Department of
Primary Industries and
Regional Development

GOVERNMENT OF
WESTERN AUSTRALIA

Protect
Grow
Innovate

Using Artificial Intelligence to move down the Invasion Curve

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Acquire images

- Satellite
- Aerial photos
  - High level - 5-10,000 ft
  - Low level - 1500 ft
  - UAV < 500 ft
  - Rovers < 20 feet
  - Microscope slides
- Serial Photos or Video

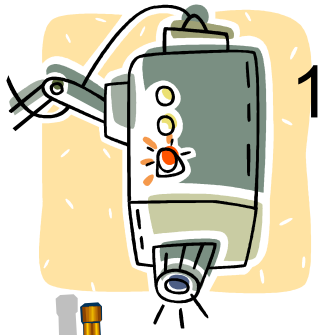
Resolution

5 m

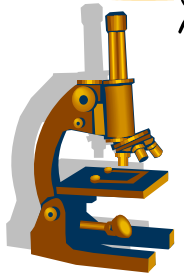
10 cm

1 cm

0.1 cm



1 mm



tiny

20 micron

Simulation and AdHoc run

KEY MESSAGES

- New innovative methods of operating will be required in the future as costs increase, returns decrease and govt support is rationalized.
- Image analysis and related technologies will allow easier monitoring and early detection of problems.
- Microwaves can control a range of species and seeds in soil which are difficult to control otherwise.

SMARTPHONES

Integrate a range of useful functions and variables very cheaply.

- Very high resolution camera
- Accelerometers – movement and direction. Gravity used in WheelCam
- Gyroscope – Which way is up. Altitude, position and dead reckoning.
- Magnetometer or compass – N,S,E,W
- GPS – Absolute position and time. Used in WheelCam and GrainCam.
- Light sensor, proximity, barometer, humidity, temperature, motion detection
- Touchscreen, fingerprint, barcode, heart rate, Geiger counter (Japan)
- Microphone, speaker, email, web, Wi-Fi, Bluetooth, storage, SD card, phone
- CAT now has one with an infra red camera (Potential for NDVI plant health and animal detection)
- Smartphones can process images on board for real time applications

WHEELCAM

- WheelCam is a device that attaches a smartphone to a wheel.
- A phone app controls the camera so that it takes a photo, time and GPS each time it points to the ground as the wheel rotates.
- This eliminates motion blur.
- We used an autonomous rover, harvester and ute but it can be fitted to any implement so the cost of collecting the data is negligible.

Mobile phone capabilities

Photos

Time and date

Map

Record to SD Card

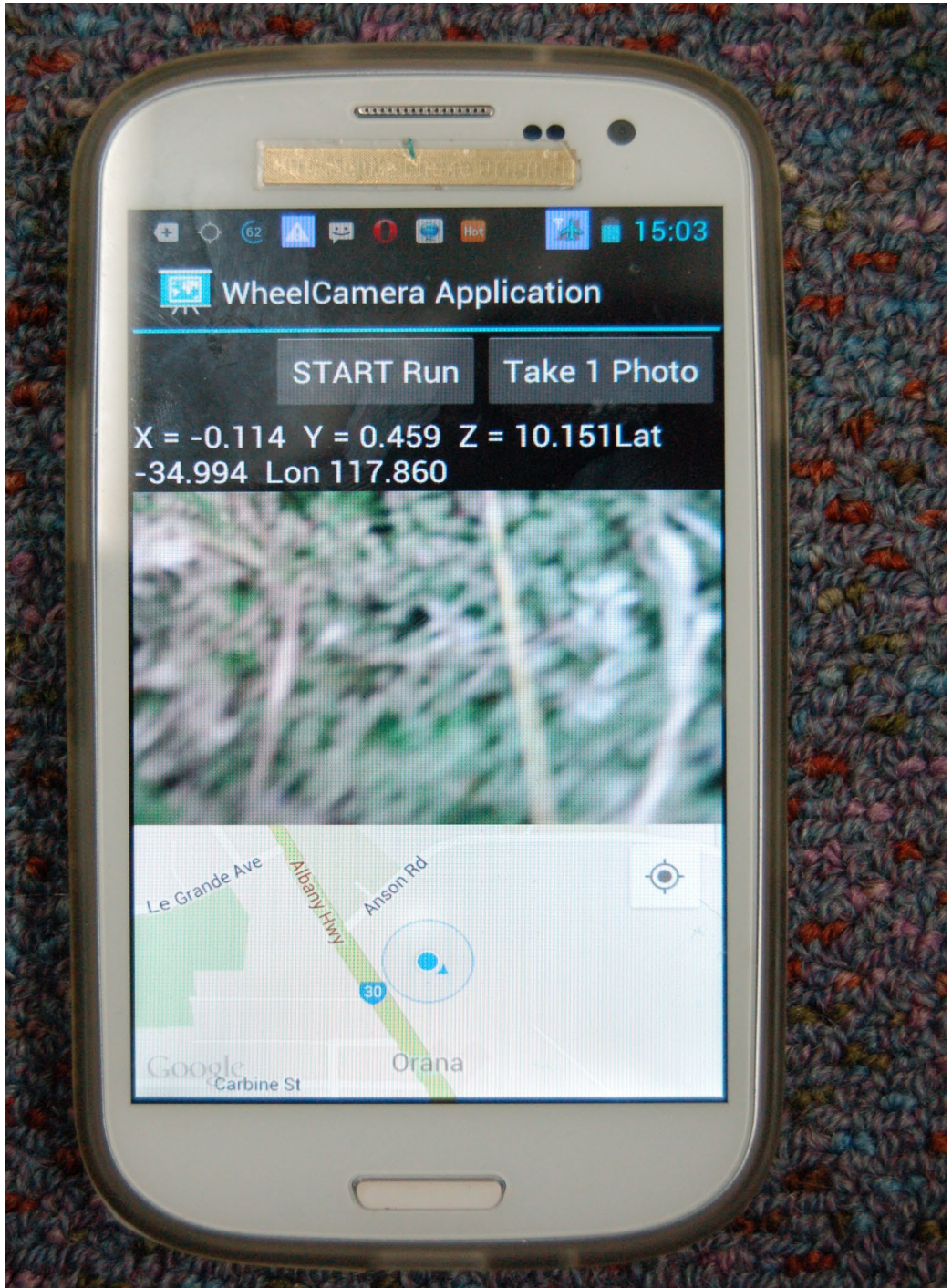
GPS coordinates

Accelerometers

Programmable (Apps)

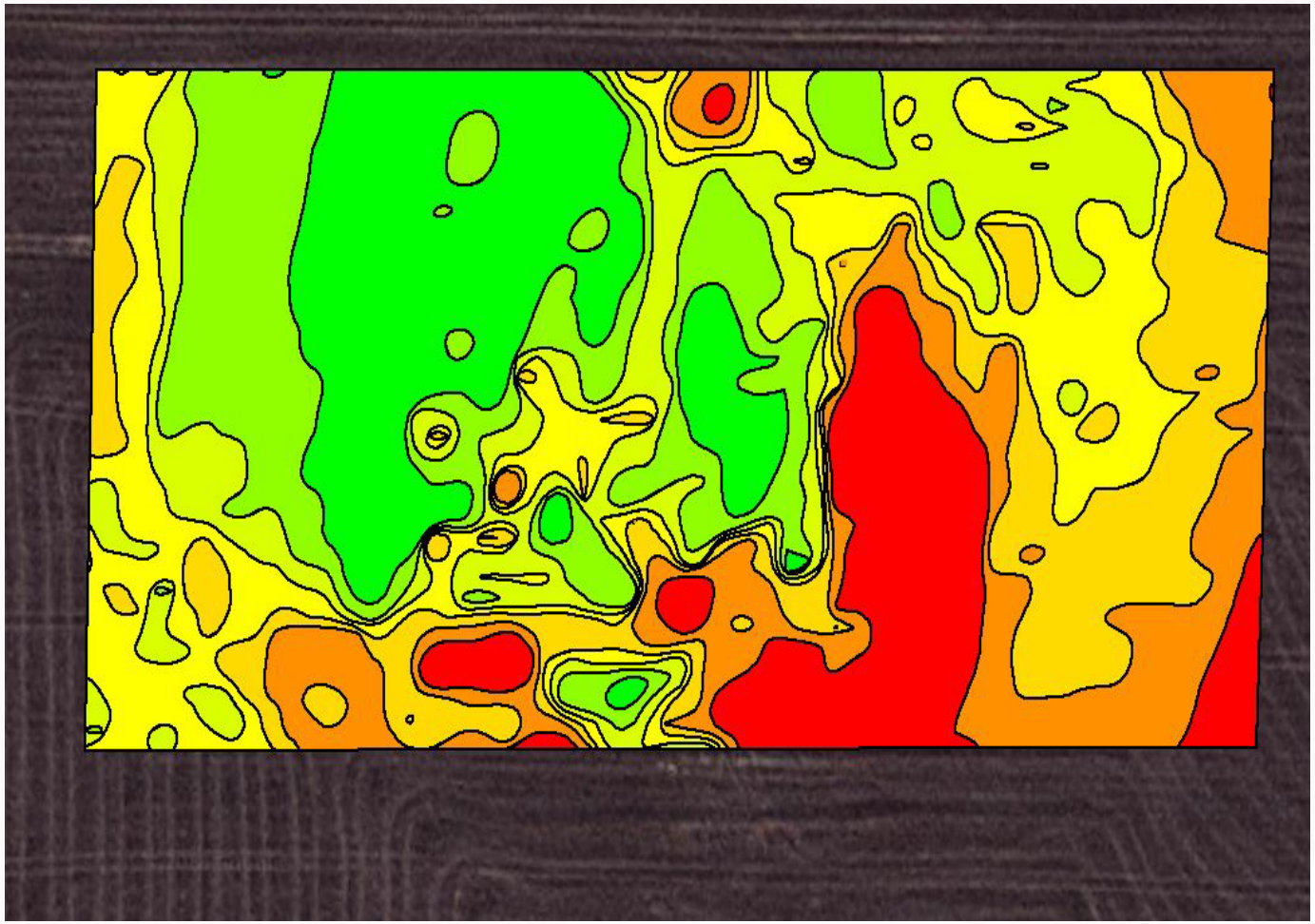
eMail, Phone or beep

Image Analysis



WHEELCAM

- Maps of snail densities and locations were made and validated with manual counts.
- Overlaid on Google maps.
- Red areas are worth treating.
- Yellow areas are clean.
- We can do this for nearly anything we can see (or make a model).
- It takes several months to make and test a model.



WHEELCAM - KEY MESSAGES

- Image analysis of field photographs taken with mobile phones attached to agricultural equipment has the potential to be used to economically make maps of pest and weed presence, distribution and density in a paddock.
- This data can be used to make management decisions that reduce economic impact or declare an area of freedom.
- We have used machine learning deep neural networks to produce models that would quickly detect snails, slugs, bedstraw and skeleton weed in images.

Evolution of Image Analysis

Initially done by floatation then visual inspection

Then camera

Now video and image analysis

DAFWA Seed Image Recognition

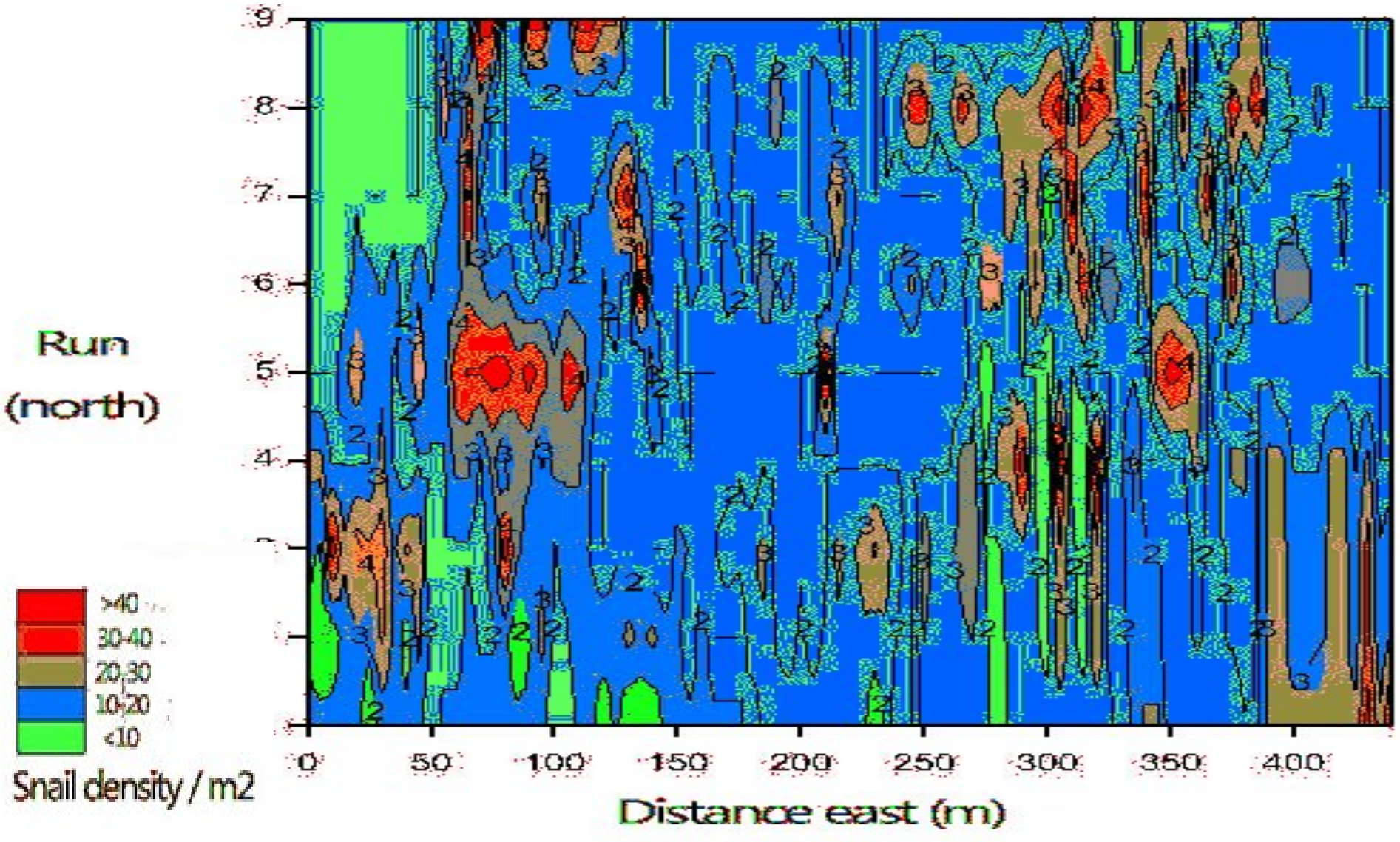
CBH EyeFoss

This is being replaced by CBH developed machines. John Moore

Grain Cam

GRAINCAM - IMAGE ACQUISITION

Infestation Map



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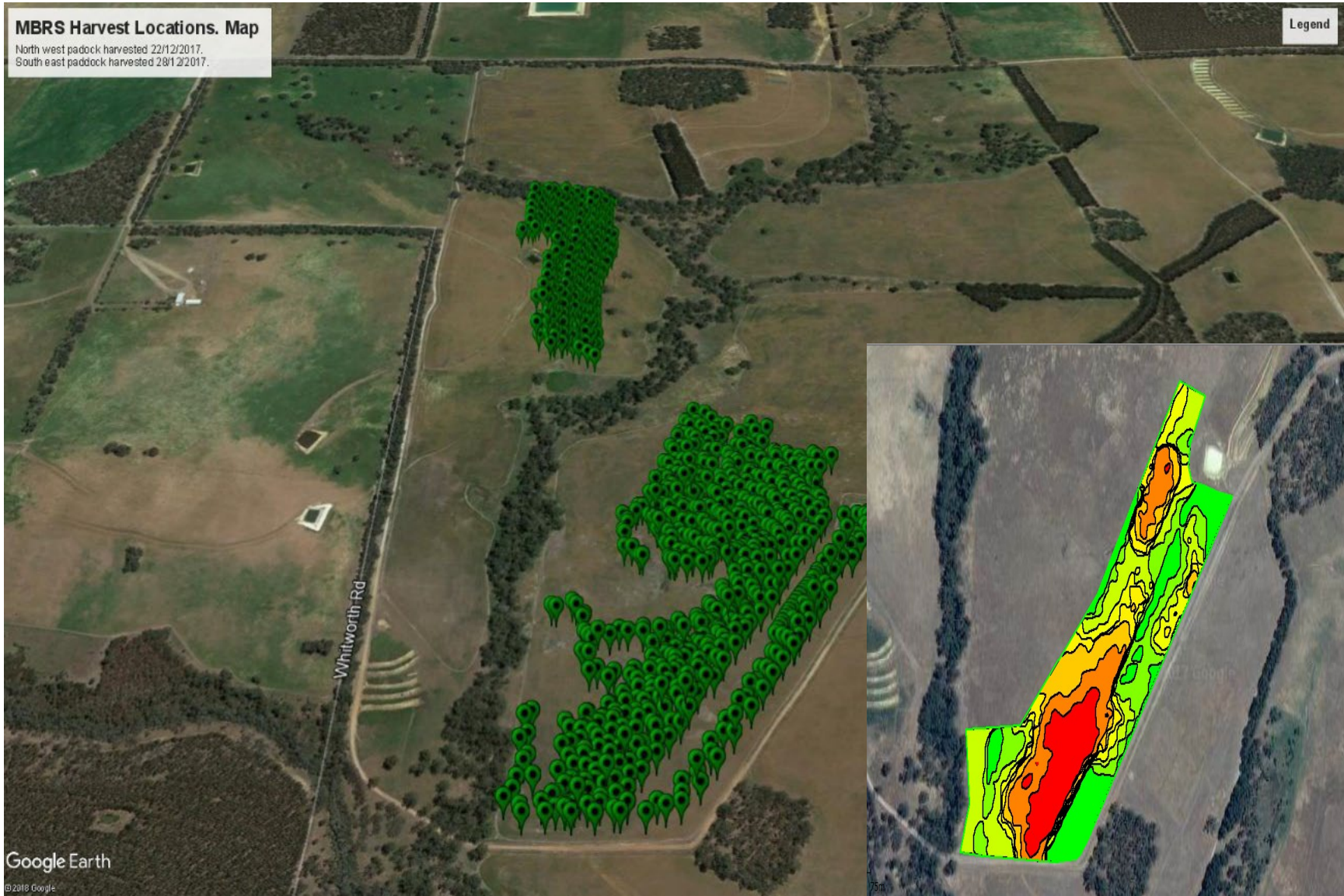
GrainCam for detecting targets during harvest

This is a map of where GrainCam was used to collect images for snail monitoring.

Proposal to make real time detection for bedstraw mapping.

Grower will then know if they have a contaminated load.

Images are taken while harvesting grain and the locations transferred to Google Maps



The Invasion Curve

Kochia near Cranbrook WA, Feb. 1992

Lines of plants near Jerramungup WA, Feb. 1993

6. Eradication program - costs

Direct costs = $176,100

herbicides (40% of total)
fuel & vehicles
aircraft hire
insurance
contract spraying
staff travel allowances

Labour costs = $318,500 (borne by DPIRD (DAWA))

Total cost = $494,600 over 8 years

$2m in todays dollars.

Biology and Geography are important.

Some quotable quotes #1

Kochia is "a suitable candidate for eradication because of its recent introduction, its limited but well documented distribution… and the limited longevity of its seeds"

(Dodd & Moore, 1993)

Some quotable quotes #2

Eradication is an easy word to say but the actualities are very different.

Early detection and decisive decision-making are crucial.

The Australia-wide interest, commitment and involvement... were crucial… the other states were keen to be involved.

Having made the decision to eradicate, do we really mean it? It's a big call to eradicate.

I think we got it right all those years ago.

(*M Clark, Agriculture Protection Officer, August 2002*)

AI and image analysis

HISTORY

Old Way

Camera acquires image

Image + Rules (size, cluster then discriminant analysis) →Prediction

Programmer makes up the rules (Feature extraction)

Bedstraw = IF (a x size + b x texture + c x roundness + ……for 25 characters for each object in the image > threshold)

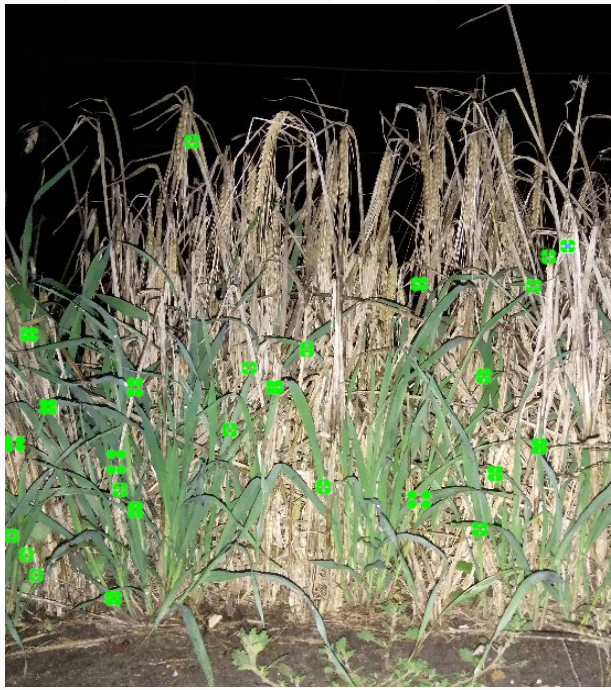
New Artificial Intelligence Way

Smartphone acquire image (+GPS, date, time, orientation etc)

Image + Prediction → Rules

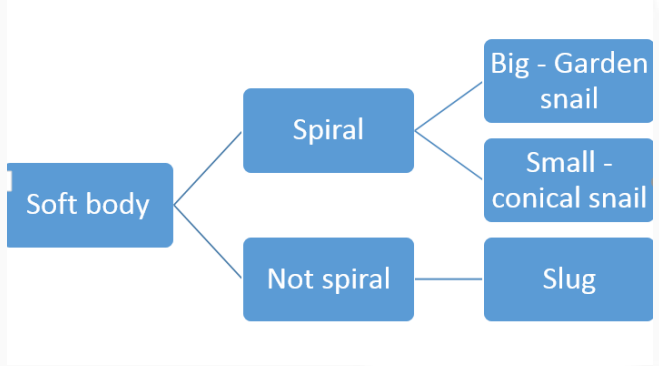
Machine makes up the rules using a deep neural network like YOLO.

Bedstraw = IF (Neural network weights for each area in the image > p=0.9).

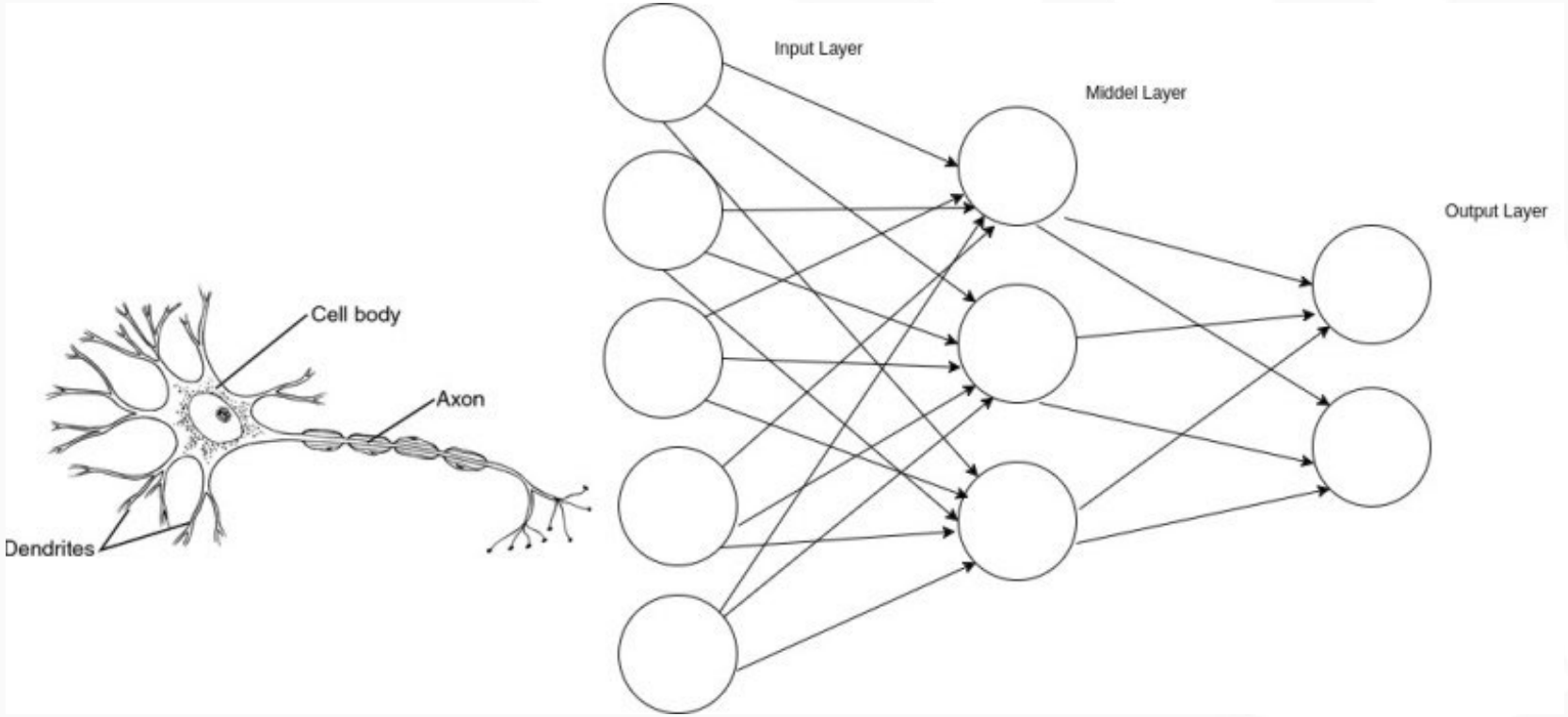


NEURAL NETWORK

- Dichotomous key
- Multi-clave key
- Decision tree

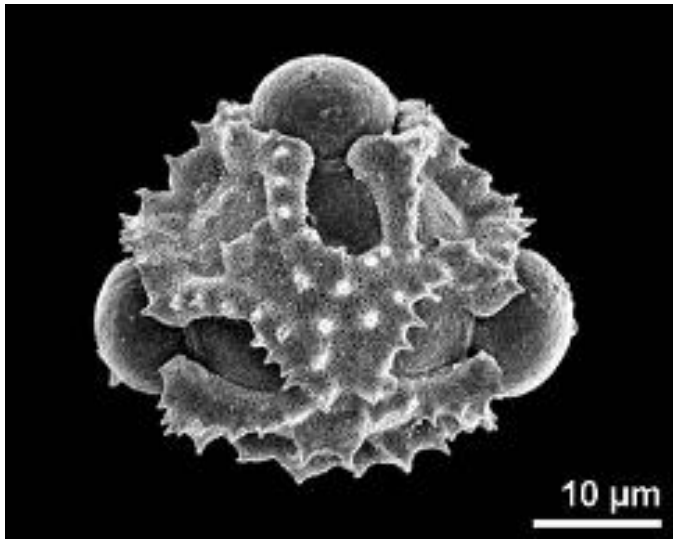


- Neuron
  & Neural Network
- Input layer is
  digital image

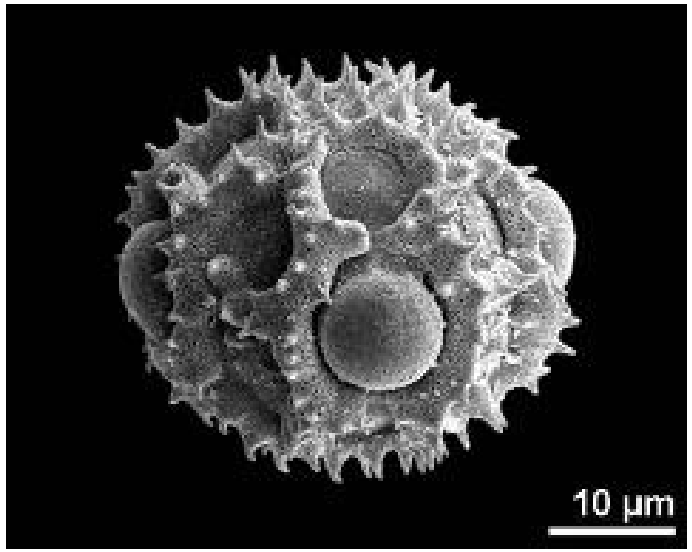


Time Lapseof slugs

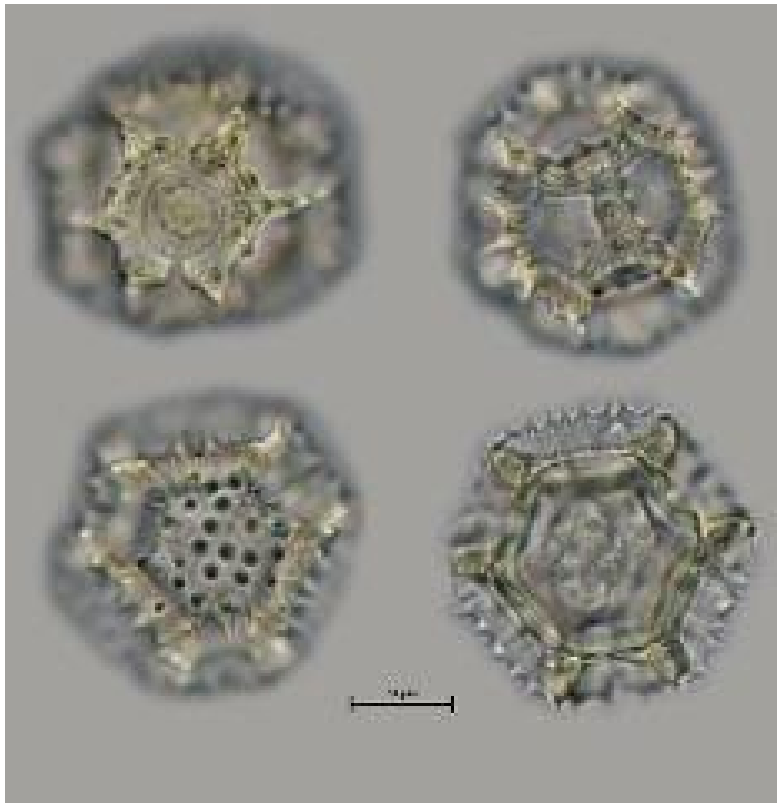
Using Pollen to find skeleton weed



Polar view



Equatorial view



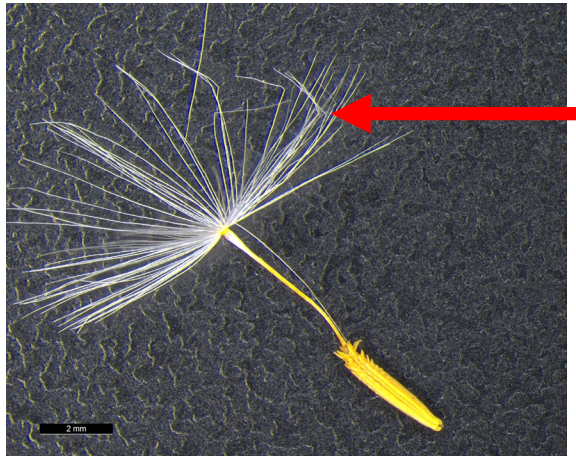
Microscope view

Using Pappus and Pollen to find Skeleton Weed

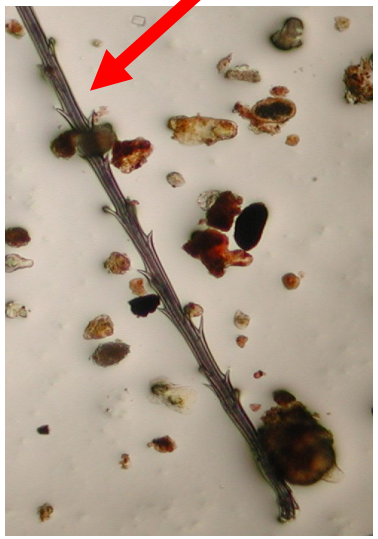
Pappus and pollen float around in the air and can be captured on in “spore” traps.

Flowers

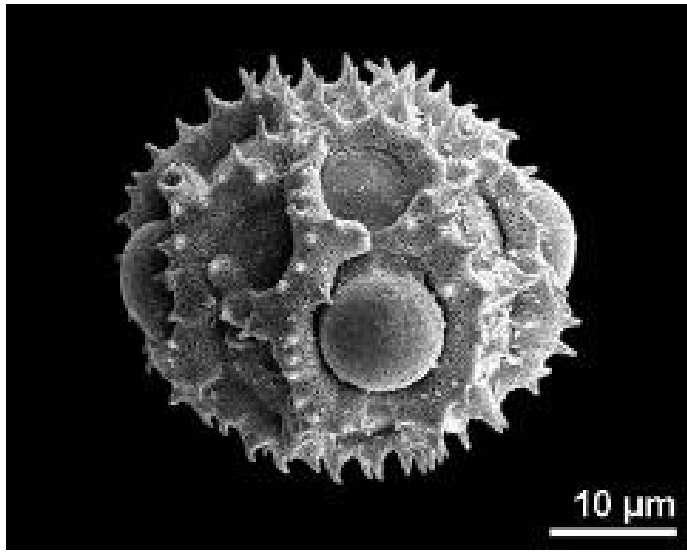
Seed



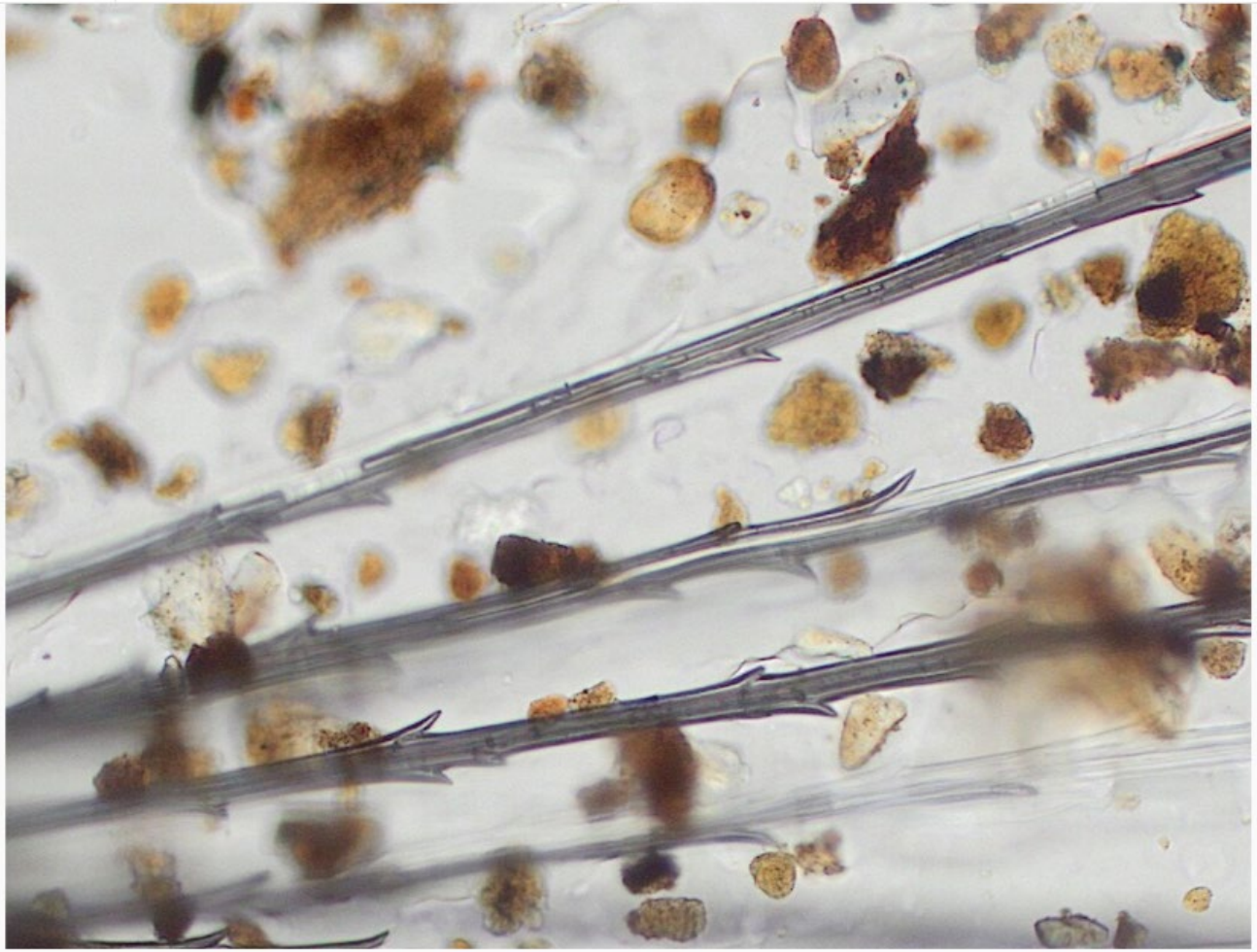
Pappus



Pollen



#760 JO john.moore #2YKcm 1/1
created, 44 minutes ago



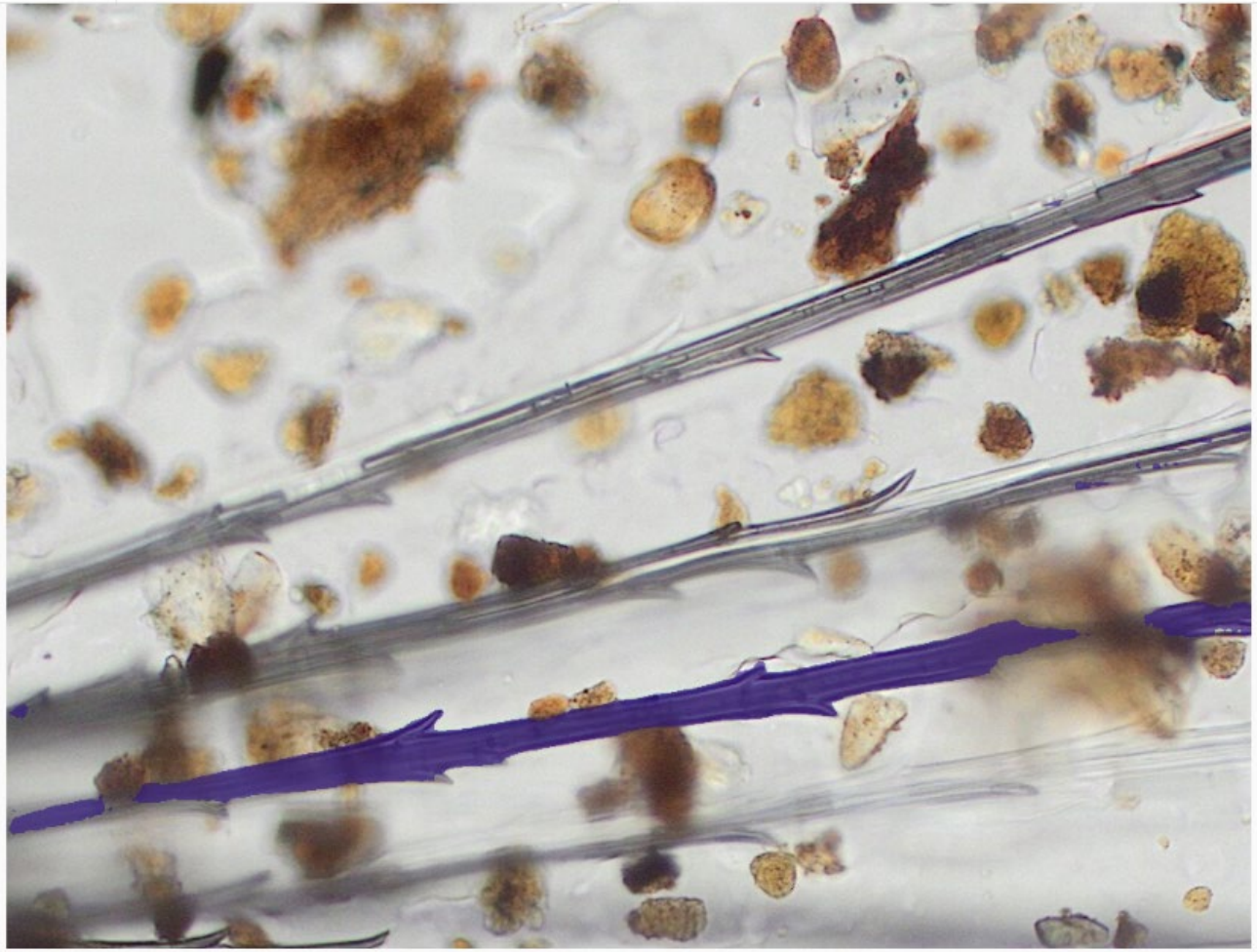
SKW pappus dark 1 | SKW pappus light 2 | SKW pollen 3 | Other pappus 4

SKW pappus dark 5 | SKW pappus light 6 | SKW pollen 7 | Other pappus 8

SKW pappus dark 9 | SKW pappus light 0 | SKW pollen q | Other pappus w | Orange Eraser e

SKW pappus dark t | SKW pappus light a | SKW pollen s | Other pappus d

#760 JO john.moore #2YKcm
created, about 1 hour ago 1/1



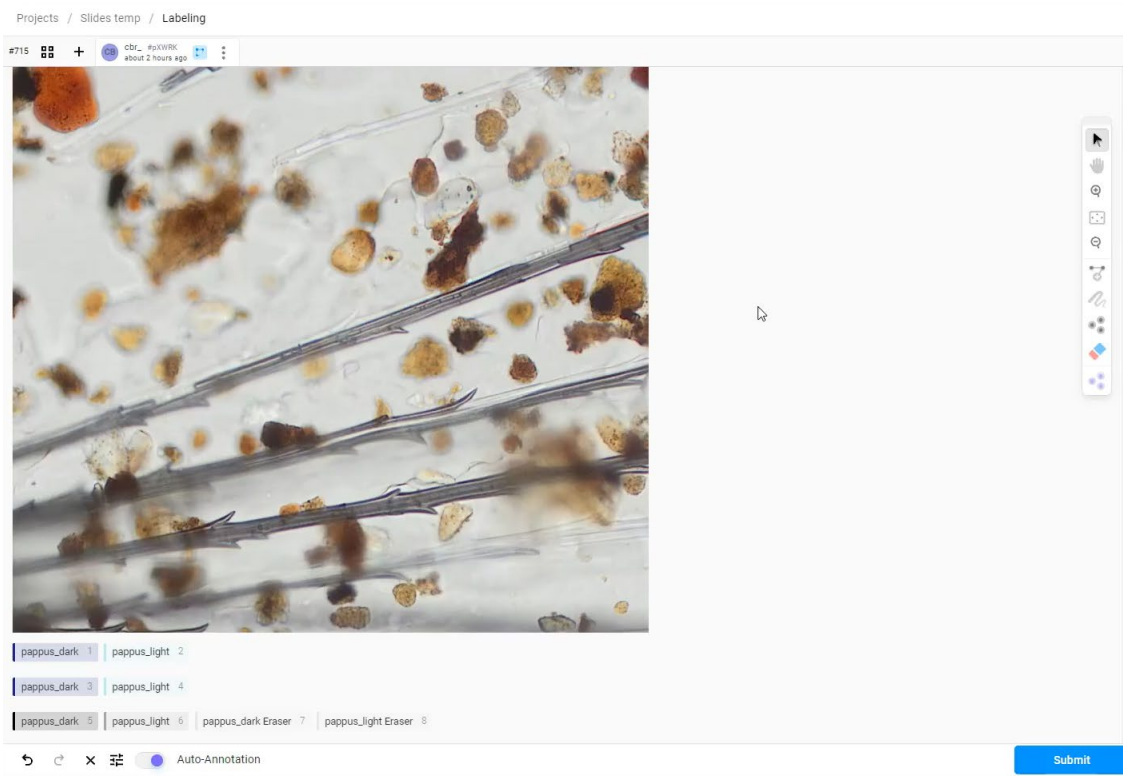
SKW pappus dark 1 | SKW pappus light 2 | SKW pollen 3 | Other pappus 4

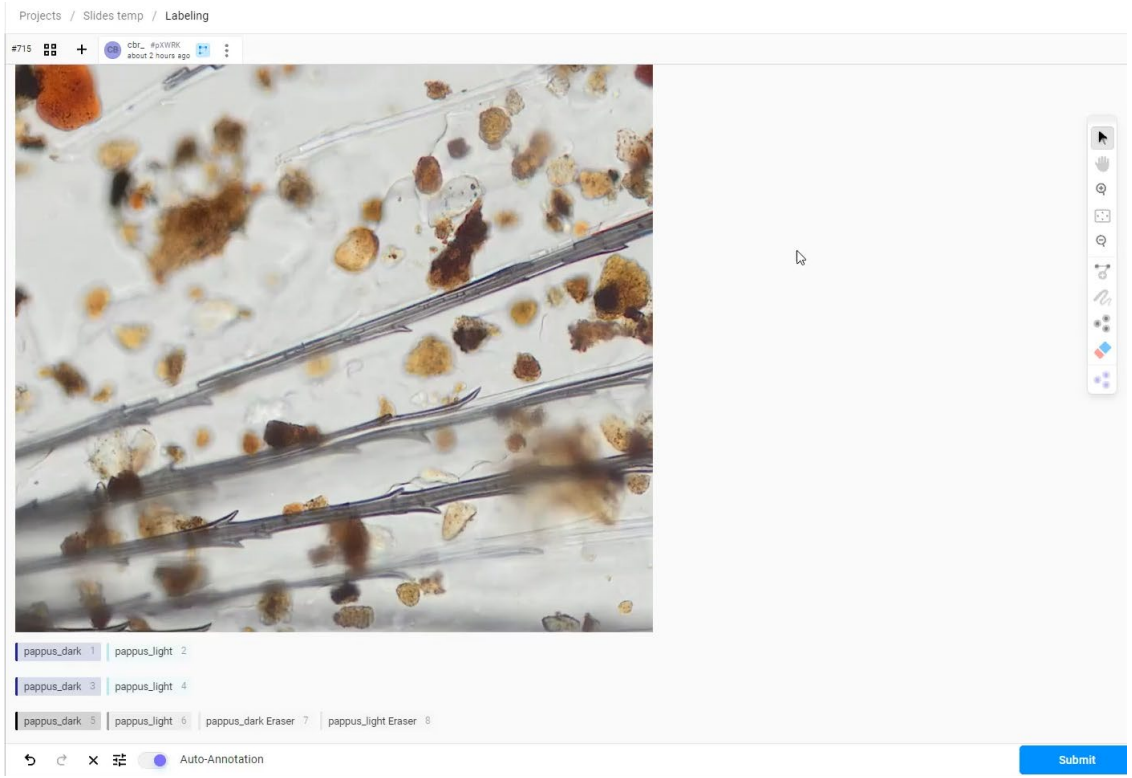
SKW pappus dark 5 | SKW pappus light 6 | SKW pollen 7 | Other pappus 8

SKW pappus dark 9 | SKW pappus light 0 | SKW pollen q | Other pappus w | Orange Eraser e

SKW pappus dark t | SKW pappus light a | SKW pollen s | Other pappus d

Auto-segmentation – Boosting capability





Case Studies

- Brookton
- 1 in 20 plants were not found during surveillance.

- 1 in 20 plants treated did not die.

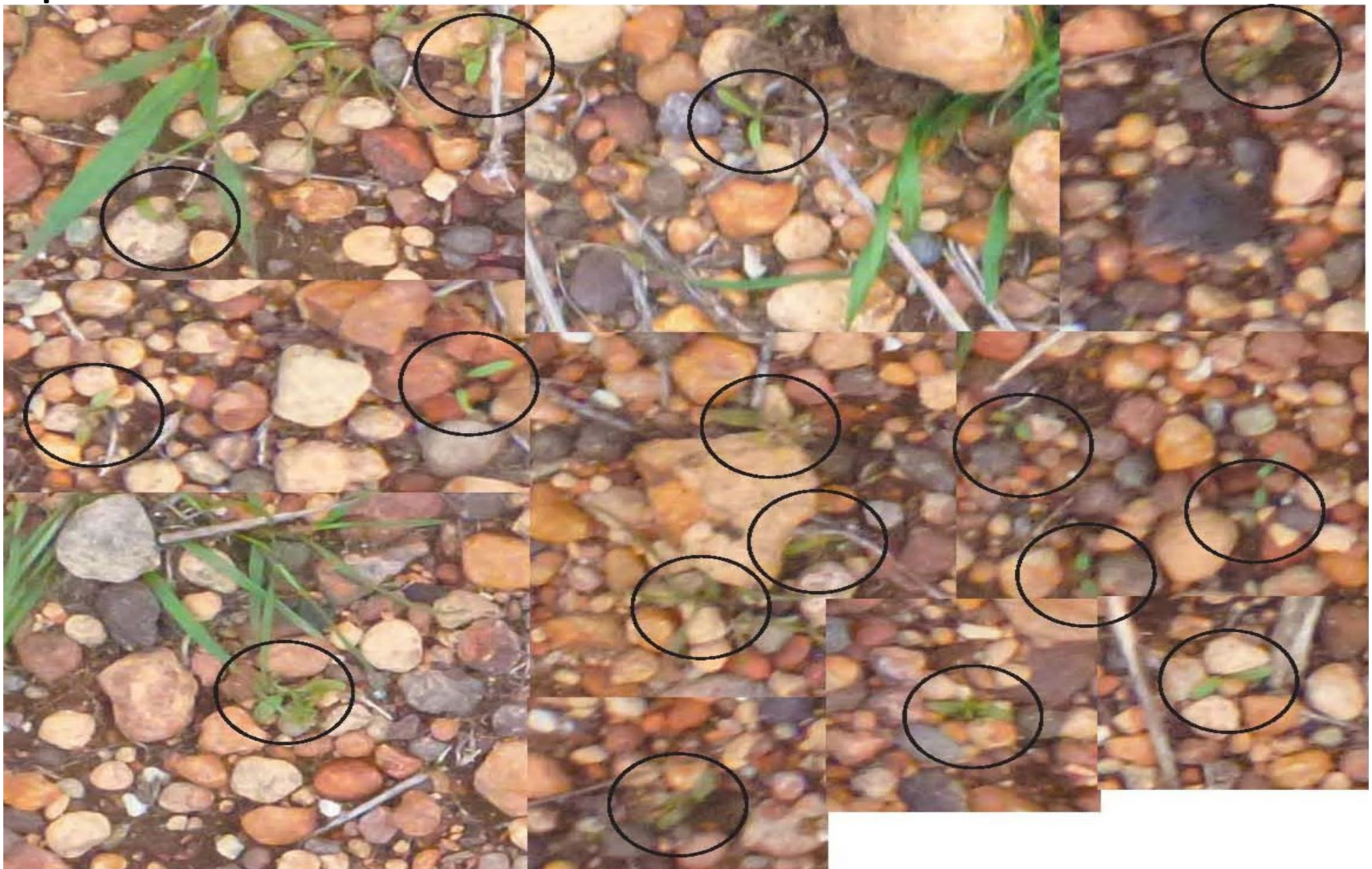
- Is 95% detection and 95% kill good enough?
- How can we improve it.

- 0.95 x 0.95 = 0.90 overall kill rate

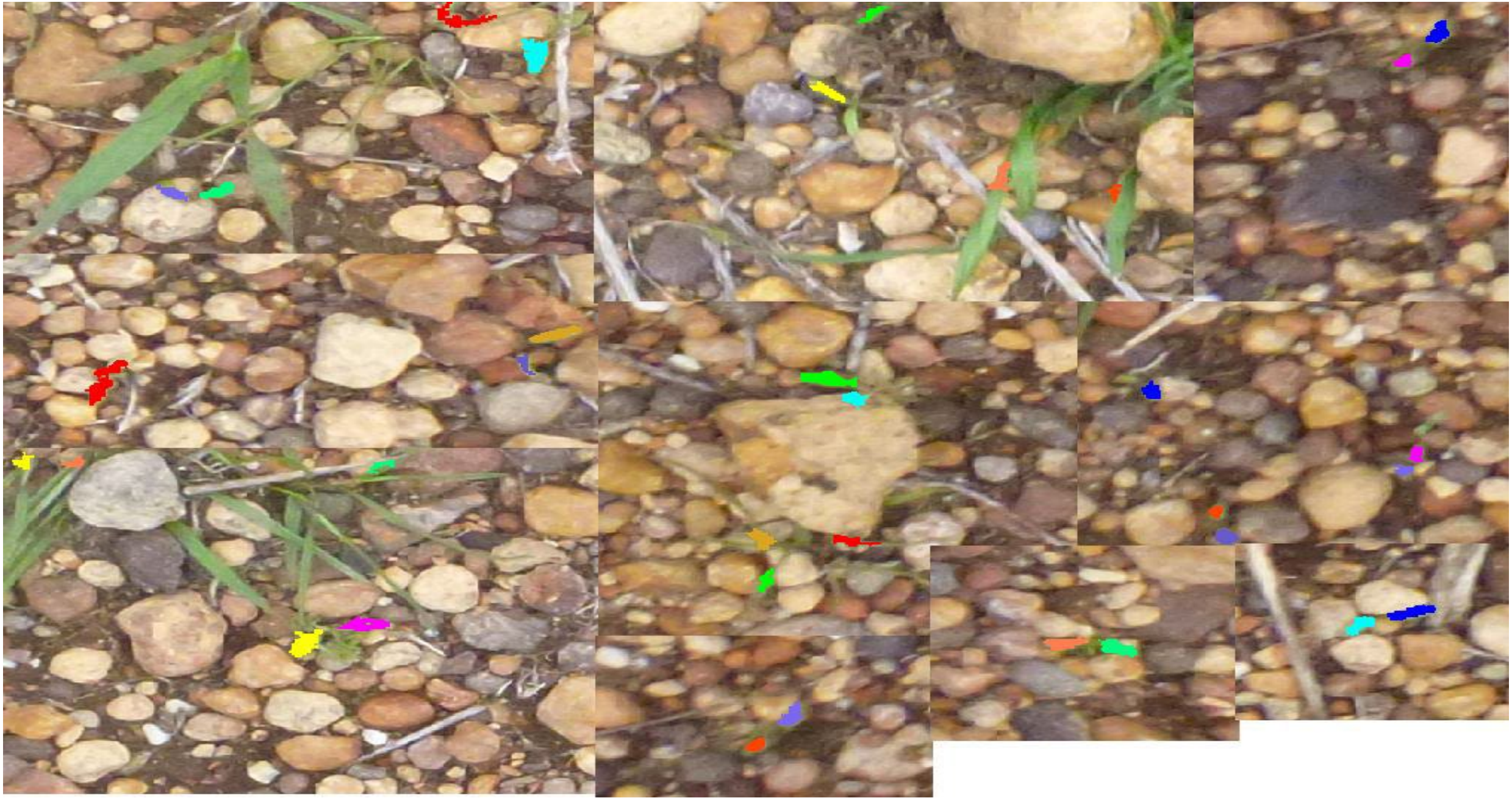
ECONOMIC IMPACT

- Early detection of weed seeds like bedstraw will save hundreds of thousands of dollars in eradication costs. (CBH is using image analysis with the EyeFoss machines).
- GrainCam can detect new infestations of invasive species allowing control before they spread.
- Mapping invasive species on the ground using WheelCam or a Drone mount is much more difficult for weeds like bedstraw.
- Image Analysis and smartphone technology has a plethora of applications with a wide range of economic benefits.

Find plants



Test classification



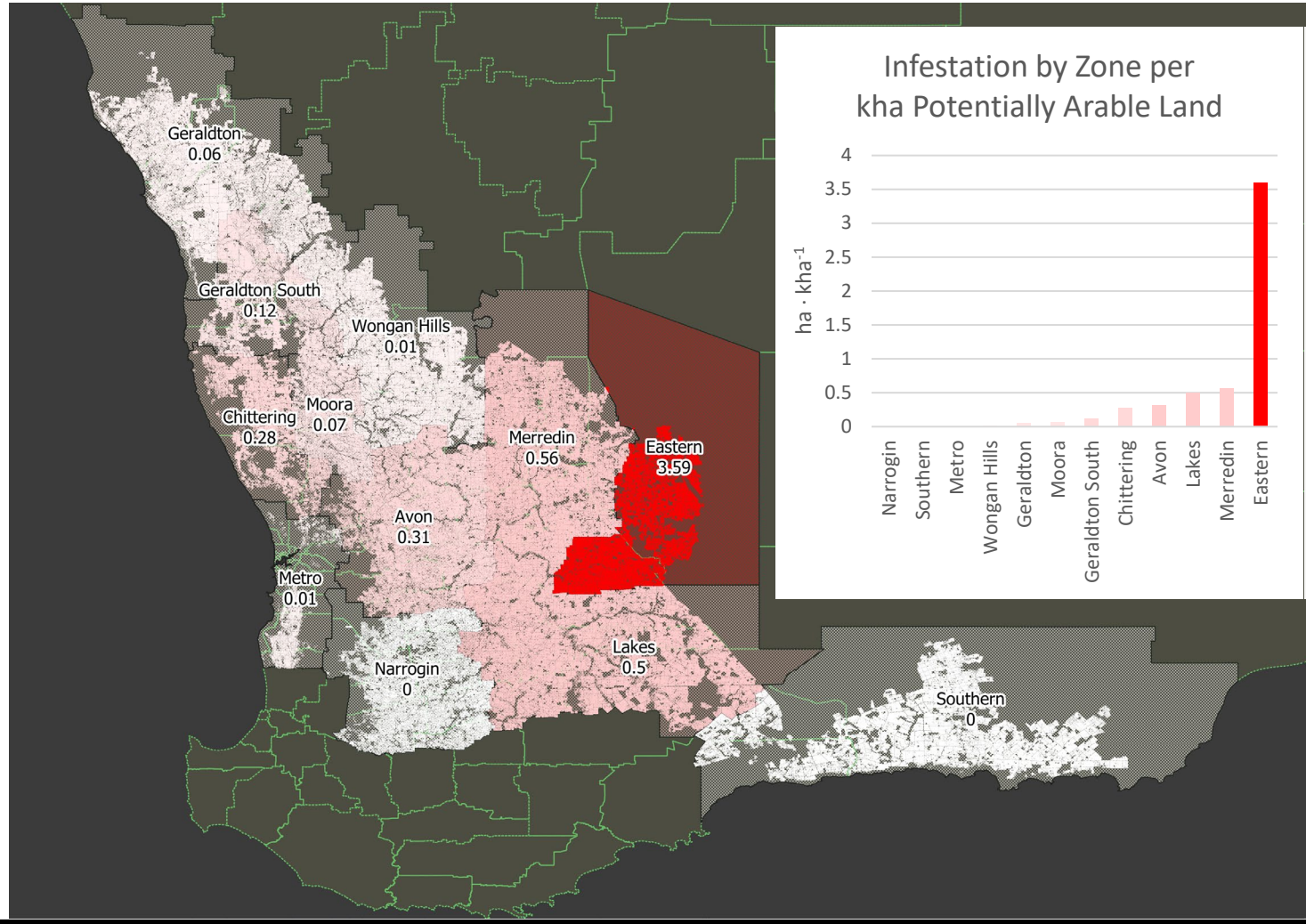
Test classification

Aerial survey of invasive wattles

Eradication vs Control

- The program operates on 16 LGA clusters comprising the Western Australian wheatbelt
- Management lead by Local Action Group (LAG) coordinators (where available) and DPIRD Biosecurity officers
- Areas are clustered in 12 Zones
- LGAs of Narembeen and Yilgarn conform the Eastern zone
- The goal is Eradication in all zones, except the Eastern zone
- Infestation per potentially arable area in Eastern Zone drives this decision

Snapshot of Infestation (ha / kha) in Season 20/21

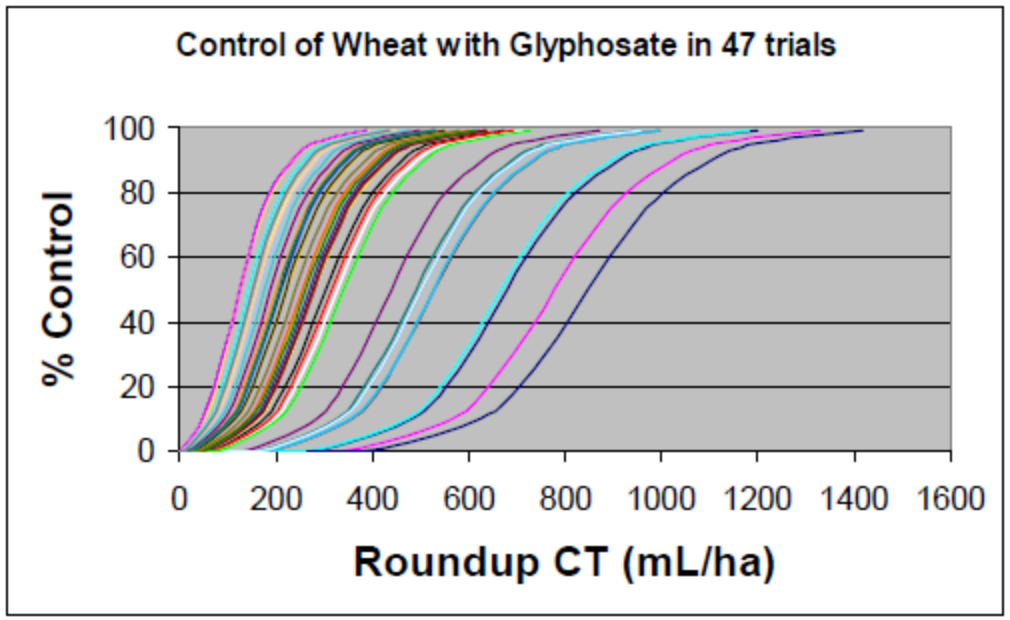


Rust

- Affects narrow-leaved biotype
- Immediate increase in wheat yields
- Infestations reduced in size over time


CAUTION

Glyphosate Dose Response in trials



eDNA = Environmental DNA

Searches for DNA from environmental samples e.g. Air, water, excrement.

Bee hive pollen analysis to see what flowers bees are visiting or bat faecal samples to see what bats are eating (Karen Bell). Search for the rare and endangered long footed potoroo in NSW by using predator scat samples (Andrew Weeks)

Can we analyse sheep or kangaroo poo for the presence of the rare and about to be endangered skeleton weed?

Google search

eDNA not Edna

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Acknlowlegements

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