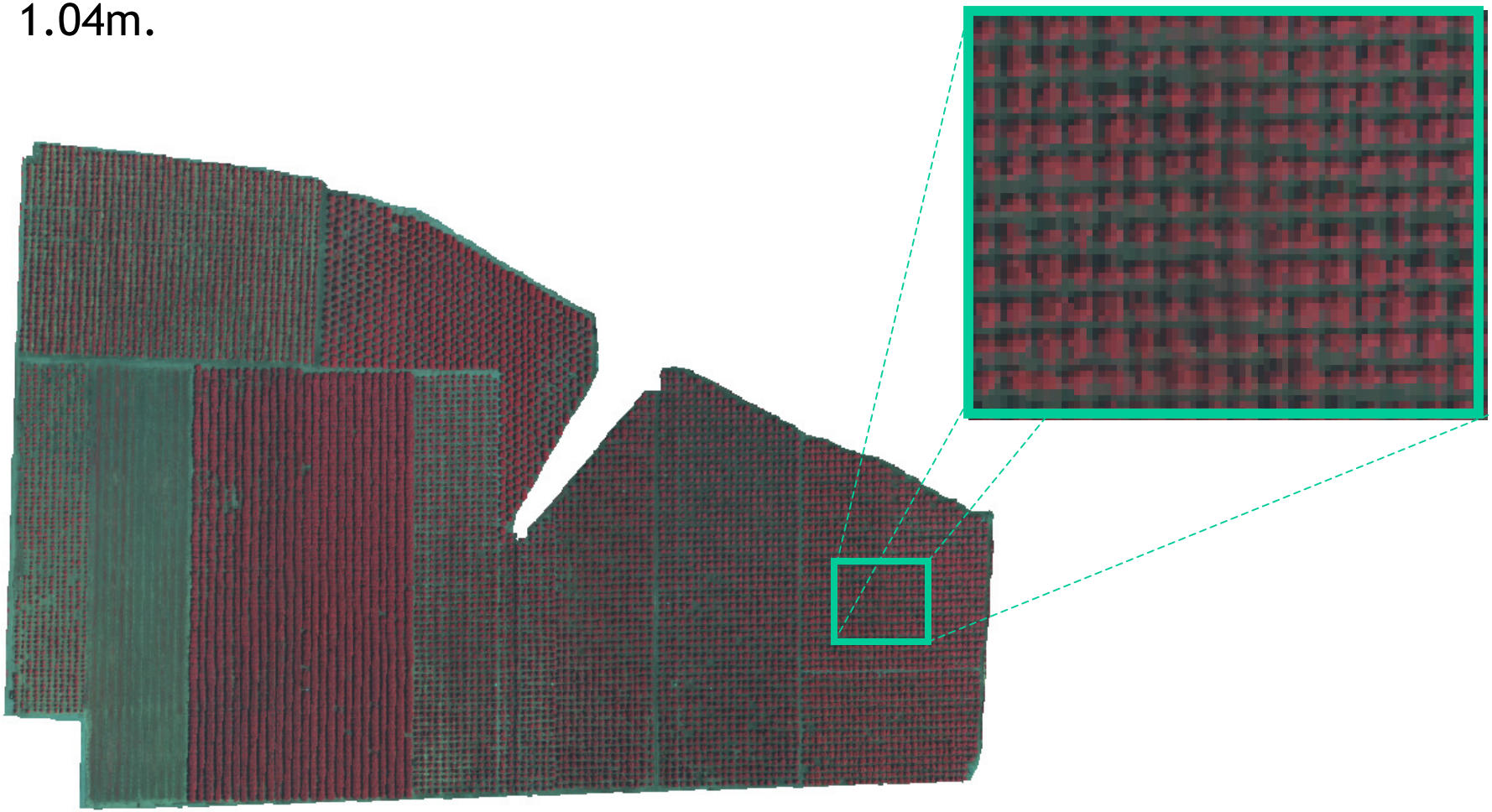
Adding Value to a picture

Ideas for additional processing of MSS data to support grove/orchard operations.

Delta Data Systems

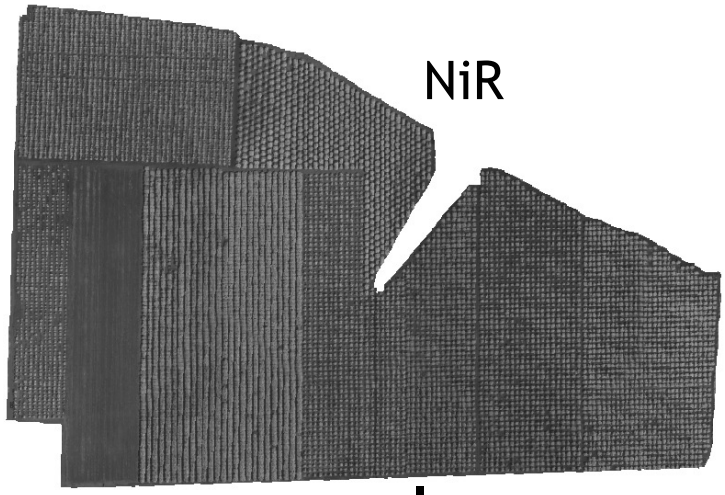
November 2006

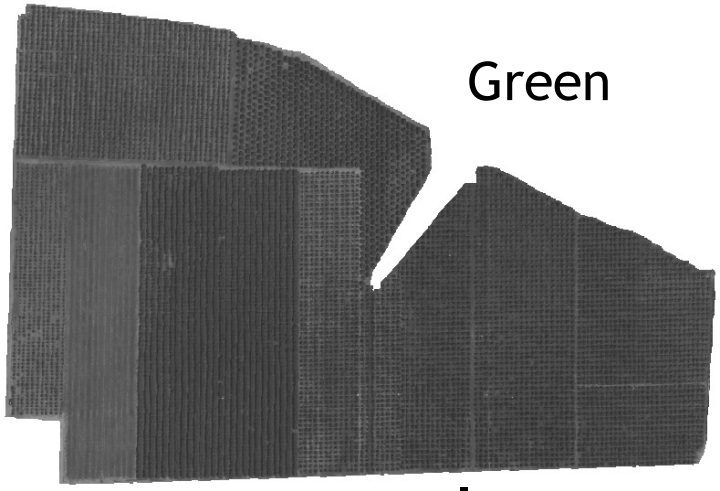
Imagery of an orange grove in California (~85 acres). Resolution is 1.04m.

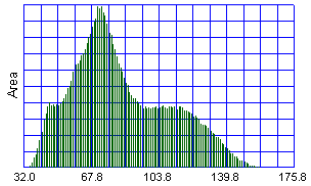


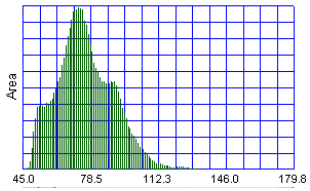
CIR composite of bands NiR, Red, Green

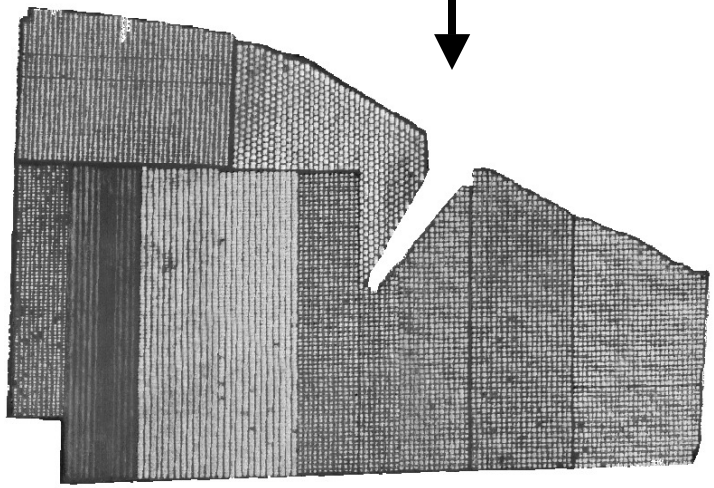
Vegetation index has the effect of canopy enhancement.



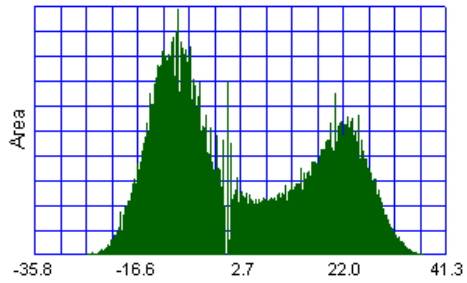








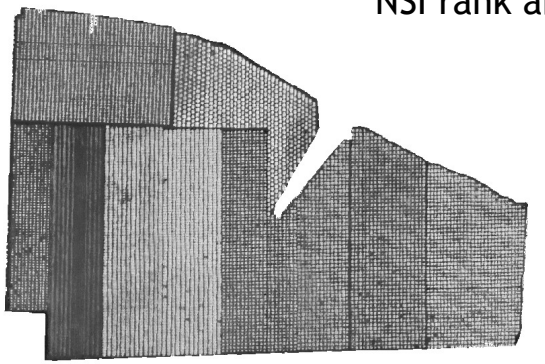
GNDVI



Negative GNDVI values are no-canopy

Positive GNDVI values are canopy

Application of NSI to GNDVI yields a normalized and ranked image of canopy segmentation. "Low Stand" is inter-row, inter-tree land cover. All other NSI values relate to canopy features. The NSI range is significant. Canopy with an NSI rank above 70 is the target.

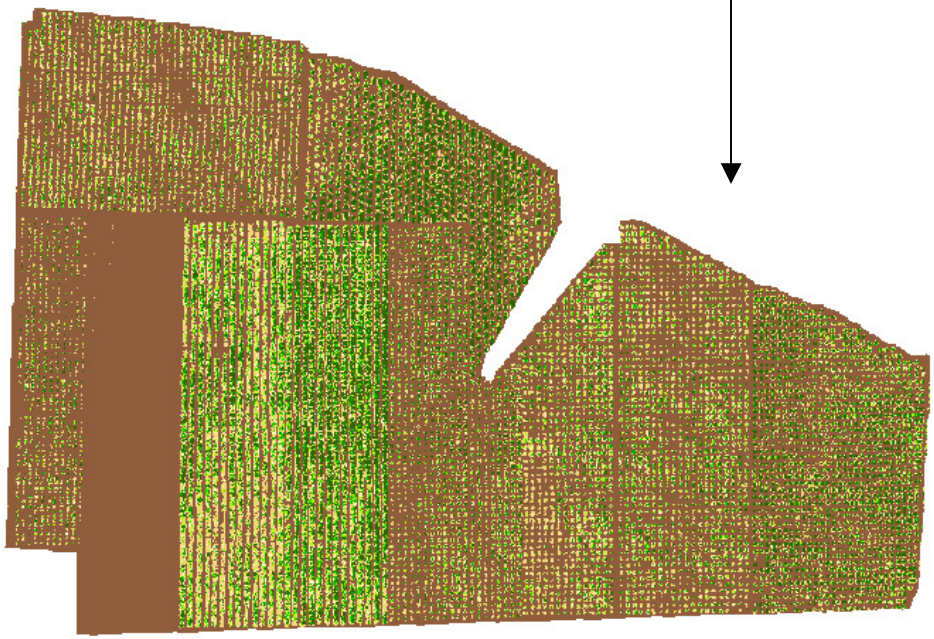


GNDVI

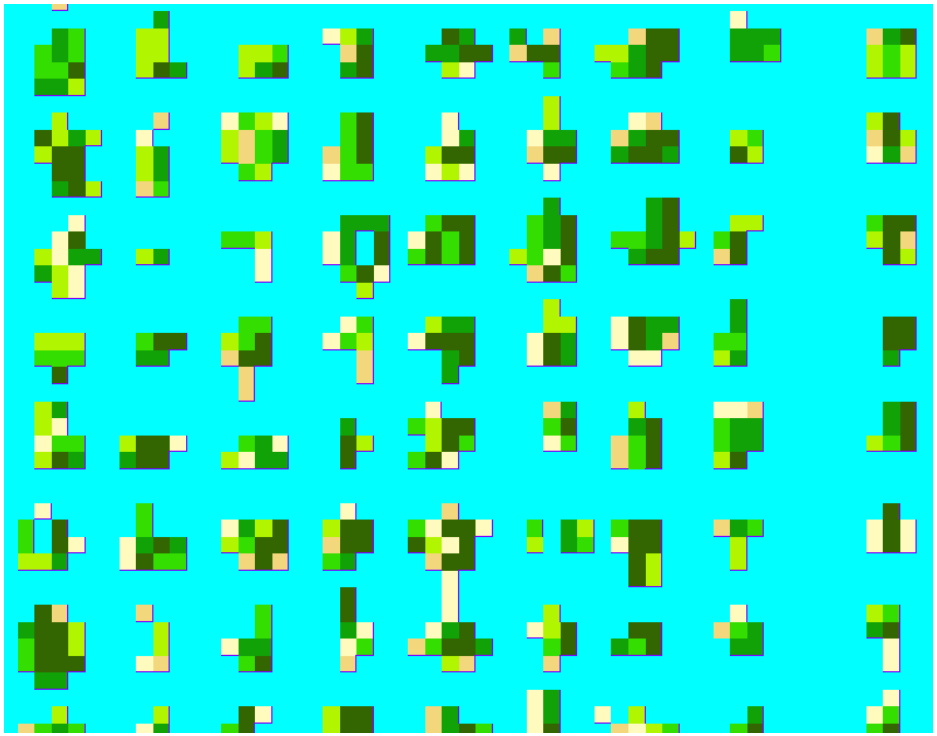
NSI Tool

NSI Class Key

- Low Stand
- Minimum to 75
- 75 to 80
- 80 to 85
- 85 to 90
- 90 to 95
- Greater than 95



NSI outcome

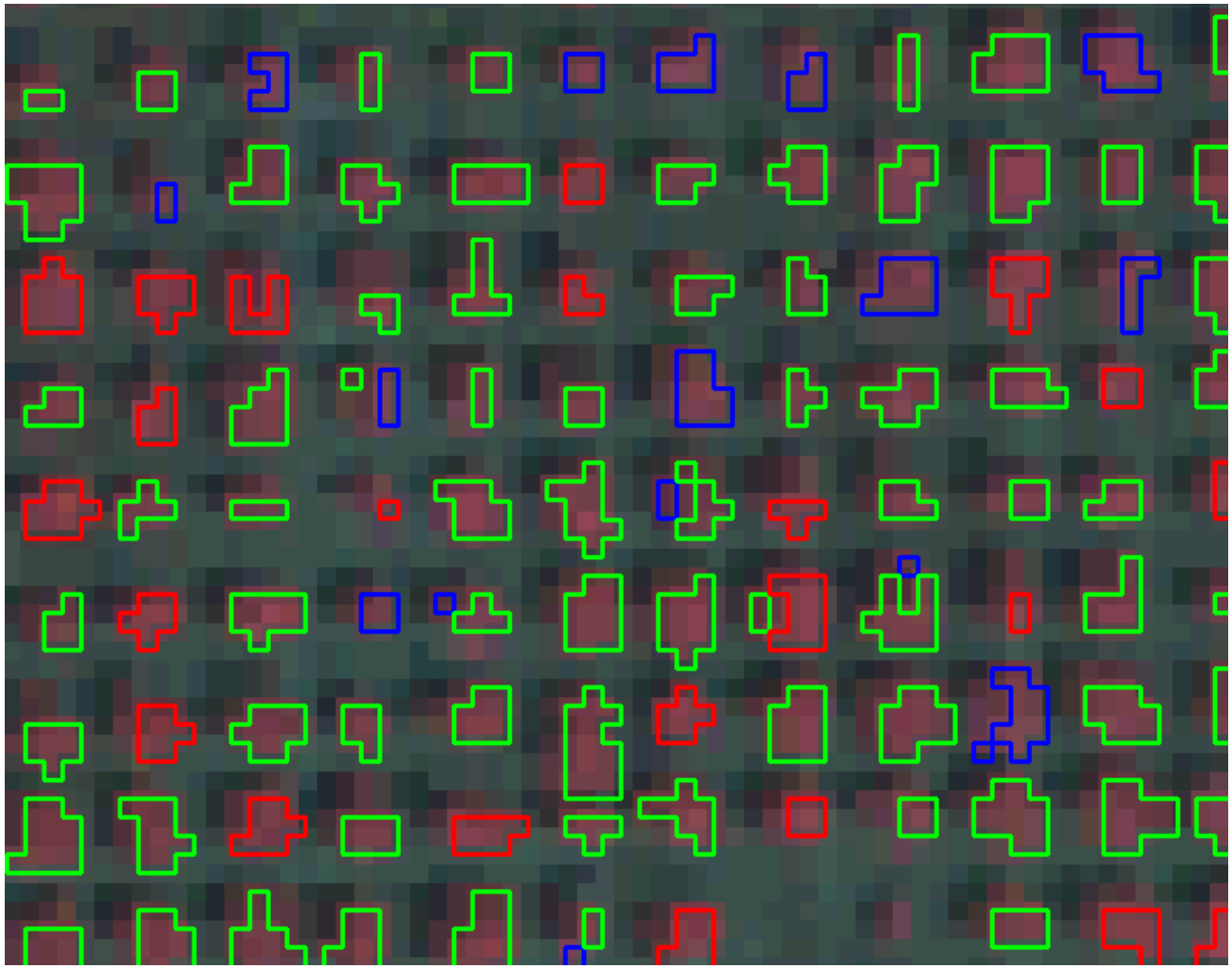


Expanded view of a section of the grove as NSI.

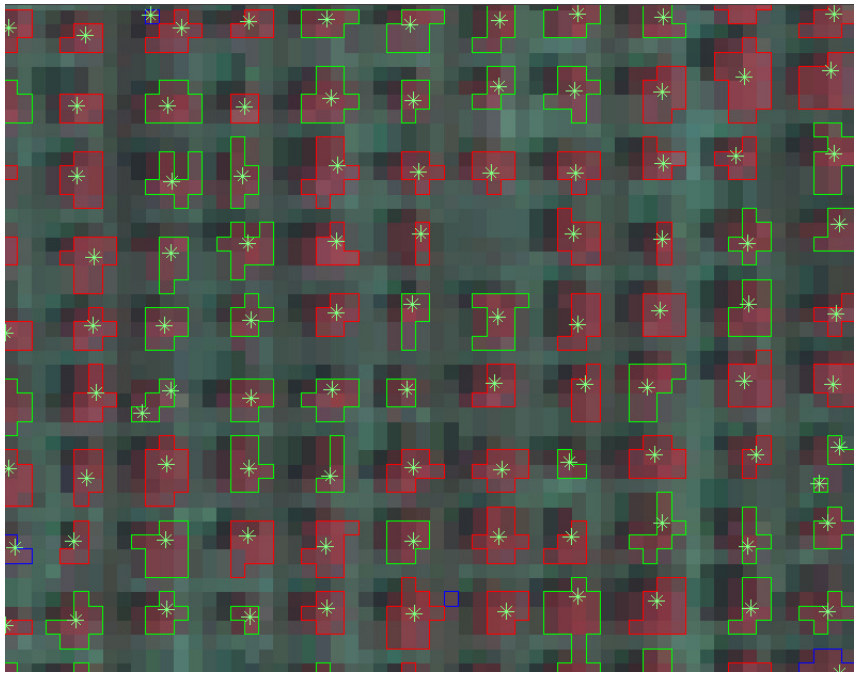
Cyan is highlighting the areas of “no canopy”. All other features are “canopy” (with NSI rank above 70).

NSI variation is a key in feature discrimination. There are different classes of canopy- implying that trees may be comparatively robust.

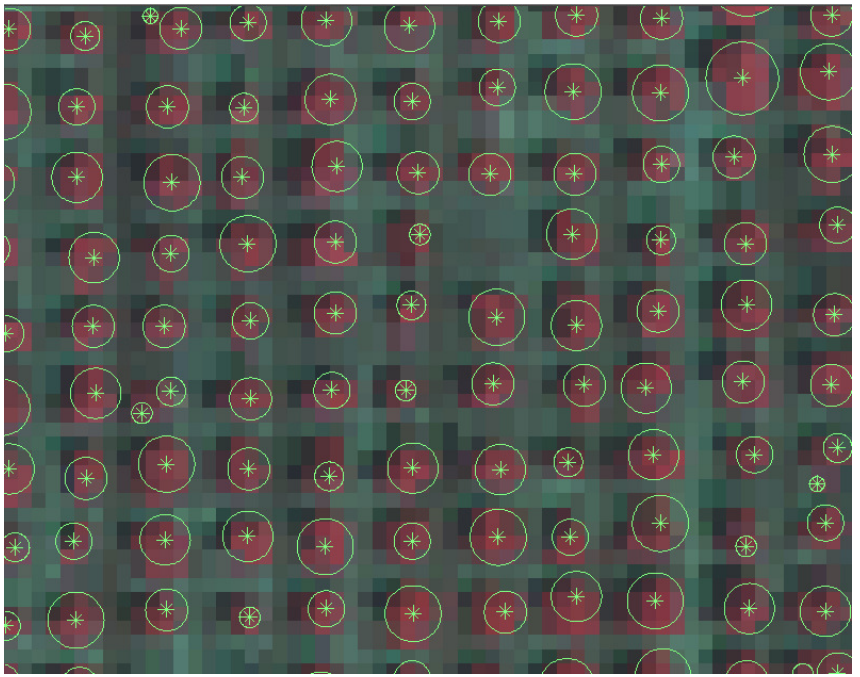
Vectorization of these features yields more possibilities.



Vectorization. These polygons are the boundary of NSI values above 70 overlaid on CIR. The bounded areas can be inventoried. The mean NSI within each polygon can be the basis of a "qualitative" measure (e.g. of robustness). The red polygons are mean NSI >90, the green polygons are mean NSI from 80 to 90 and the blue polygons are mean NSI from 70 to 80.



Centroids of polygons can be calculated.



Canopy circles can be constructed from these centroids with radius as a function of polygon area. This is perhaps a more ‘human’ presentation of canopy and canopy size.

What's being proposed?

A qualitative tree inventory is an important grove/orchard management input.

Cruising with these canopy mappings (on a handheld) can support sampling and VRT strategies, push/plant decisions, etc.

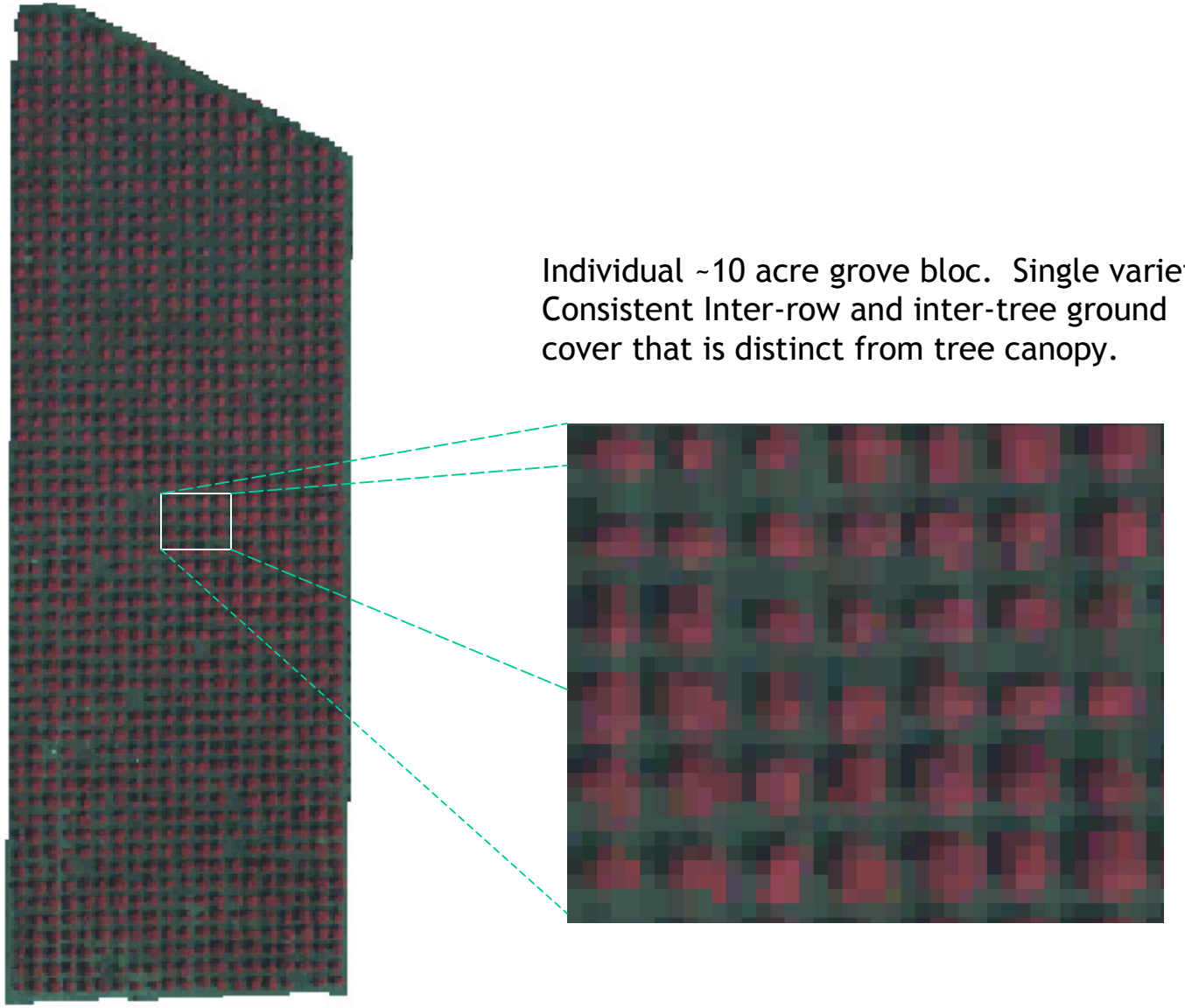
1. MSS ➔ GNDVI ➔ NSI yields an image data set of canopy vs. non-canopy.
2. Within the canopy area, there are ranges of NSI which imply differences in canopy characteristics.
3. Vectorization offers an opportunity for extracting/mapping tree count, tree size and tree condition (as a mean NSI index).

Is this eyewash? No, this is a repeatable outcome that can be achieved by a minimally trained operator.

However, the process is highly sensitive to:

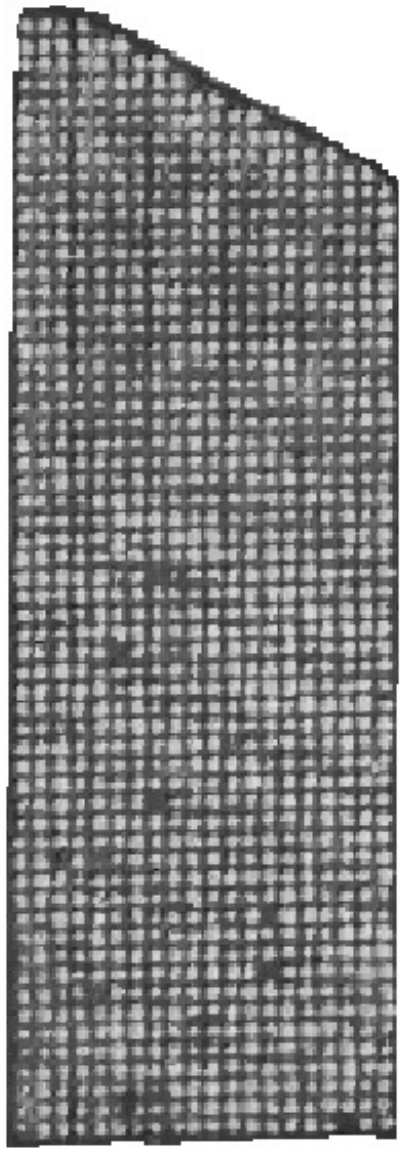
1. **Data quality**. Artificially enhanced band-to-band ratios, poor atmospherics and low data (numeric) resolution adversely effect outcomes.
2. **Data (spatial) resolution**. A rule of thumb is that resolution needs to be half of the smallest object target. For example, canopy features with a 2m spread are predictably resolved with 1m data. If the individual canopy features are smaller than 2m, "spectral confusion" can defeat the process. "New sets" and young trees in a citrus grove would be difficult to resolve with 1m data.
3. **Ground conditions**. This process is based on "spectral differentiation". Tree separation and inter-row/inter-tree groundcover characteristics are critical. If the inter-row/inter-tree groundcover is heavily vegetated and that vegetation is spectrally indistinct from tree canopy, spectral separation is defeated. If the trees grow together, forming 'hedgerows', their spatial separation as individual features is difficult if not impossible.

A processing outcome from nearly ideal image and grove conditions

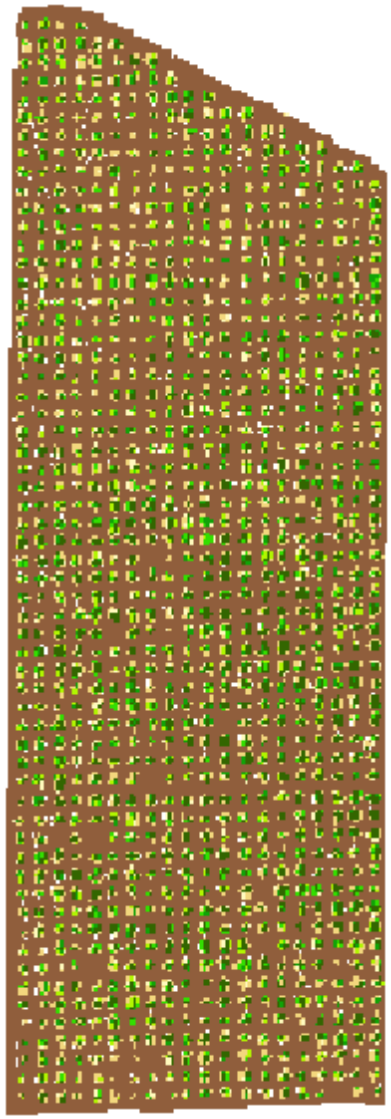


Individual ~10 acre grove bloc. Single variety. Consistent Inter-row and inter-tree ground cover that is distinct from tree canopy.

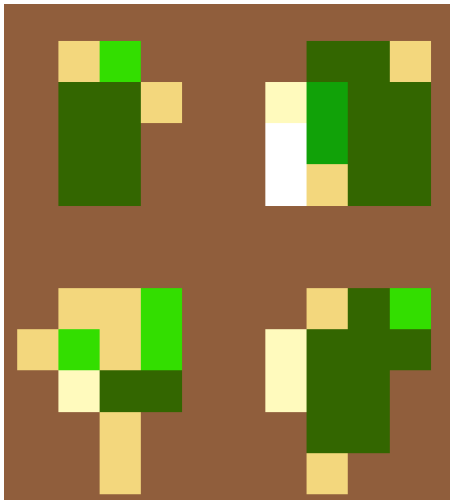
Primary Processing is 4channel ➔ GNDVI ➔ NSI



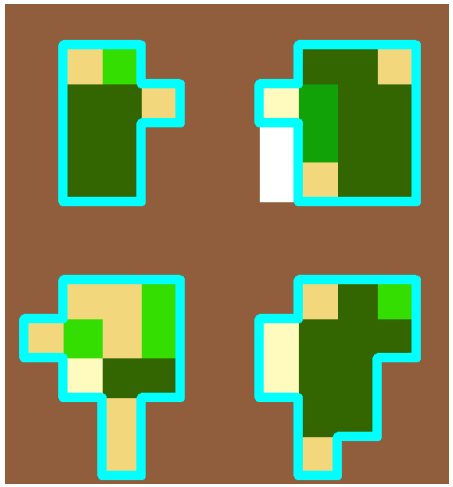
GNDVI



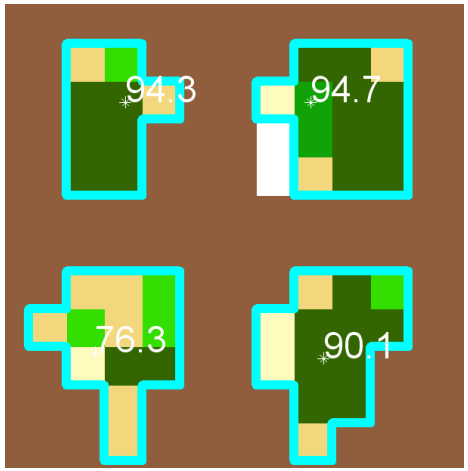
NSI



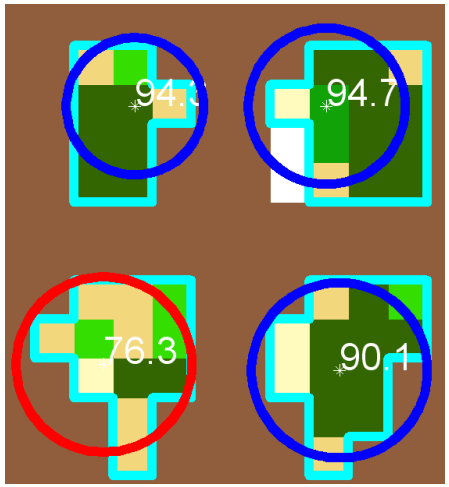
NSI image. Four canopy features with varying NSI levels. NSI >50.



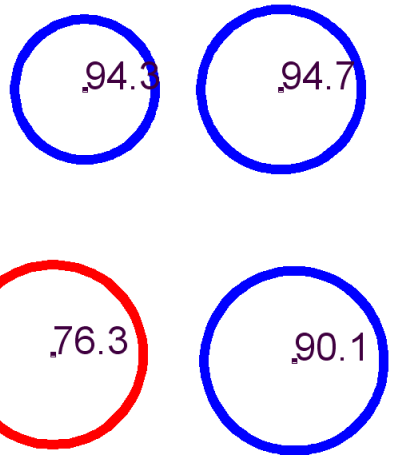
Vectorization of canopy features. Computation of feature centroid. Calculation of bounded average NSI is indication of canopy robustness.



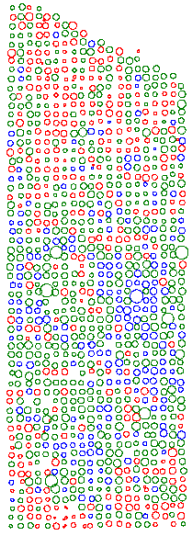
Creation of point features from canopy centroids with average NSI reported.



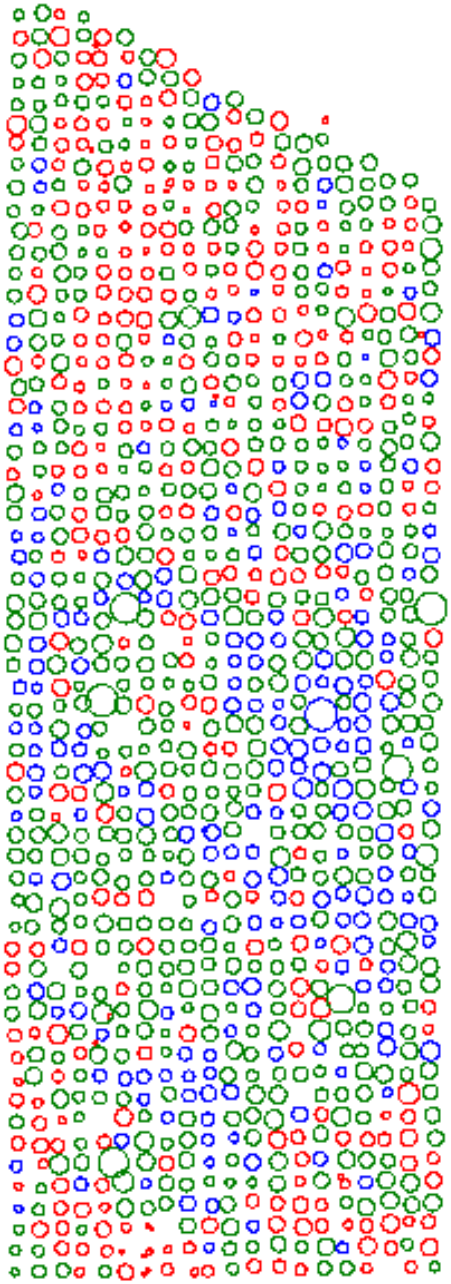
Generation of canopy circles (point-radius) as a function of polygon area.



Map abstraction of canopy features with NSI report.



Total grove bloc map with canopy features segregated by size and NSI average. Tree count is 1,097.



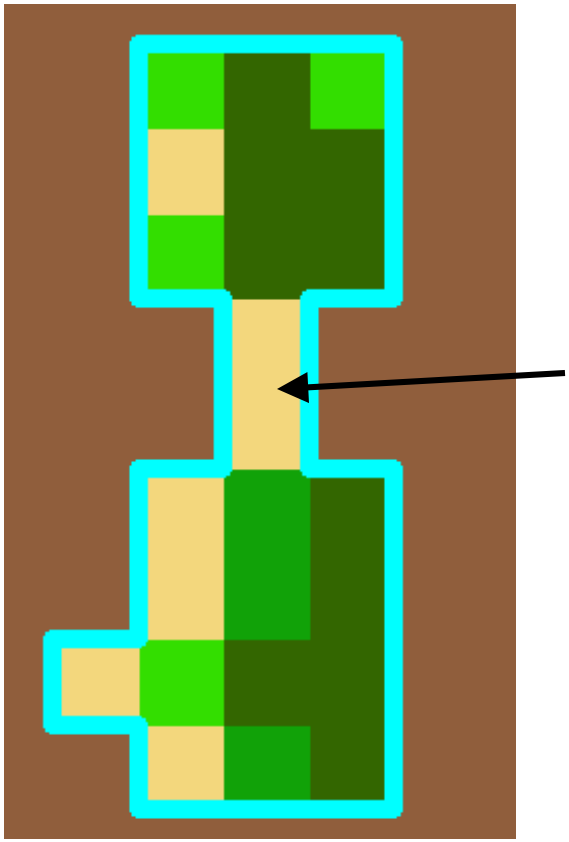
High NSI Canopy Index 206 trees

Medium NSI Canopy Index 560 trees

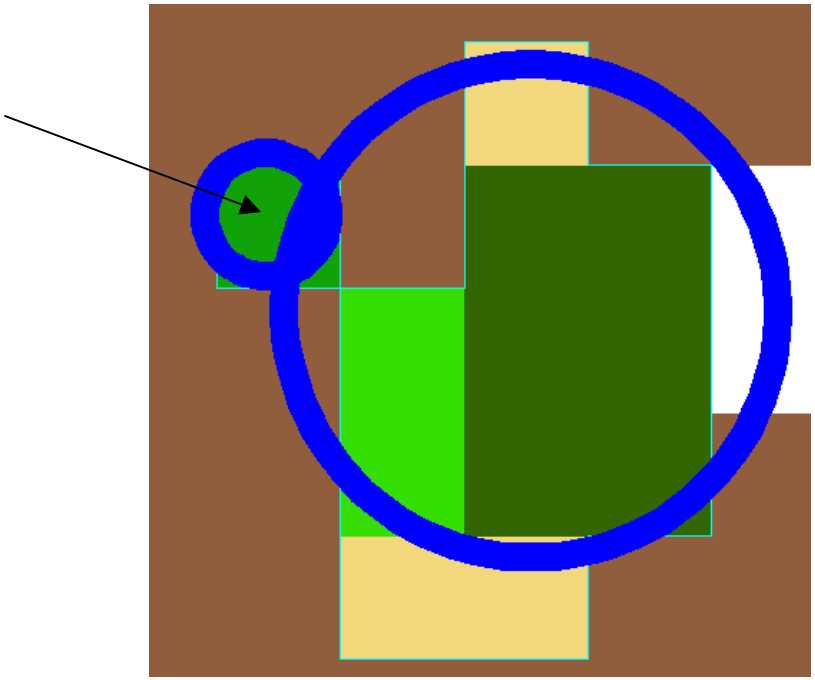
Low NSI Canopy Index 331 trees

This abstract “map” could be used on a handheld in grove cruises. Is there a reason for the low NSI canopy index in the upper third and lower end of the bloc?

“Nearly Ideal” means that errors are still possible.



NSI threshold of 50 was too low. The identified value is 57. As a result, two canopy areas were connected into a single canopy feature. This decreases the tree count by 1.



The identified pixel was ‘orphaned’. It is a member of the larger canopy feature but resolves separately. This increases the tree count by 1.

Under these nearly ideal conditions, errors of this type tend to be minimal and they tend to balance out relative to gross tree count.

We would expect these errors to be reduced further with higher quality/higher resolution data.