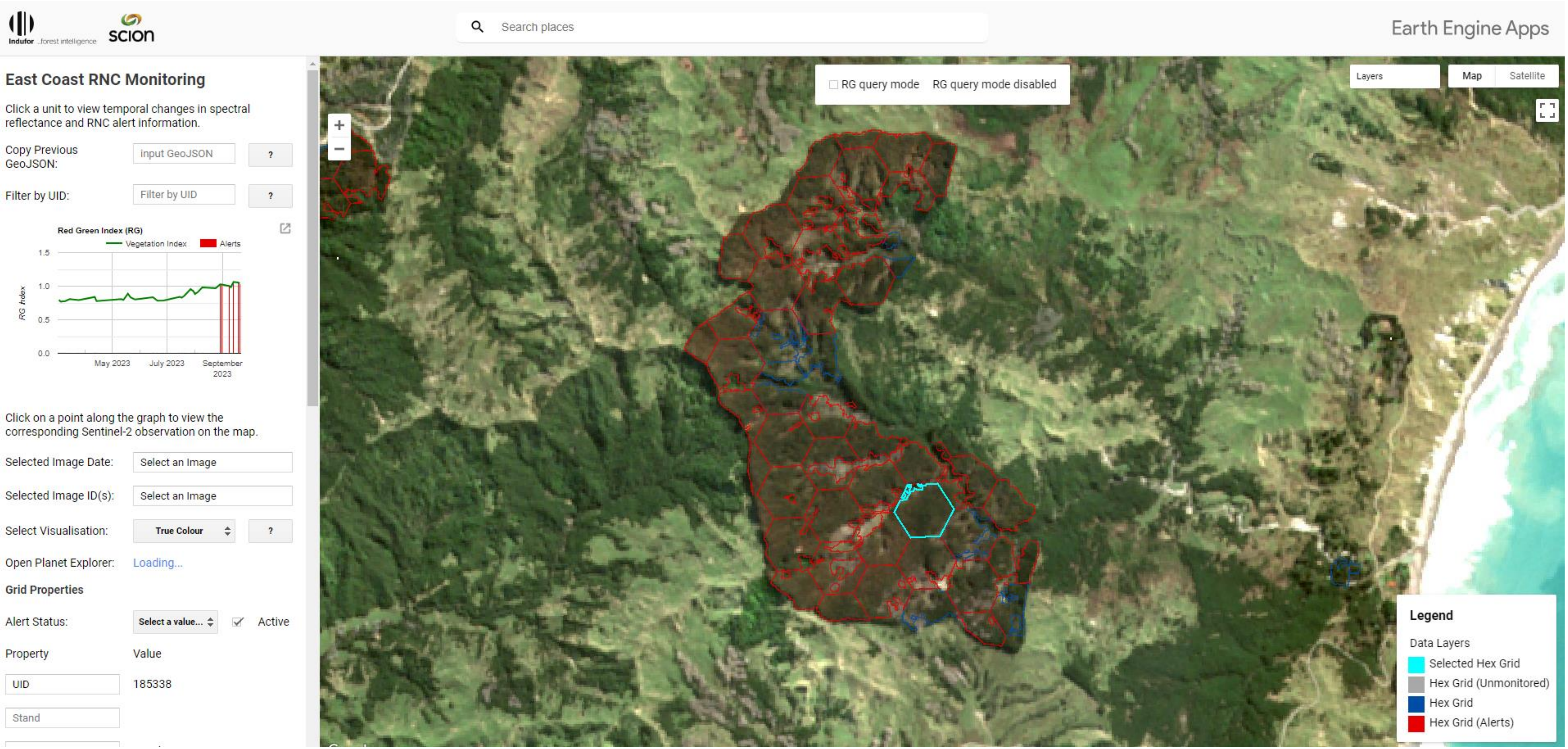
Building and scaling the alerts system

- Indufor's existing landscape monitoring system has been modified to detect change based on this red/green index
- This system takes an area of interest and divides it into a tessellated grid of hexagons
- For RNC monitoring, the Scion Digital Forest project boundaries were subset into 5 ha hex units
- Each one of these units are monitored individually, with any cloud free portions of all available Sentinel-2 imagery compared against a baseline to detect change through time. When a change of sufficient magnitude is recorded, the unit is given an alert status
- This information is stored per grid for expert review using the monitoring dashboard.



Contains Copernicus Sentinel-2 2023

Monitoring Dashboard



Scoring RNC Severity

The alert is trigged when alert threshold is met – which is binary (expression/no expression)

An extension of this is to score severity by measuring the difference in red/green index between pre and peak expression

A greater difference indicates a more severe expression at that location

This approach has a range of benefits:

- It removes subjectivity from the assessment
- Provides more granular results than stand level assessment and greater area coverage than field-based or drone approaches.

Contains Copernicus Sentinel-2 2023

Further Work

This project (ends Dec 2023)

Final deliverable is to share the RNC dashboard with users (by agreement) so we can test if it's an effective way to deliver and confirm alerts.

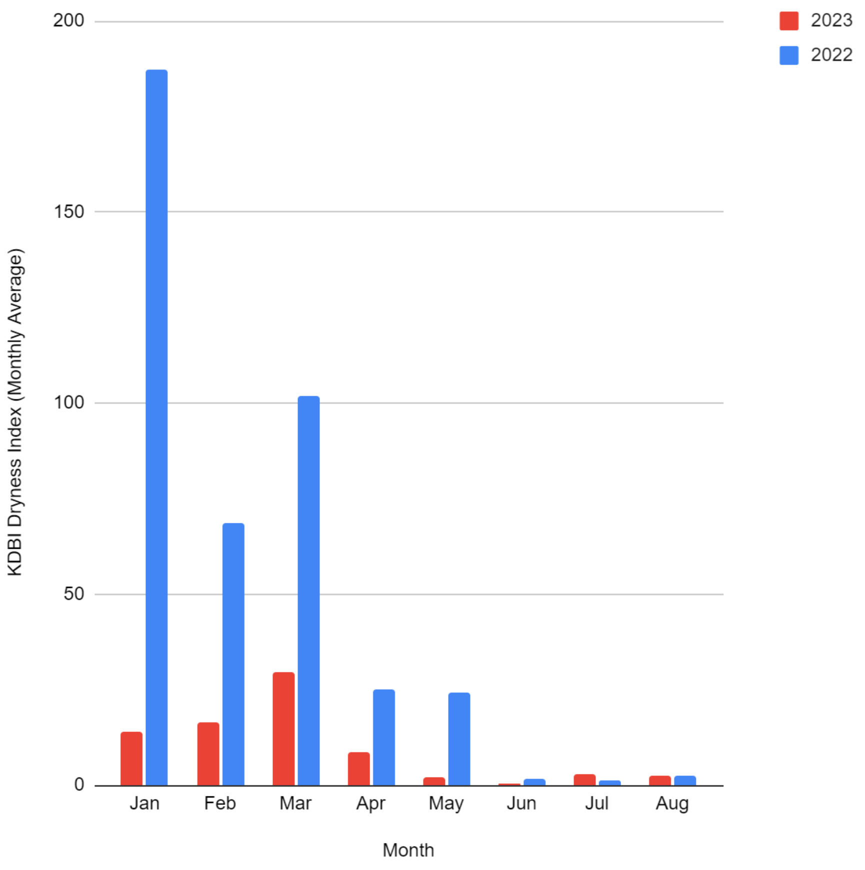
Continuation

If supported move towards operational implementation of the monitoring system. Work out how most efficient way of doing so, user requirements, maintenance and updates to the system.

Combine with Dr Nicolò Camarretta's VHR detection to review alert areas where appropriate to derive more accurate local extents.

In collaboration with Scion evaluate the detected expression areas against a range of environmental surfaces that describe rainfall, humidity, exposure etc., with the aim of exploring the relationships between these known and possible drivers at a large spatial scale.

If meaningful add this to the monitoring system.



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Citations

Processed in Google Earth Engine:

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*.

Contains modified Copernicus Sentinel data 2018 to 2023

Cloud masking uses https://github.com/sentinel-hub/sentinel2-cloud-detector

Credit Bryan McKinlay NZCF

Aerial imagery sourced from the LINZ data service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand

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