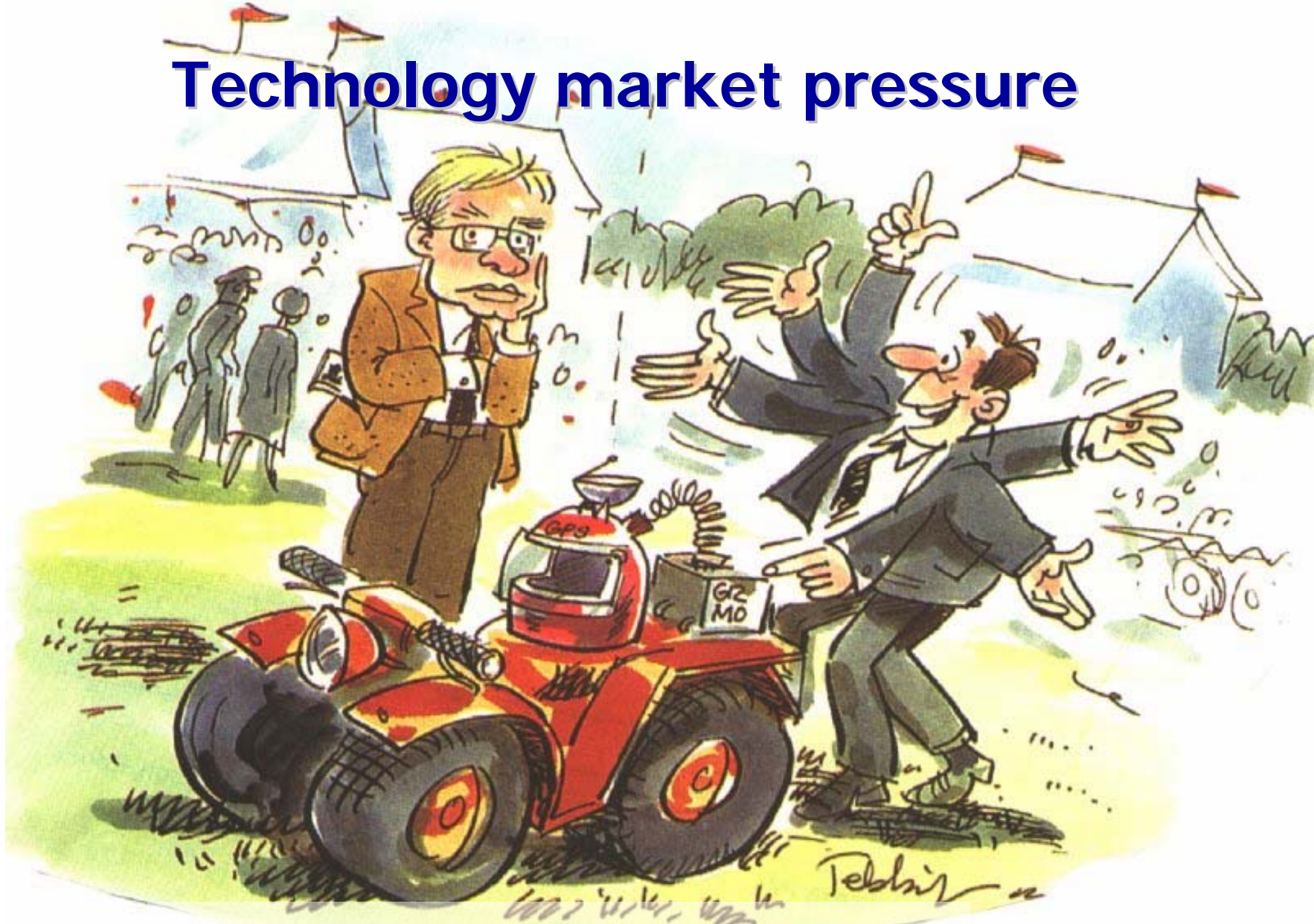


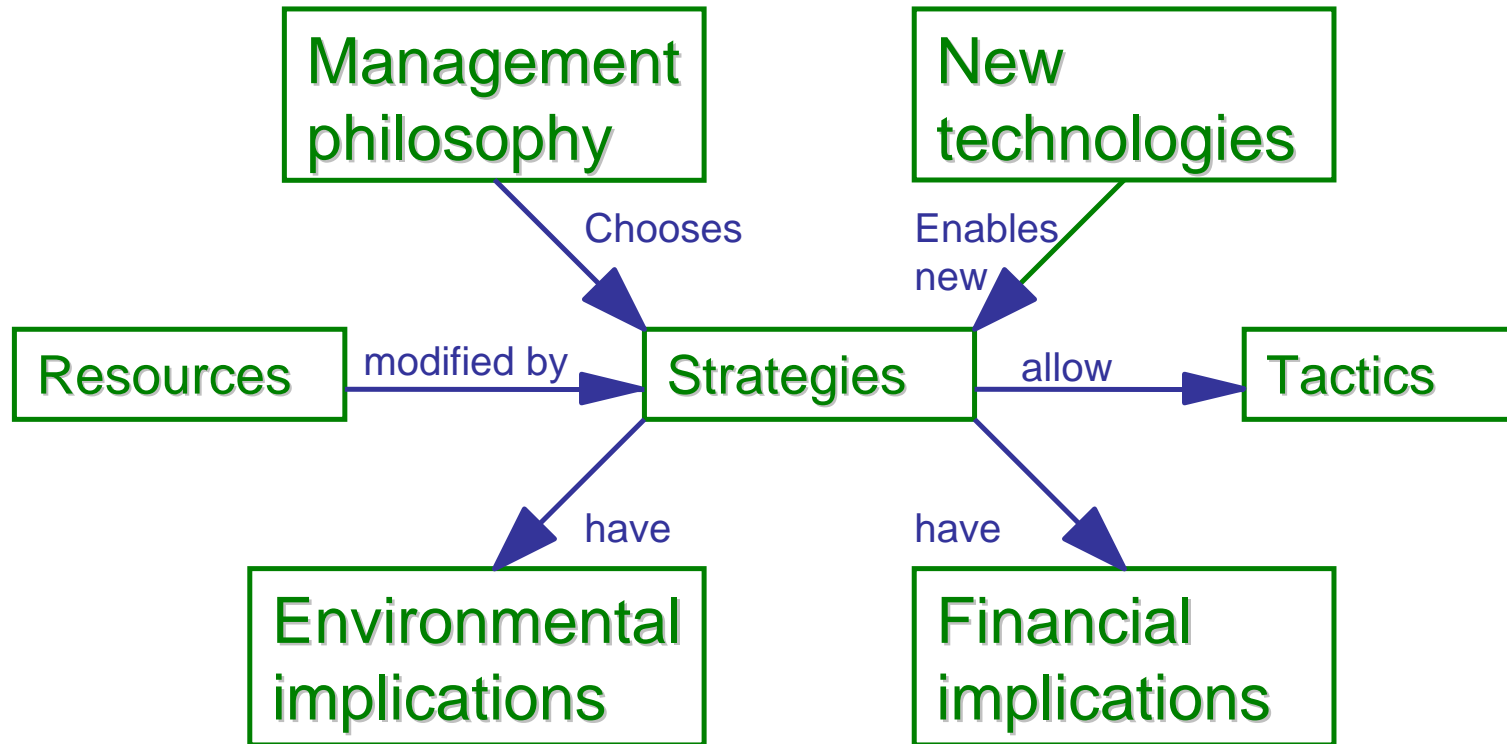
Technology market pressure



- We need knowledge transfer as well as technology transfer

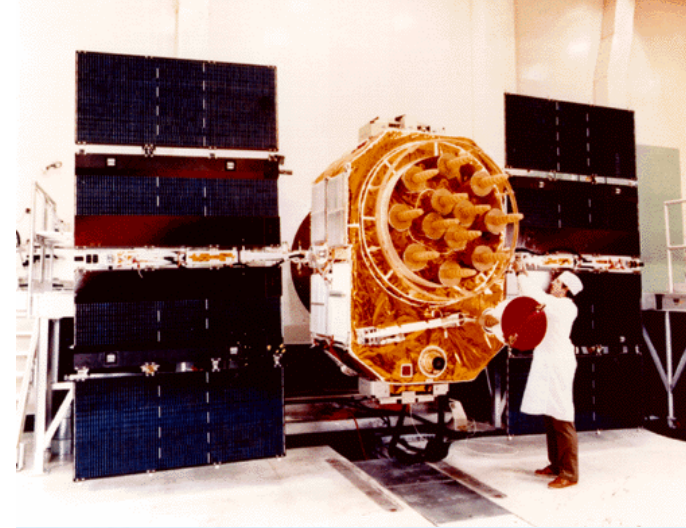
Thanks to Farmer's Weekly

Precision Farming is all about management (sometimes aided by new technologies)



How is this achieved?

- Some of the tools
 - Global Positioning Systems (GPS)
 - Yield mapping
 - Geographic Information Systems (GIS)
 - Rapid assessment techniques (EMI, ADP)
 - Remote sensing and airborne digital photography (RS ADP).

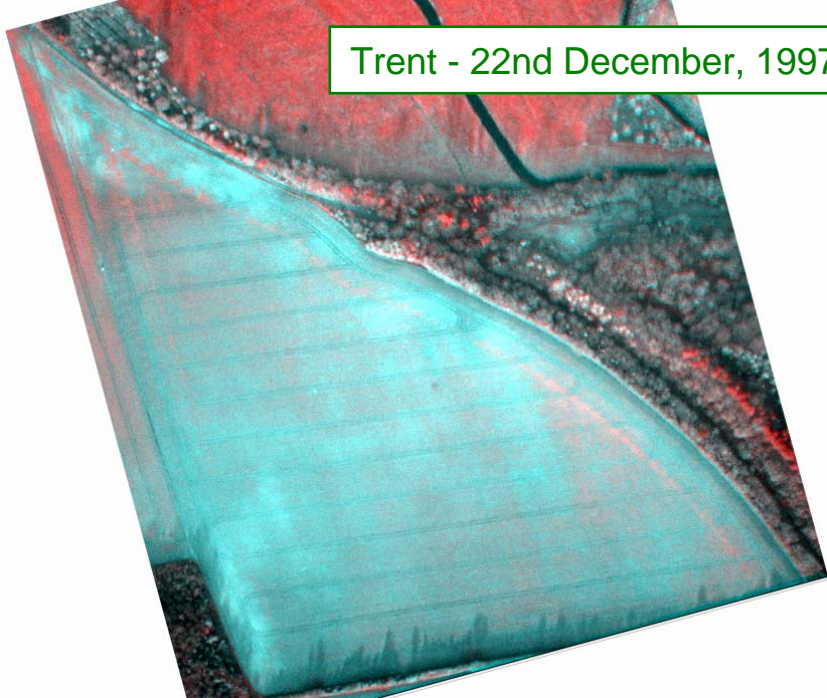


Airborne Digital Photography (ADP)

- 2 Kodak-Nikon DCS420 digital cameras mounted in a light aircraft
- Spatial Resolution (equivalent ground dimension) is controlled by flying height - 50cm to 100cm
- $640 \pm 10.4\text{nm}$ (visible red)
- $840 \pm 11.7\text{nm}$ (near infra-red)
- Immediate digital processing



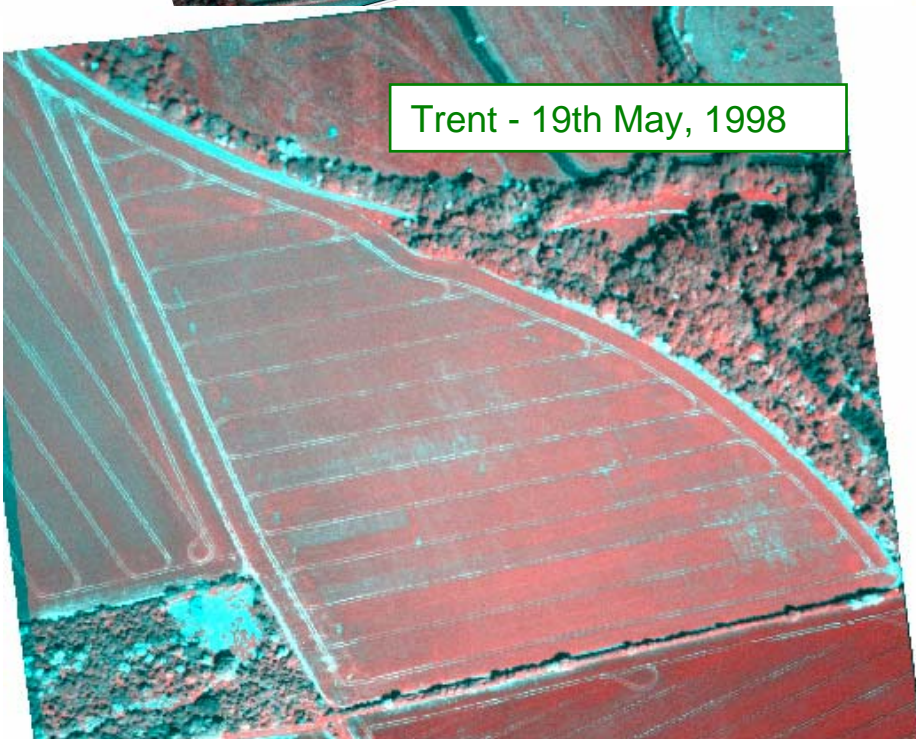
Trent - 22nd December, 1997



Trent - 28th February, 1998



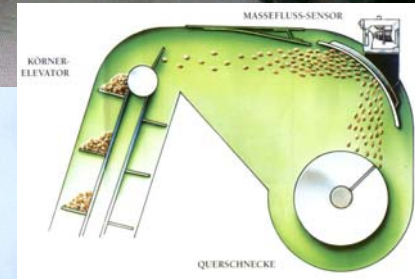
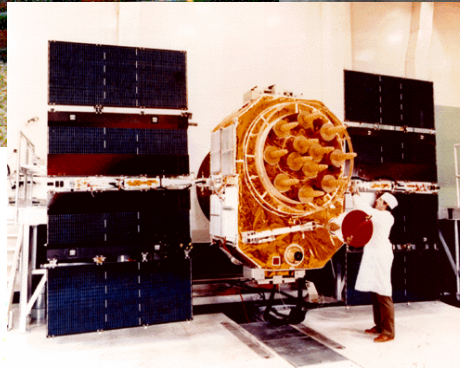
Trent - 19th May, 1998



Trent - 27th June, 1998



Yield mapping combines

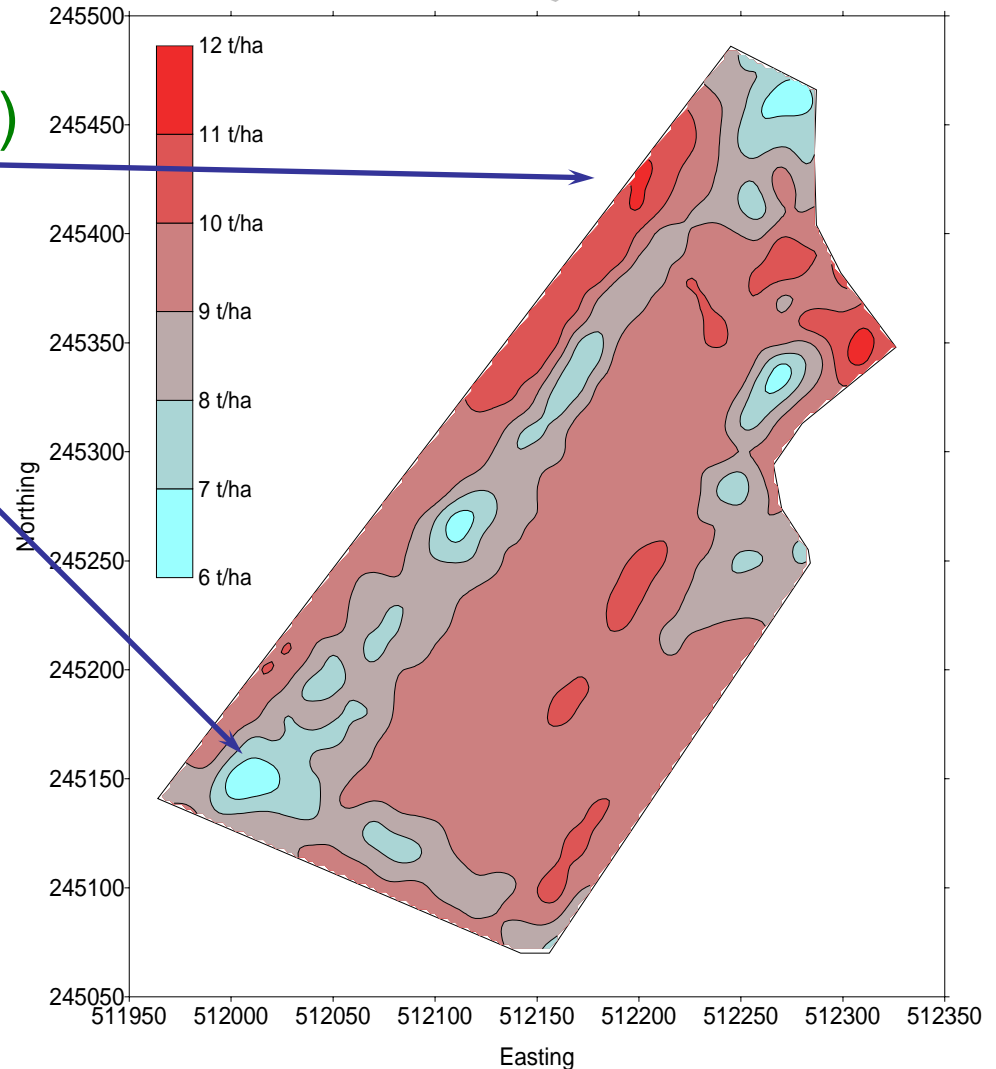


Spatial variability (Changes over an area)

High yielding area (12t/ha)

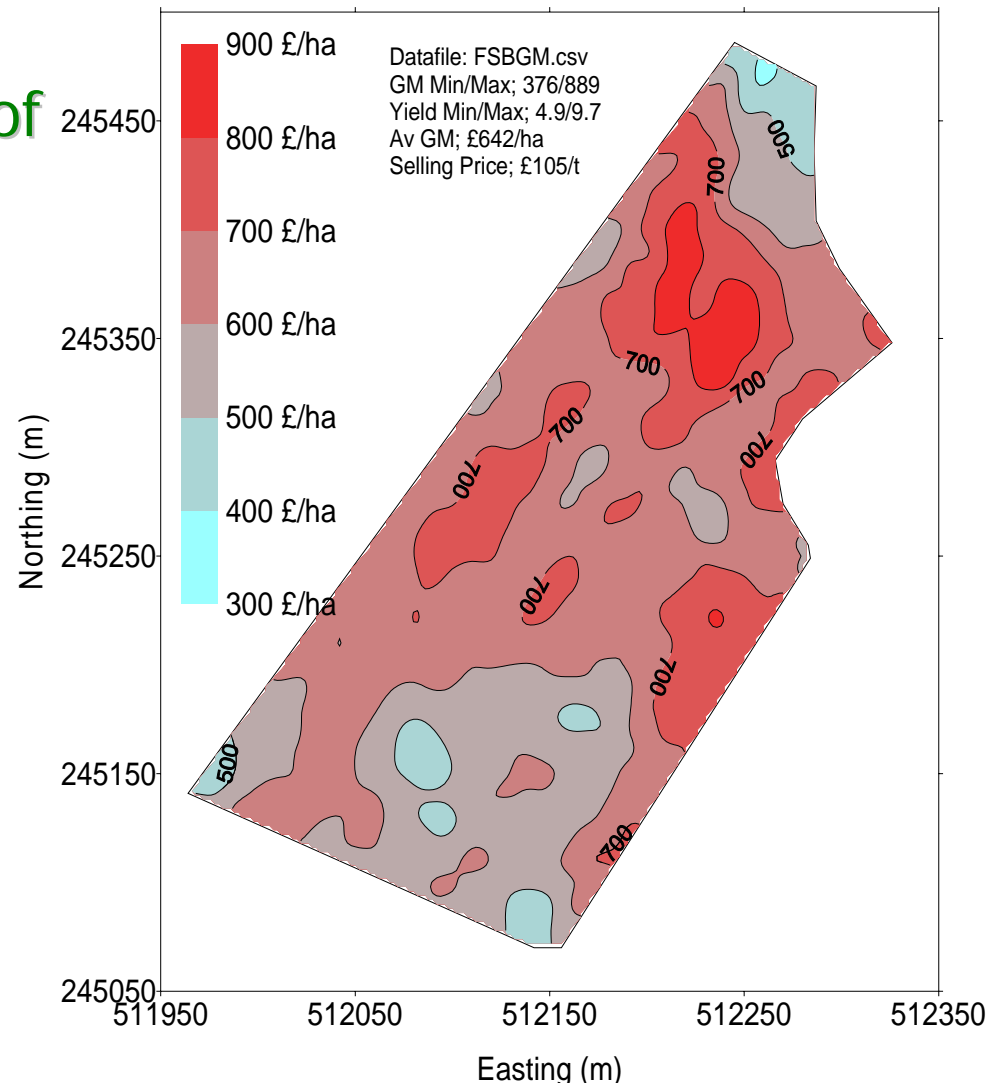
Low yielding area (6t/ha)

Quantifies spatial
variability.

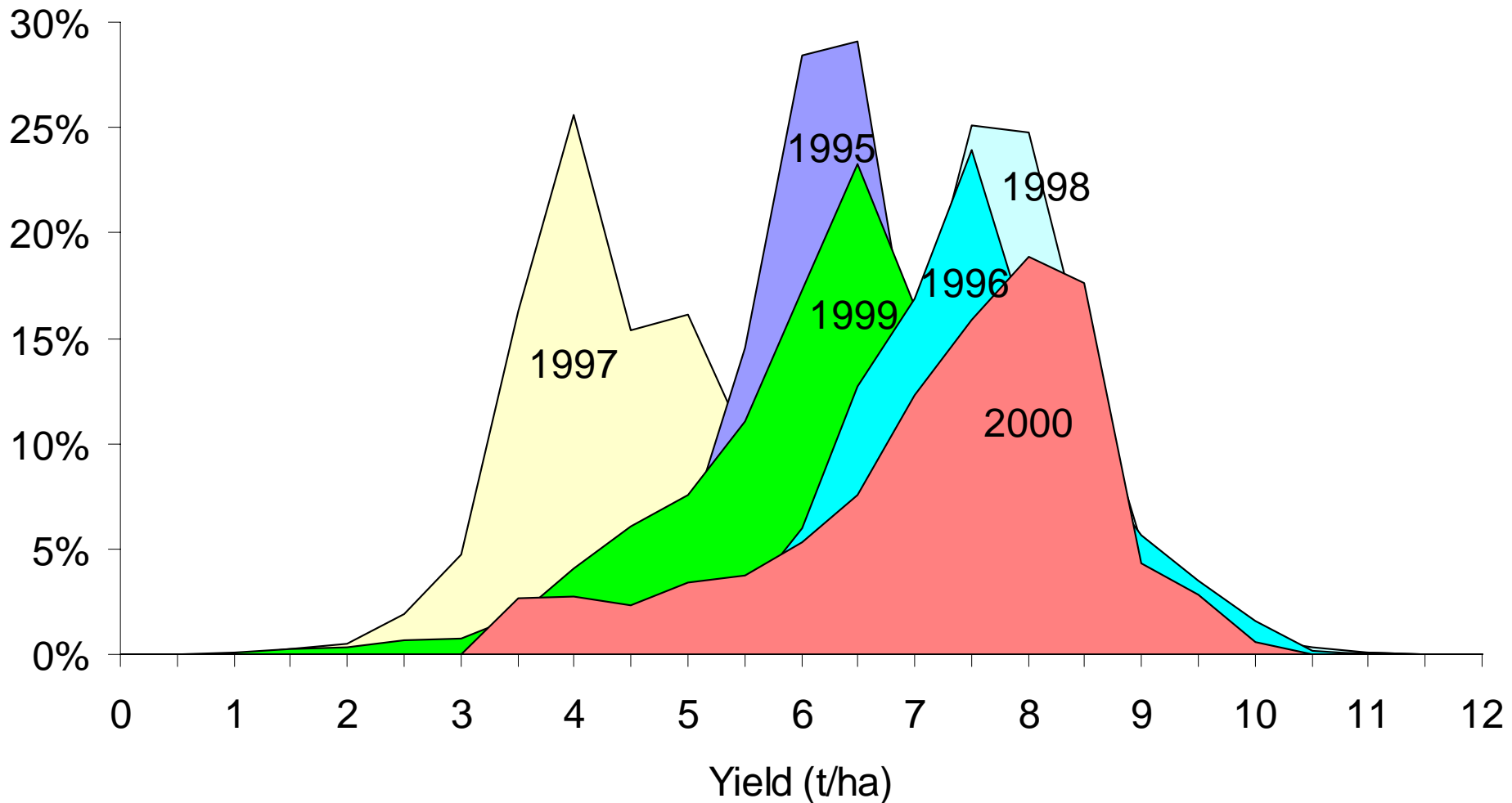


Gross margin map; The cost of spatial variability

- Shows the variability of returns
- Ranges between €500 – €1400 per hectare within one field.

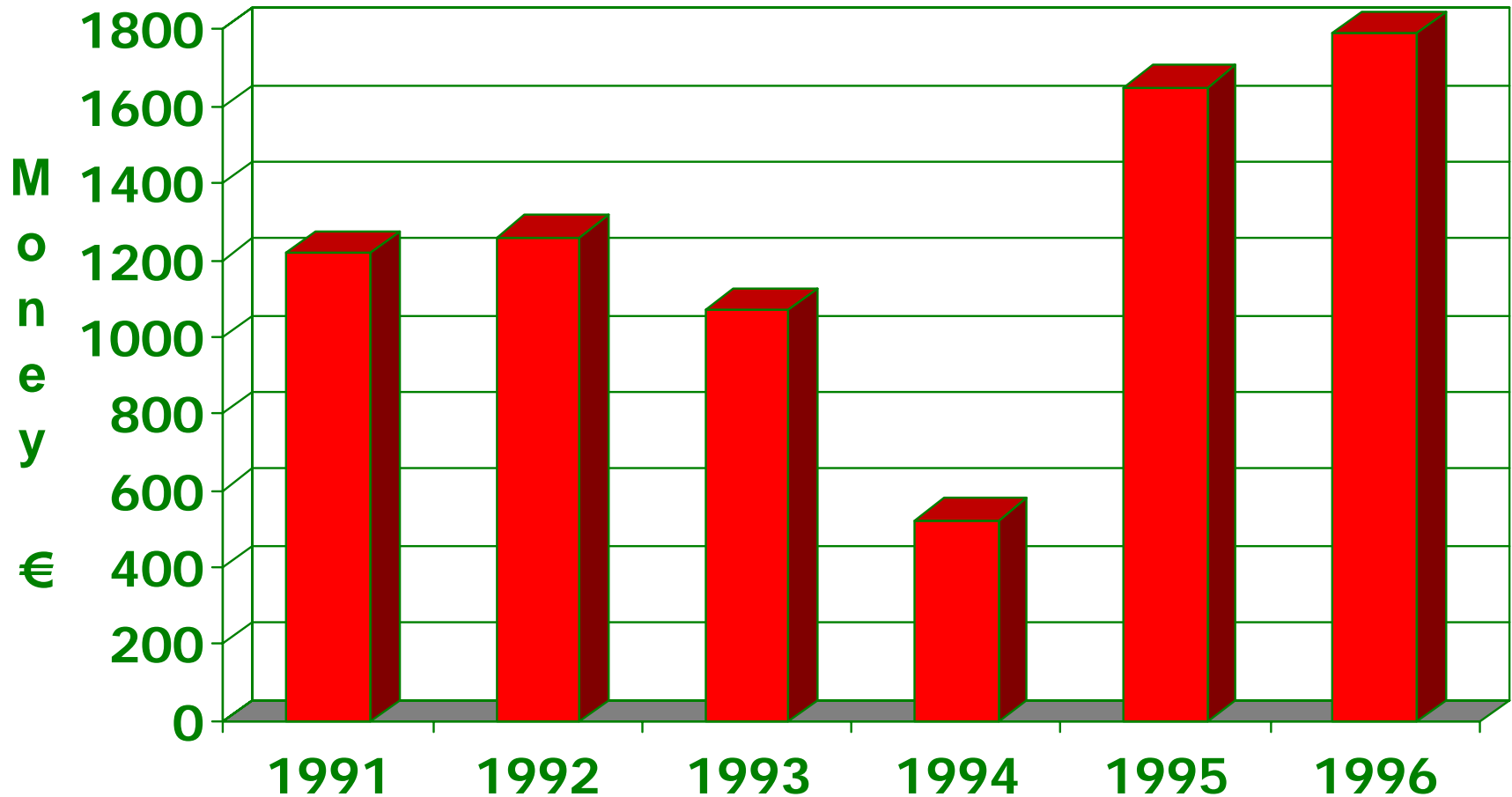


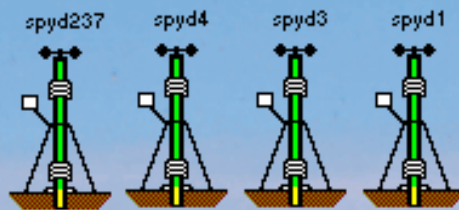
Temporal variability (Changes over time)



Predictive variability

Gross Margins (& price changes)





HARDI Metpole

Temperature
Relative humidity

Wind
Surface wetness
Solar radiation

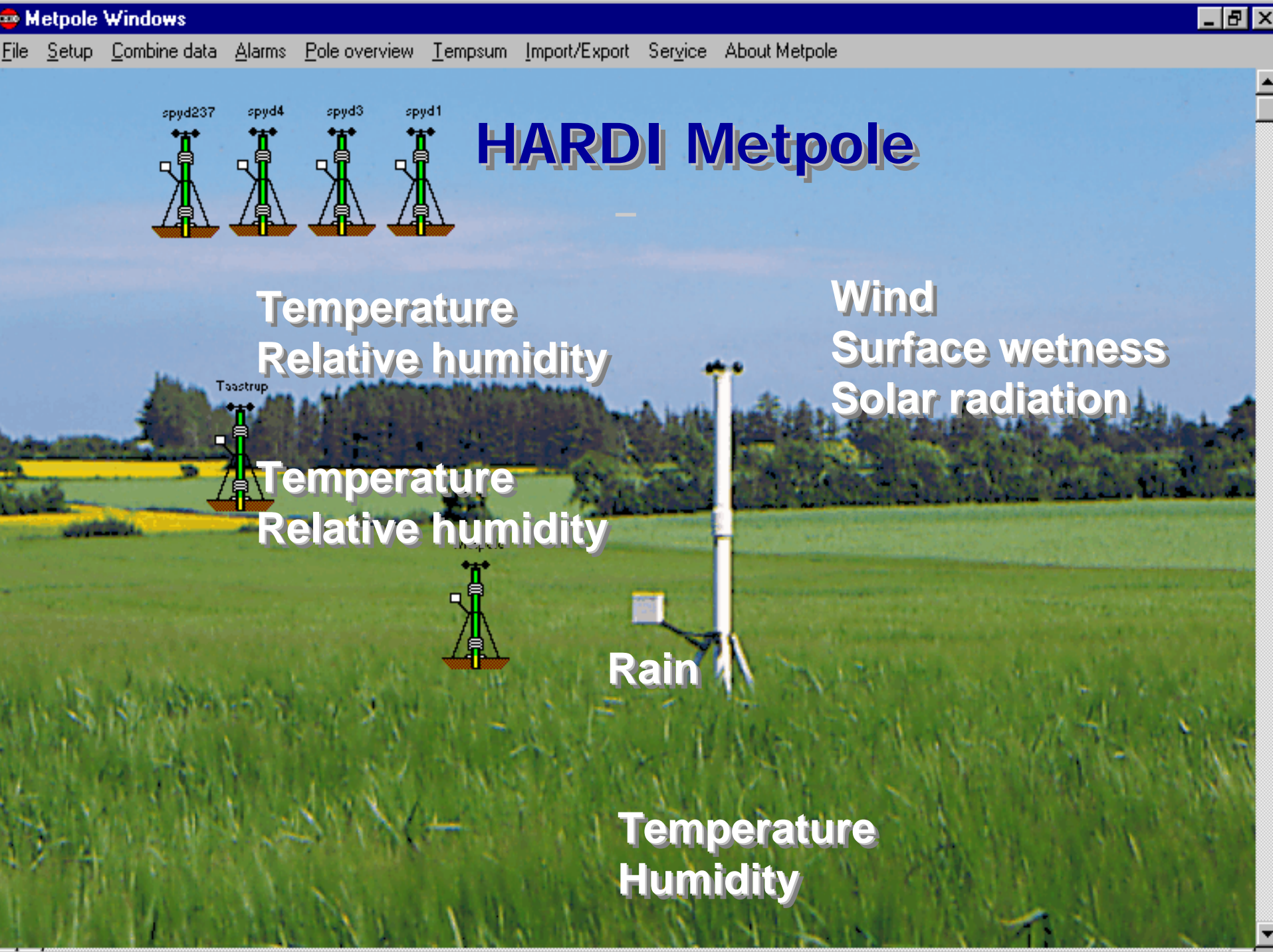


Temperature
Relative humidity



Rain

Temperature
Humidity



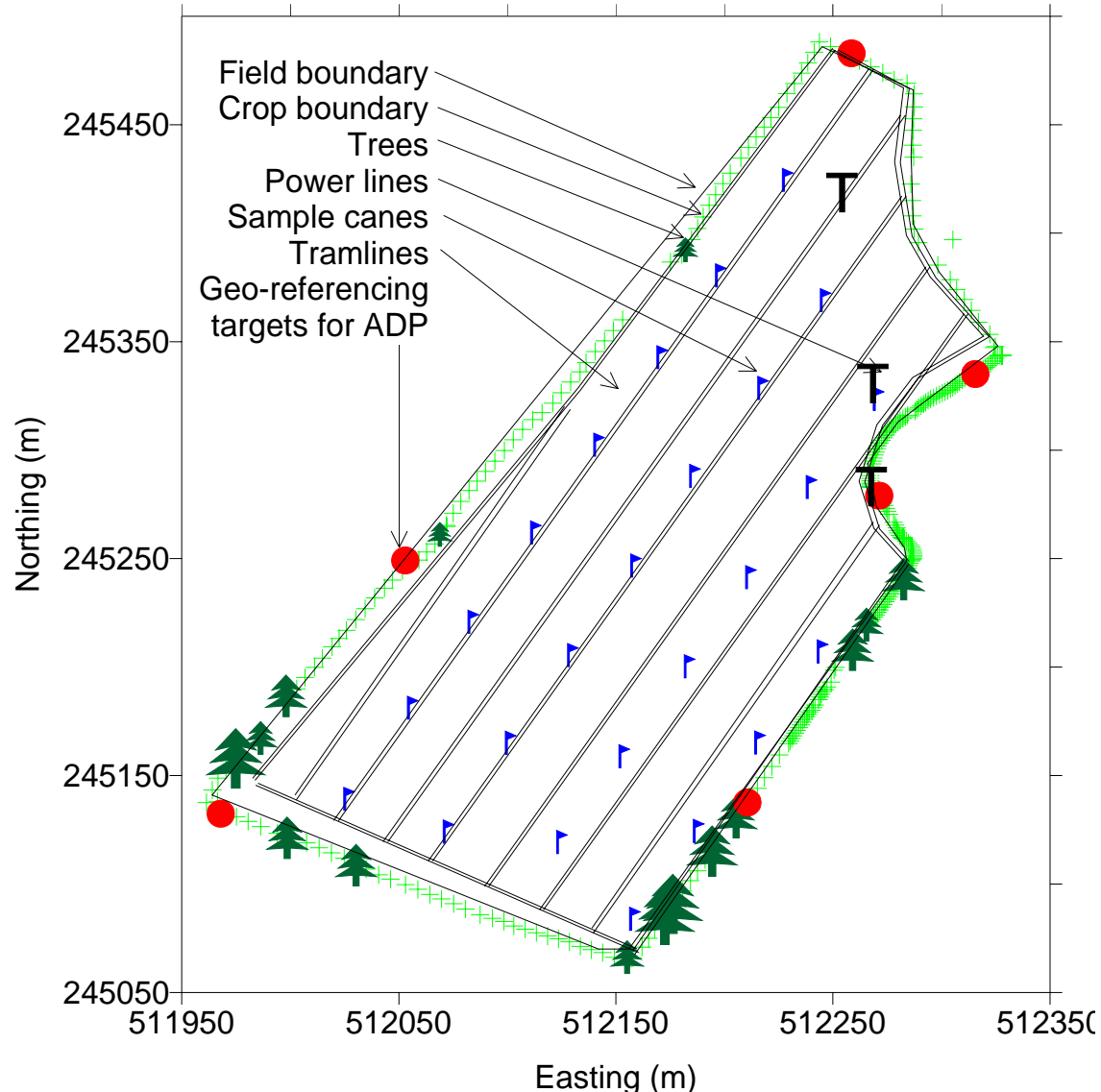
Maps as management tools

- Yield maps show the actual result
 - After harvest (historic)
 - Too late to do anything this year
 - Quantify spatial and temporal variability
- Crop, soil, weed and 'experience' maps
 - During the growing season
 - Show quantity and quality of variability.

DGPS – RTK GPS Positioning **KVL** AgroTechnology



Inventory through field walking



Rapid assesment of soil properties

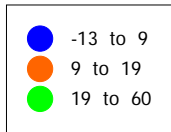
Geonics EM38

- Non contact soil measurement
- Soil conductivity (mS/m)
- Surrogate (indirect) measurement

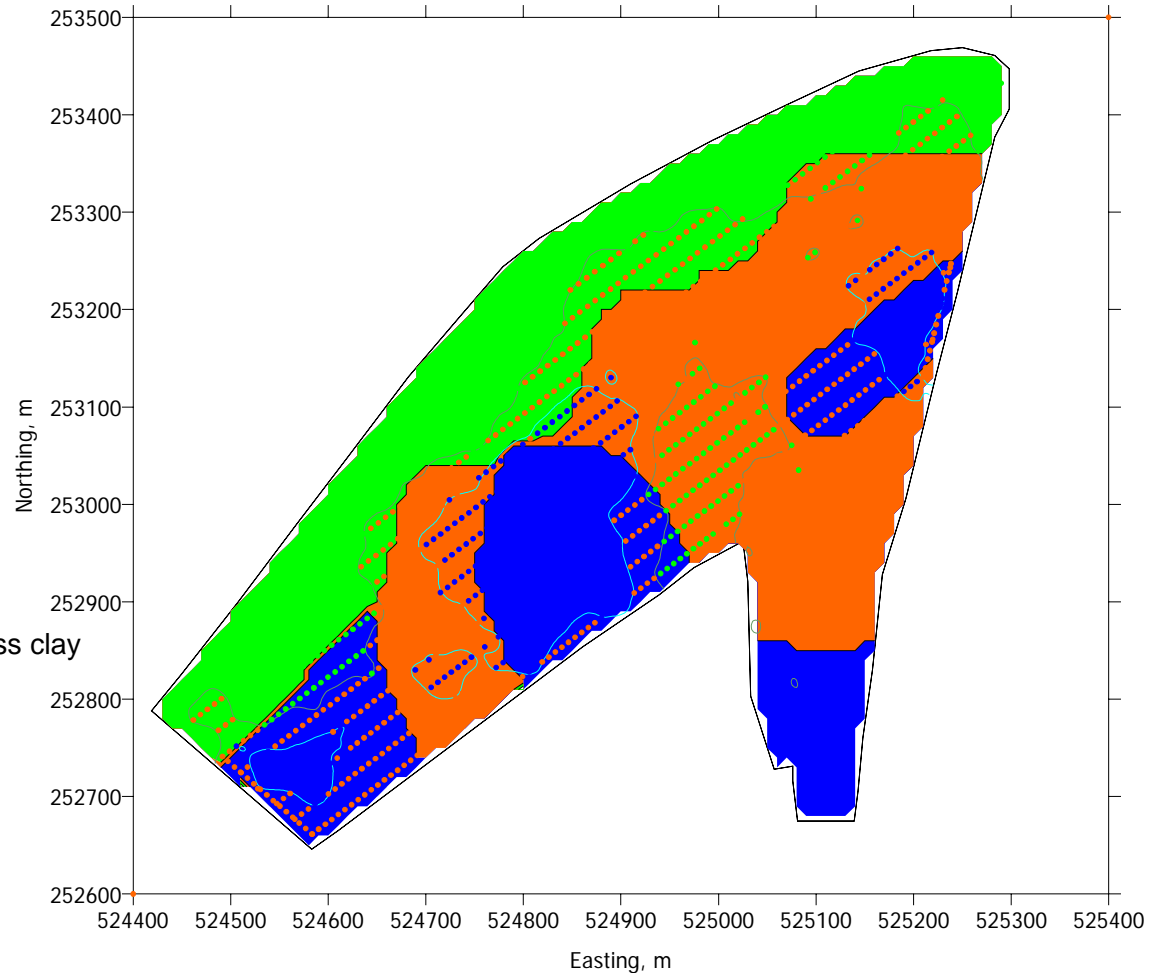
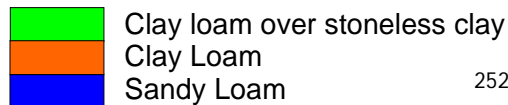


Apparent conductivity with classified soil types

EM Soil conductivity
 mS/m, surveyed by Toby Waine

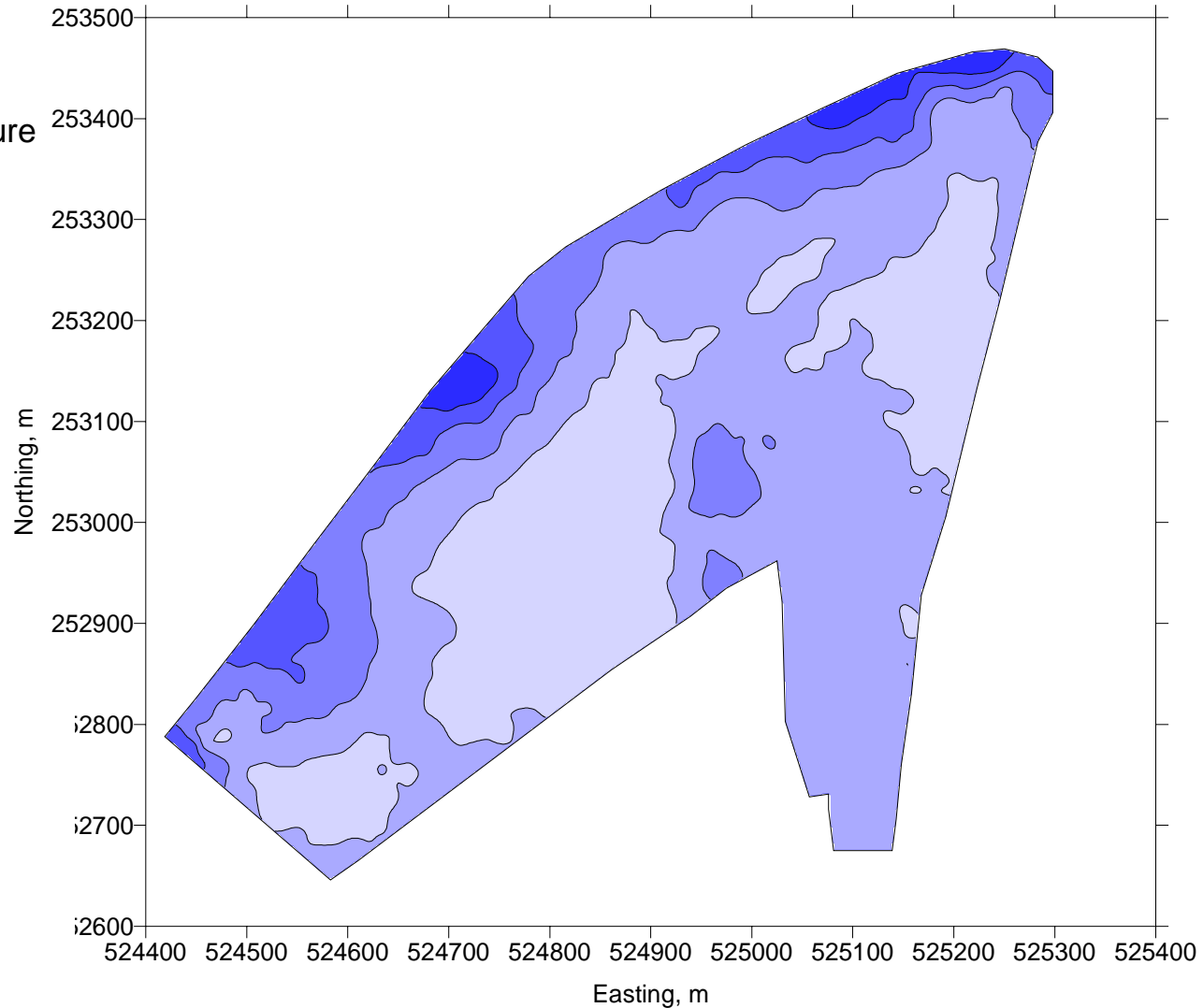
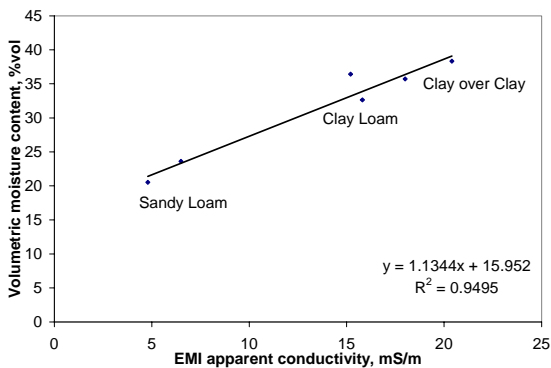
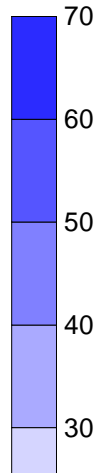


Surveyed by Ian Bradley SSLRC

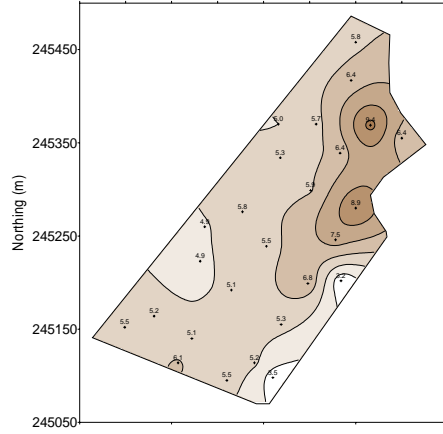


Volumetric moisture content

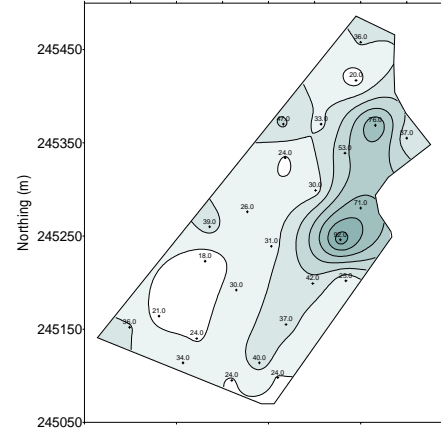
Volumetric moisture content, %vol



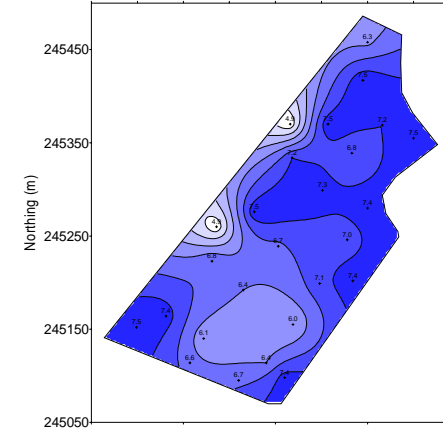
Soil Maps



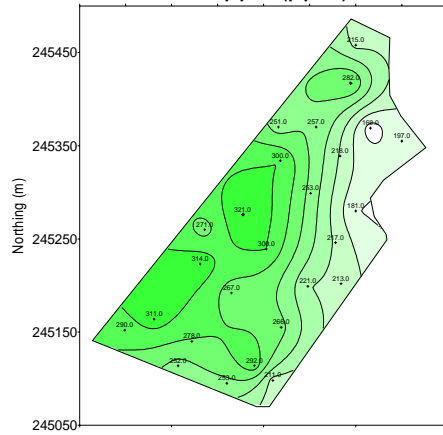
Plot of Copper(ppm)



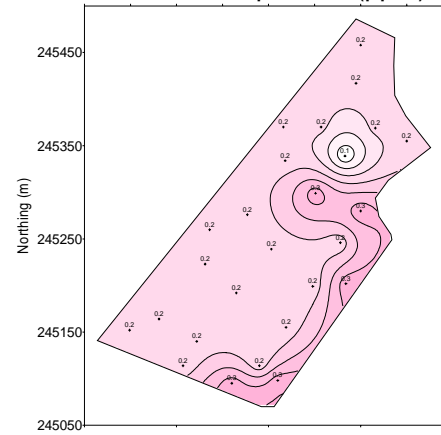
Plot of Phosphorous(ppm)



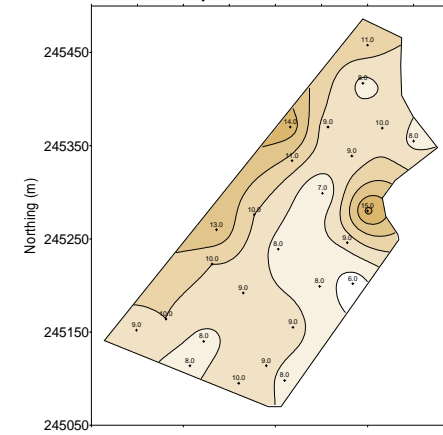
Plot of pH



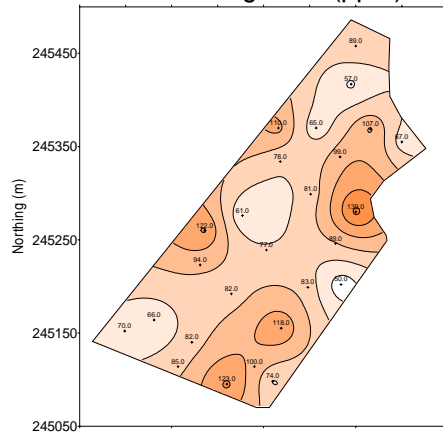
Plot of Manganese(ppm)



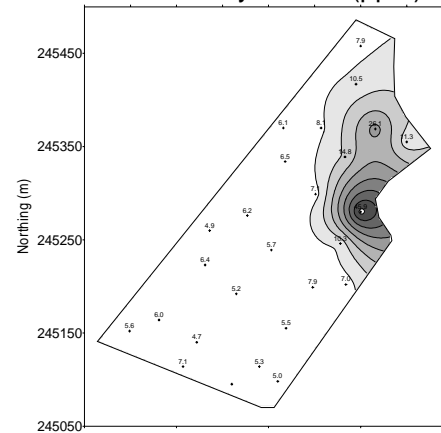
Plot of Molybdenum(ppm)



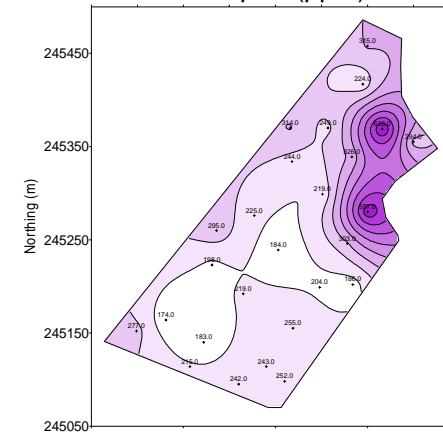
Plot of Sulphur(ppm)



Plot of Magnesium(ppm)

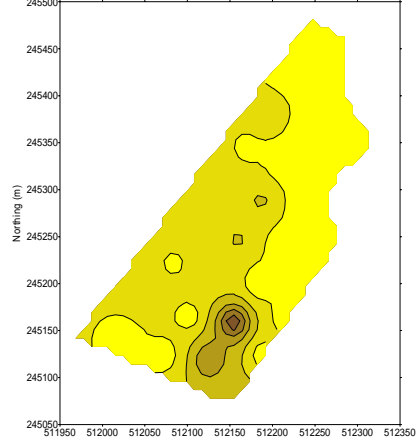


Plot of Zinc (ppm)

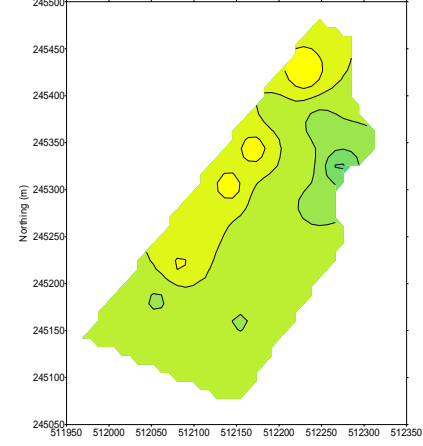


Plot of Potassium(ppm)

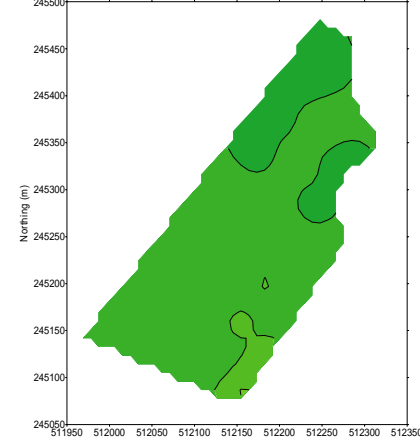
Tissue maps (Data)



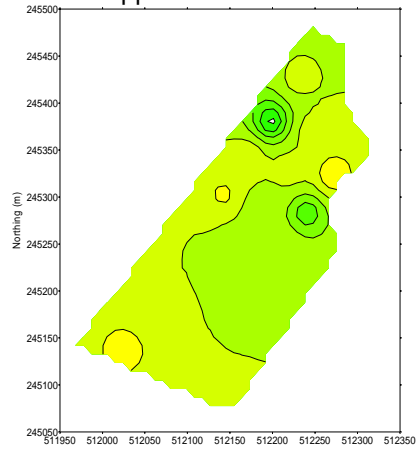
Copper



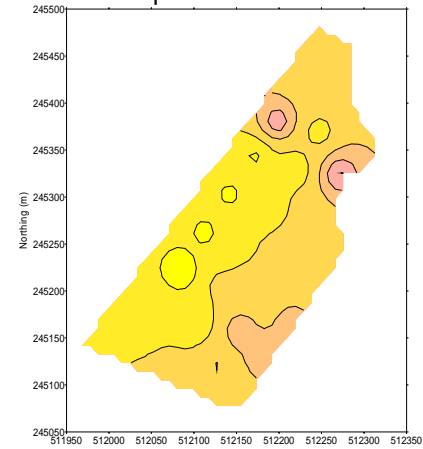
Phosphorous



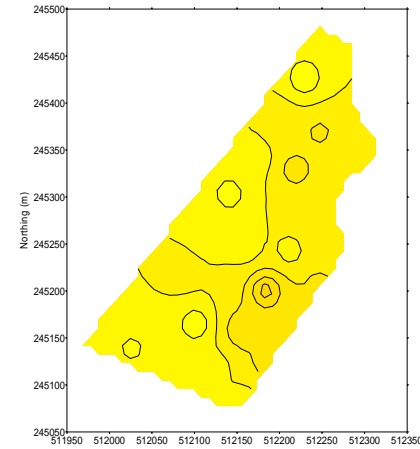
SPAD



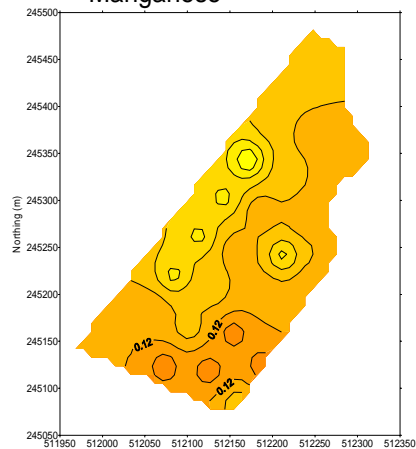
Manganese



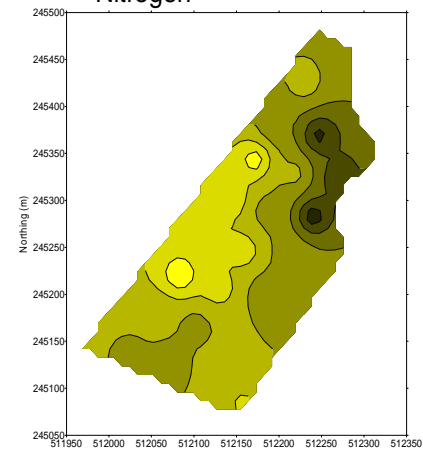
Nitrogen



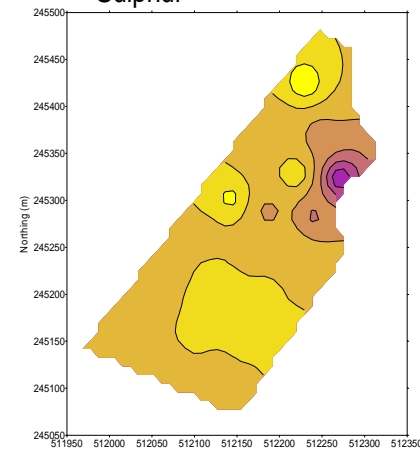
Sulphur



Magnesium

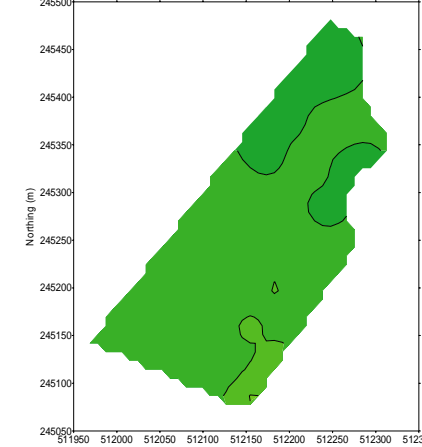
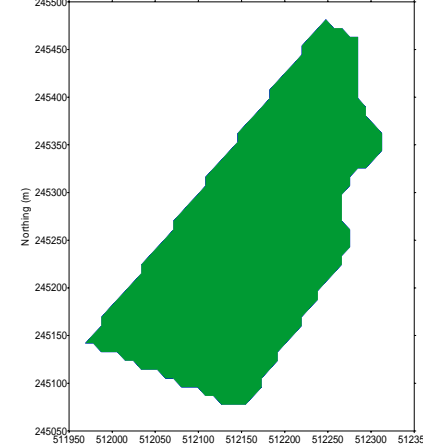
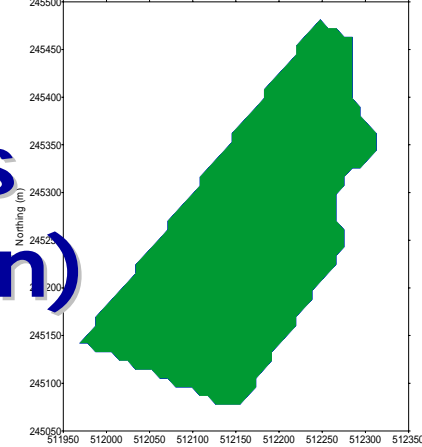


Zinc



Potassium

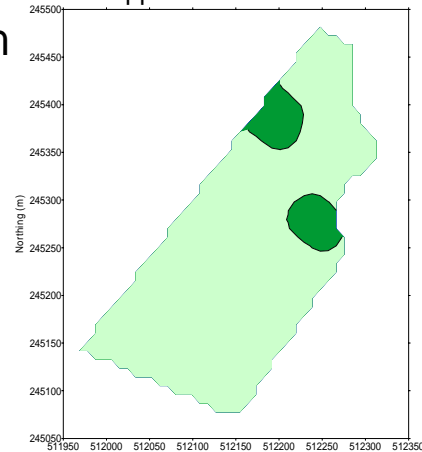
Tissue maps (Information)



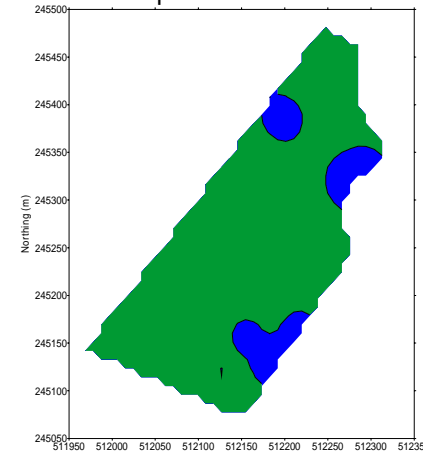
Plant Tissue Maps with
Expert Classification
Far SweetBrier,
Shuttleworth, Beds.

- High
- Normal
- Slightly Low
- Low
- Very Low

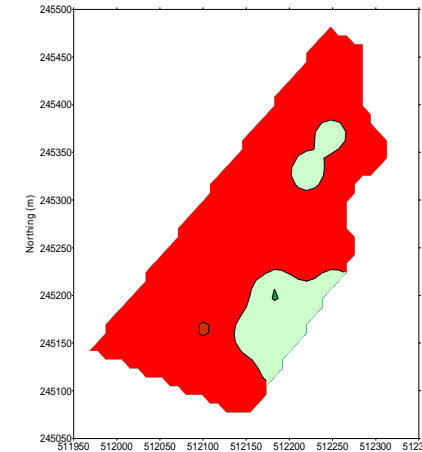
Copper



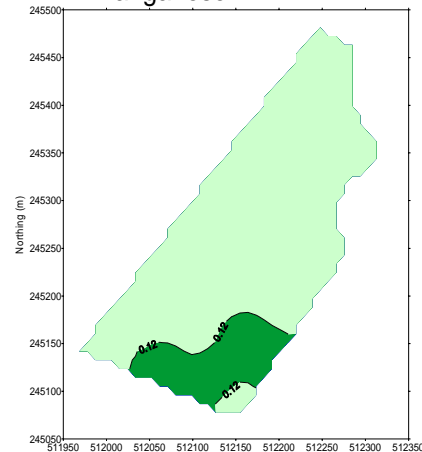
Phosphorous



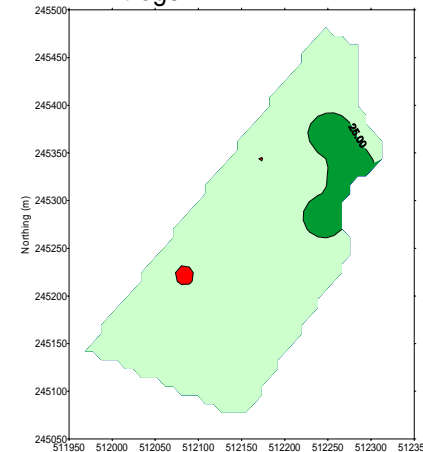
SPAD



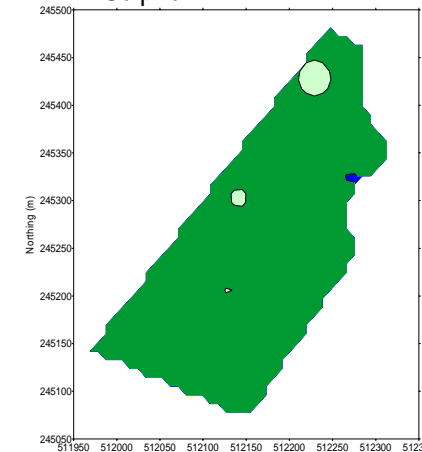
Manganese



Nitrogen



Sulphur

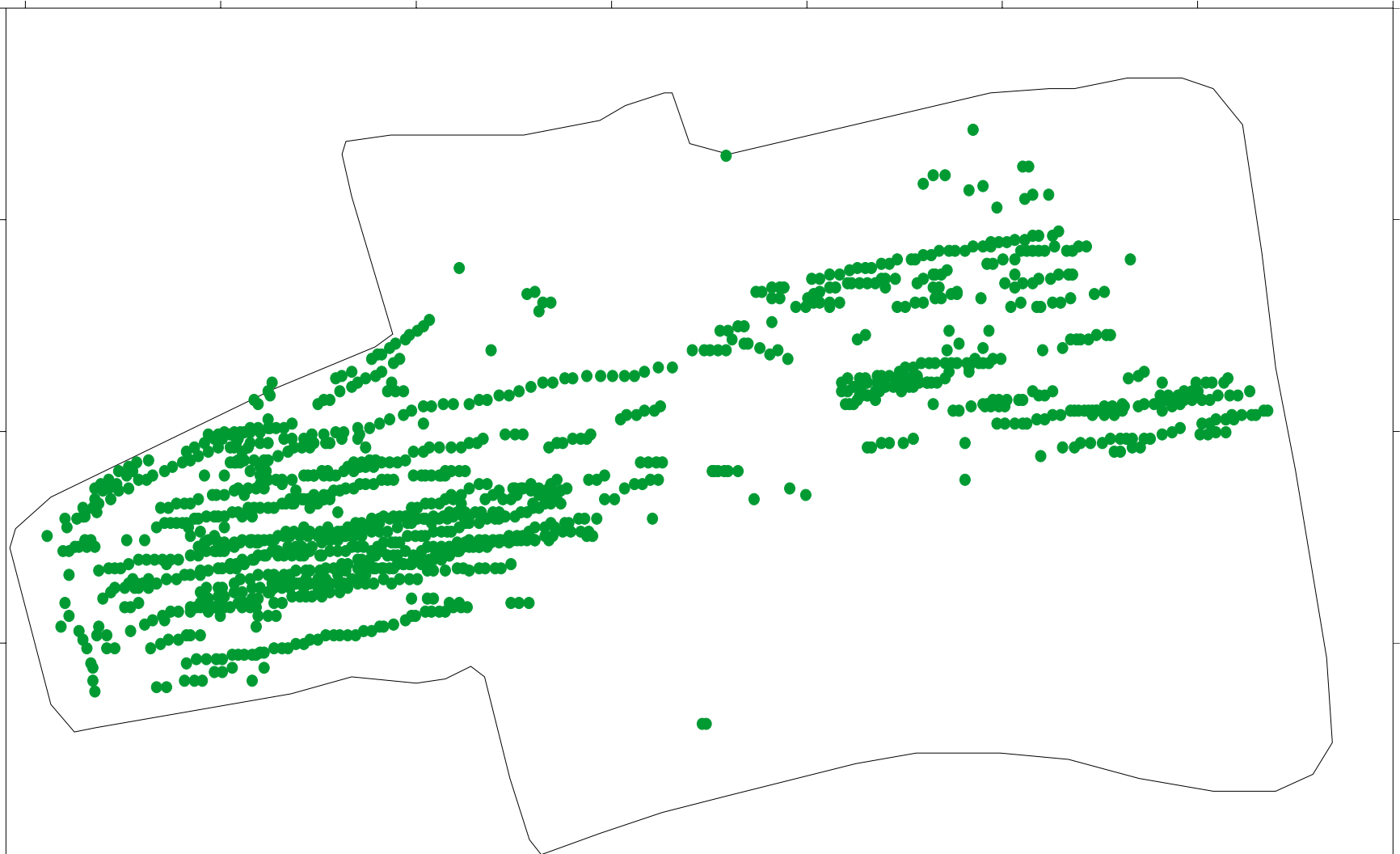


Spatially variable weed distribution



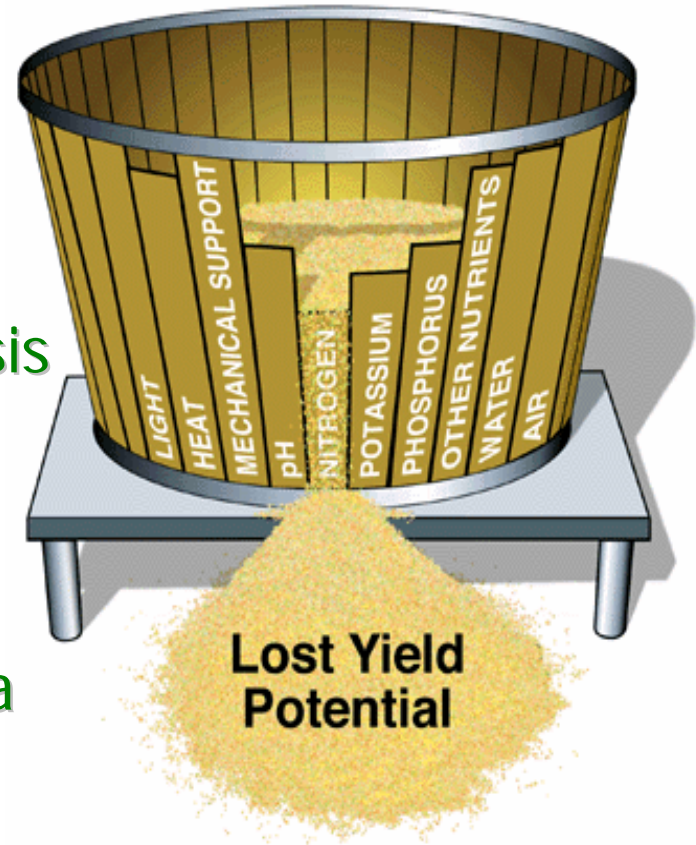
Thanks to Paul Miller

Weed map (wild oats) Big field, Shuttleworth 1994



What are the reasons for the variability?

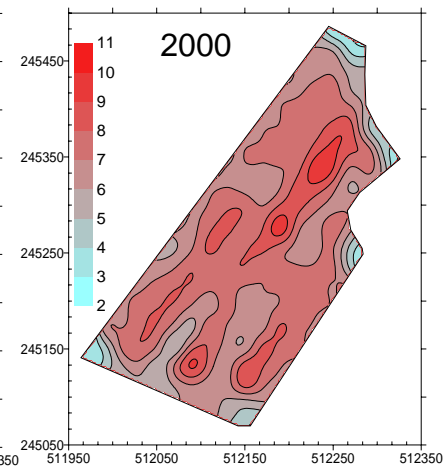
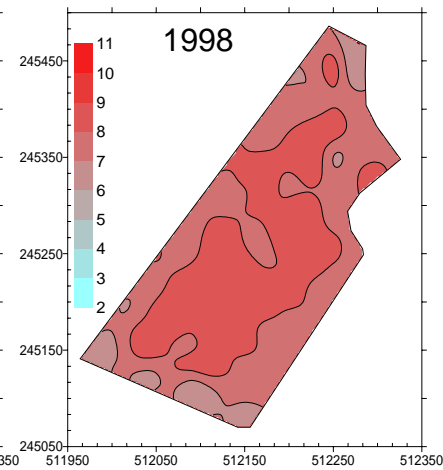
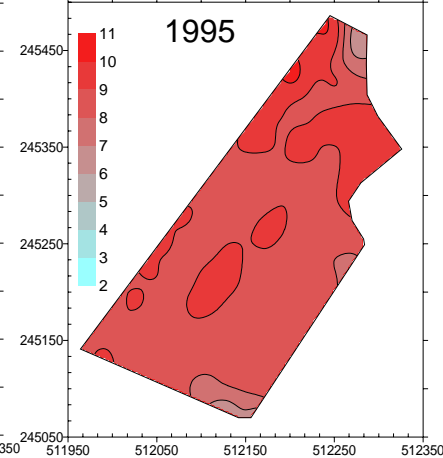
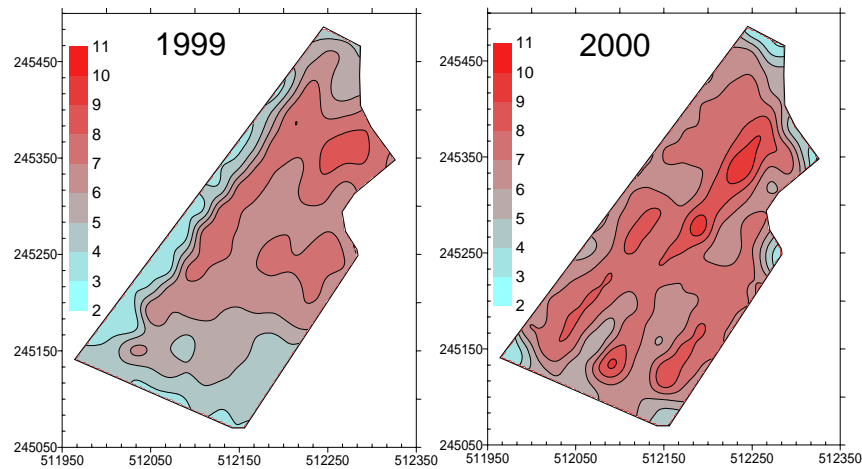
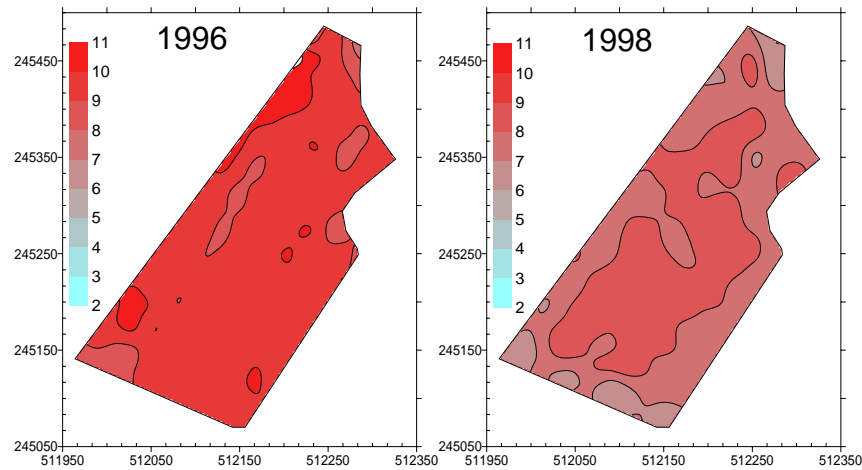
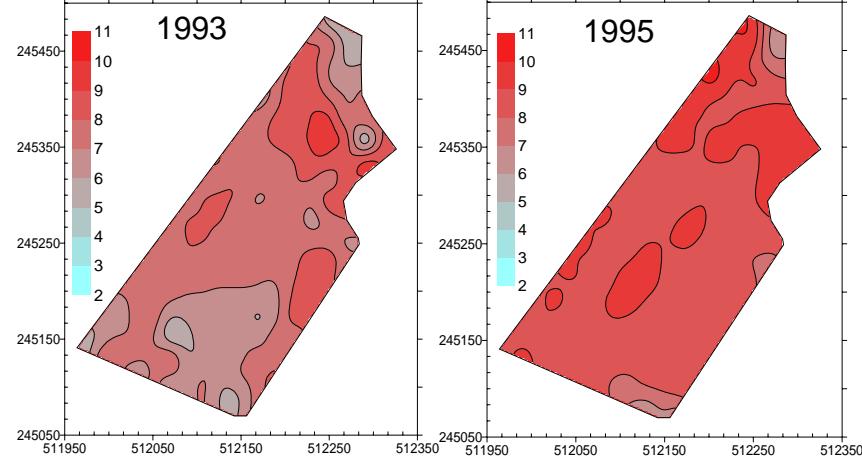
- Any one of many crop environment features
 - All interacting
- Practical and agronomic analysis is required
- Geostatistical techniques can help the analysis
- A start can be made by using a GIS
 - Look for spatial trends
 - Look for temporal trends.



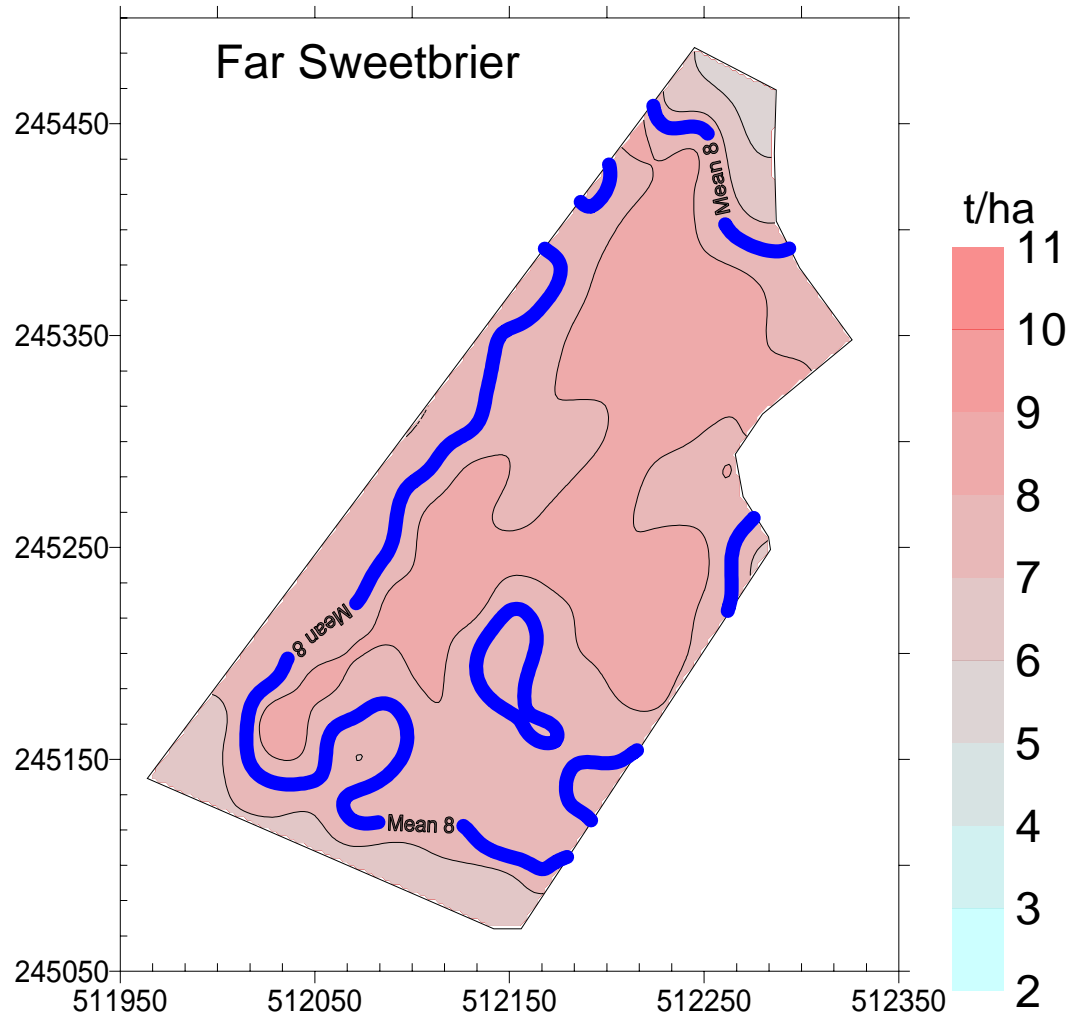
Understanding variability

- Spatial trends
 - Remove temporal effects
 - Shows consistent high and low yielding areas
- Temporal stability
 - Shows areas that do not change from year to year
 - (and those that do).

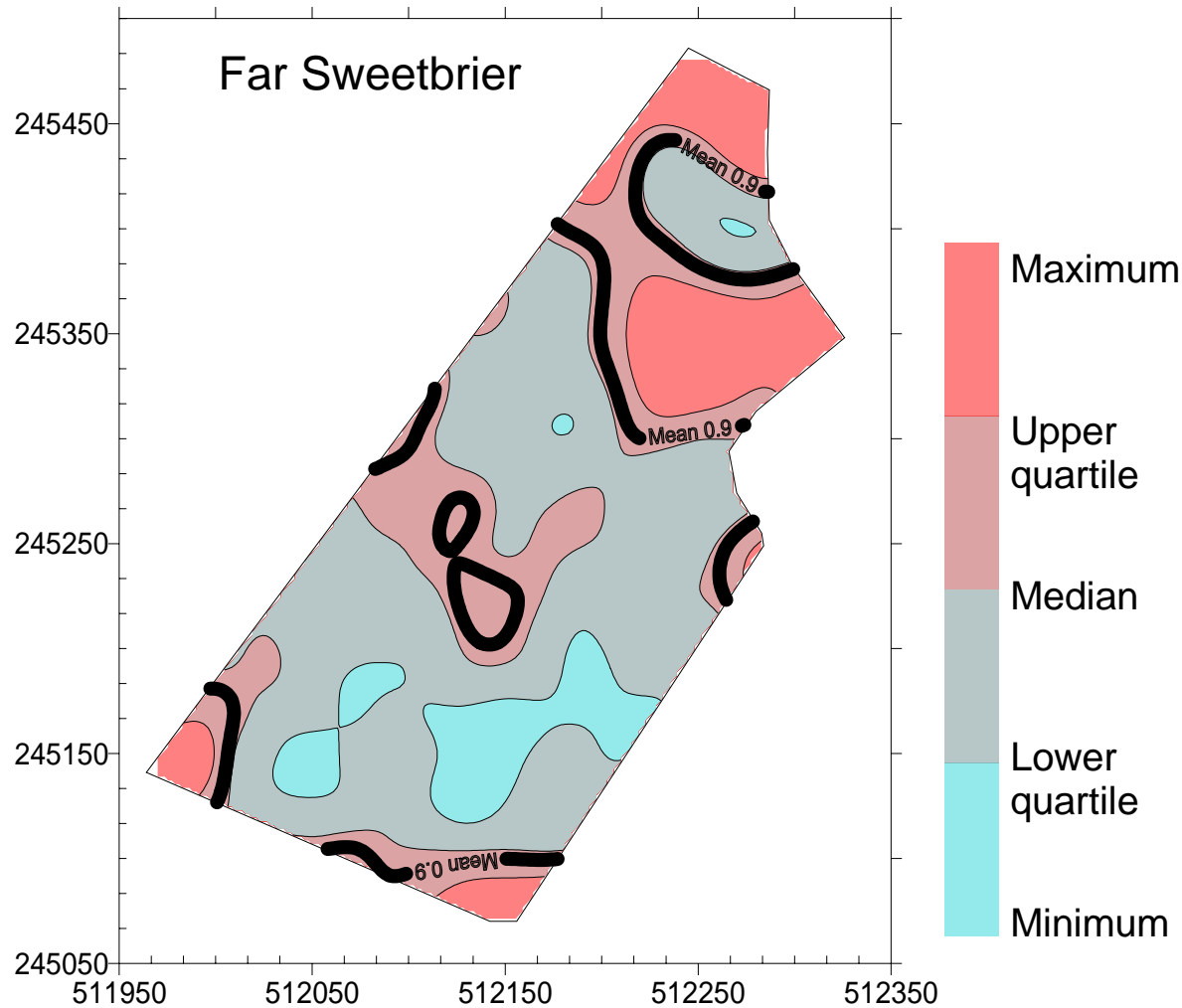
Yield maps Winter wheat 1993 - 2000



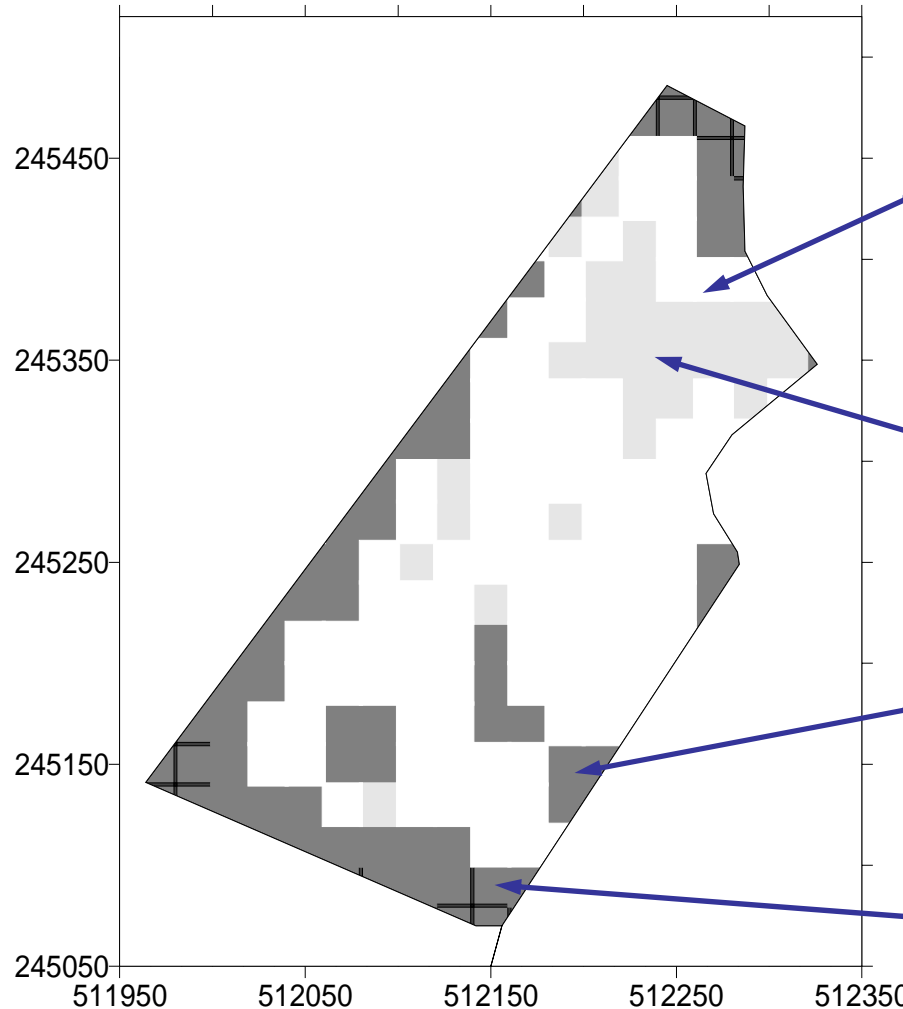
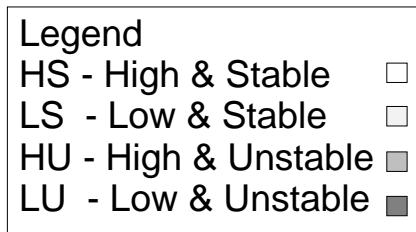
Yield – Spatial trend map 1993-2000



Yield – Temporal variance 1993 - 2000



Spatial – temporal trend map 1993 - 2000



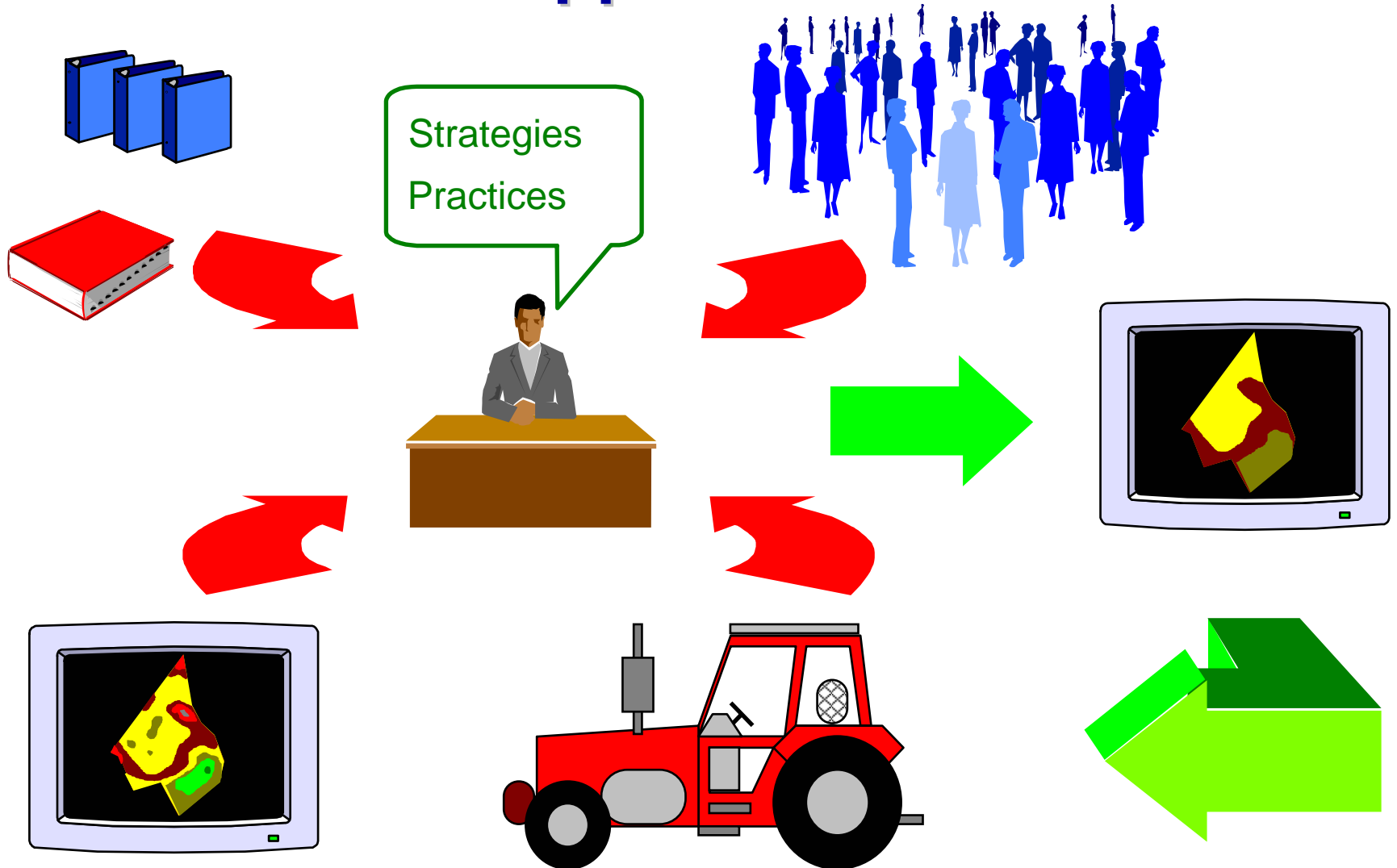
High Yielding
& Stable
€1200

Low Yielding
& Stable
€500/ha

High Yielding
& Unstable
€670/ha

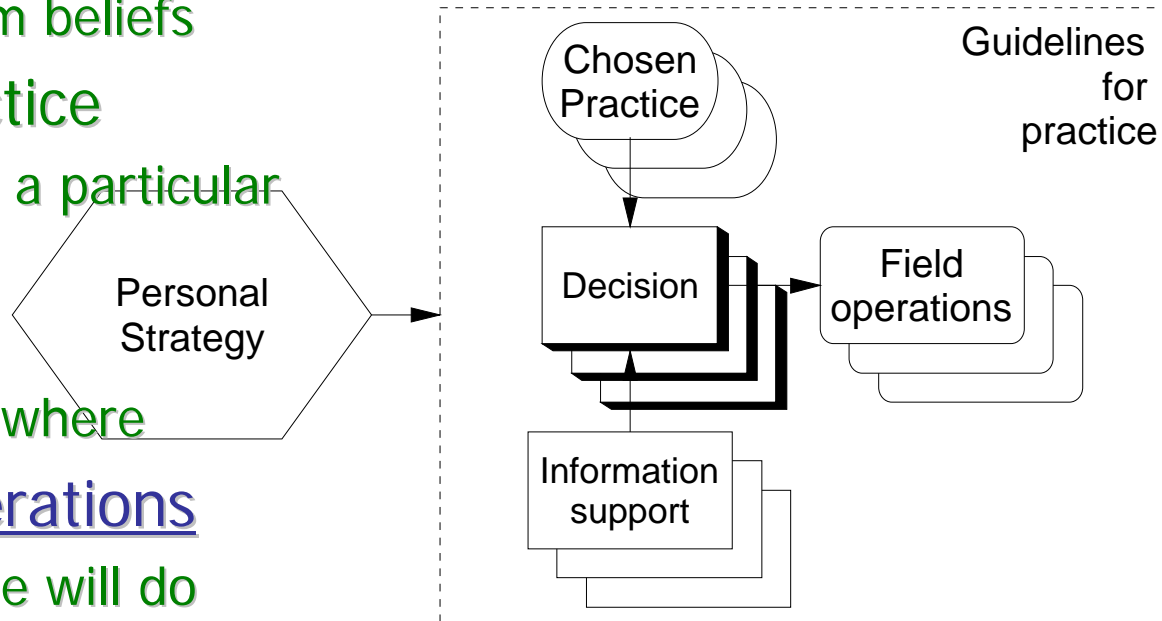
Low & Unstable
€330/ha

Decision Support Systems must support decisions!

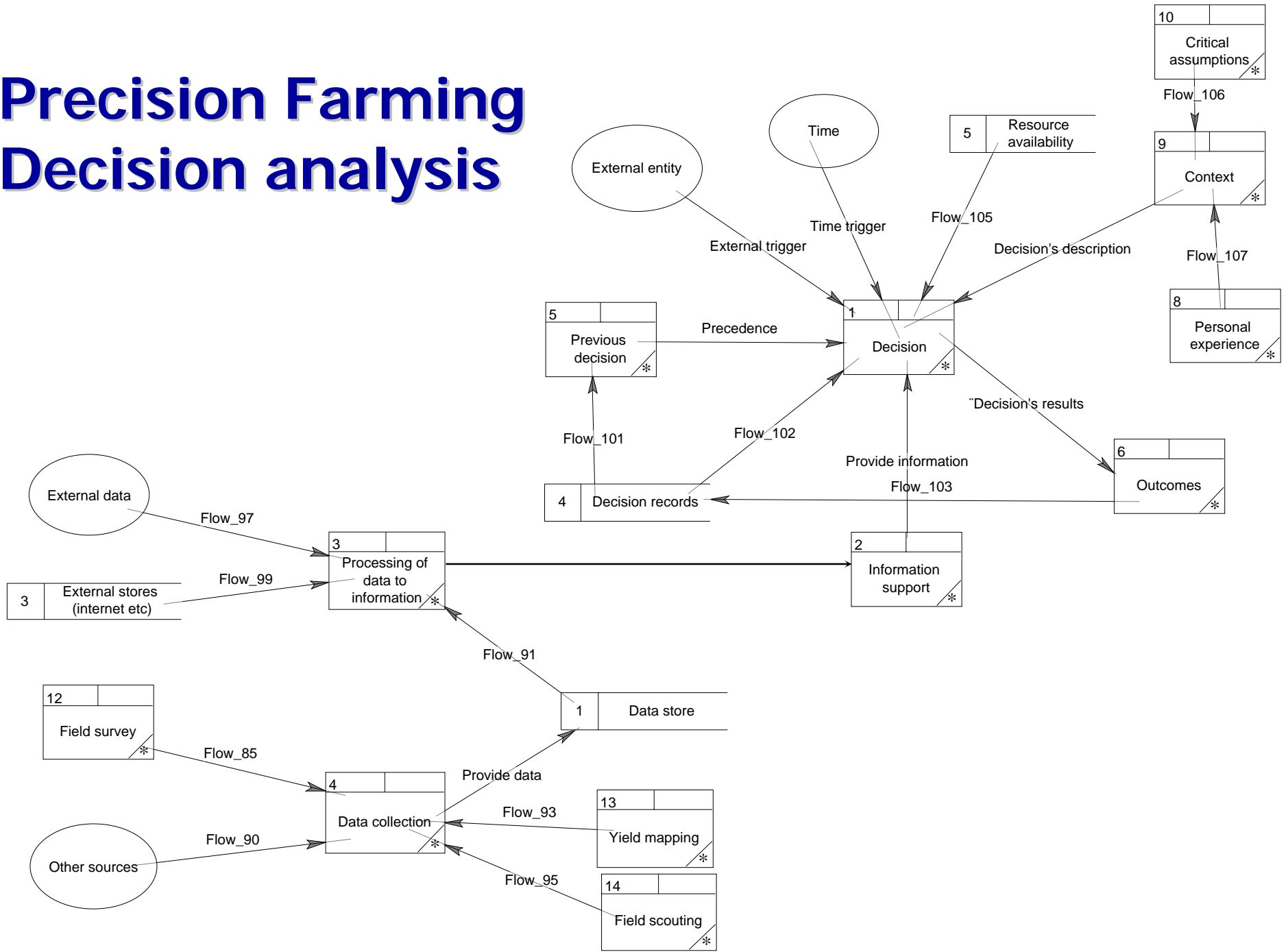


Precision Farming Management

- Personal strategies
 - Reflects long term beliefs
- Chosen field practice
 - How to deal with a particular field
- Decision
 - What to put and where
- Variable field operations
 - What the machine will do
- Information Support
 - To help with the decision.



Precision Farming Decision analysis



Operational practices

- Seeding
 - Soil protection
 - Varietal mix
 - Seed density
 - Maximized yield
 - Maximized return
- Fertilizer
 - Replenishment
 - Nutrient balance
 - Organic
 - Maximized yield
 - Maximized return
- Spray
 - Maximized protection
 - Minimum operations
 - Minimum inputs
 - Maximized yield
 - Maximized return
- Cultivation
 - Soil protection
 - Minimum tillage
 - Selective cultivation

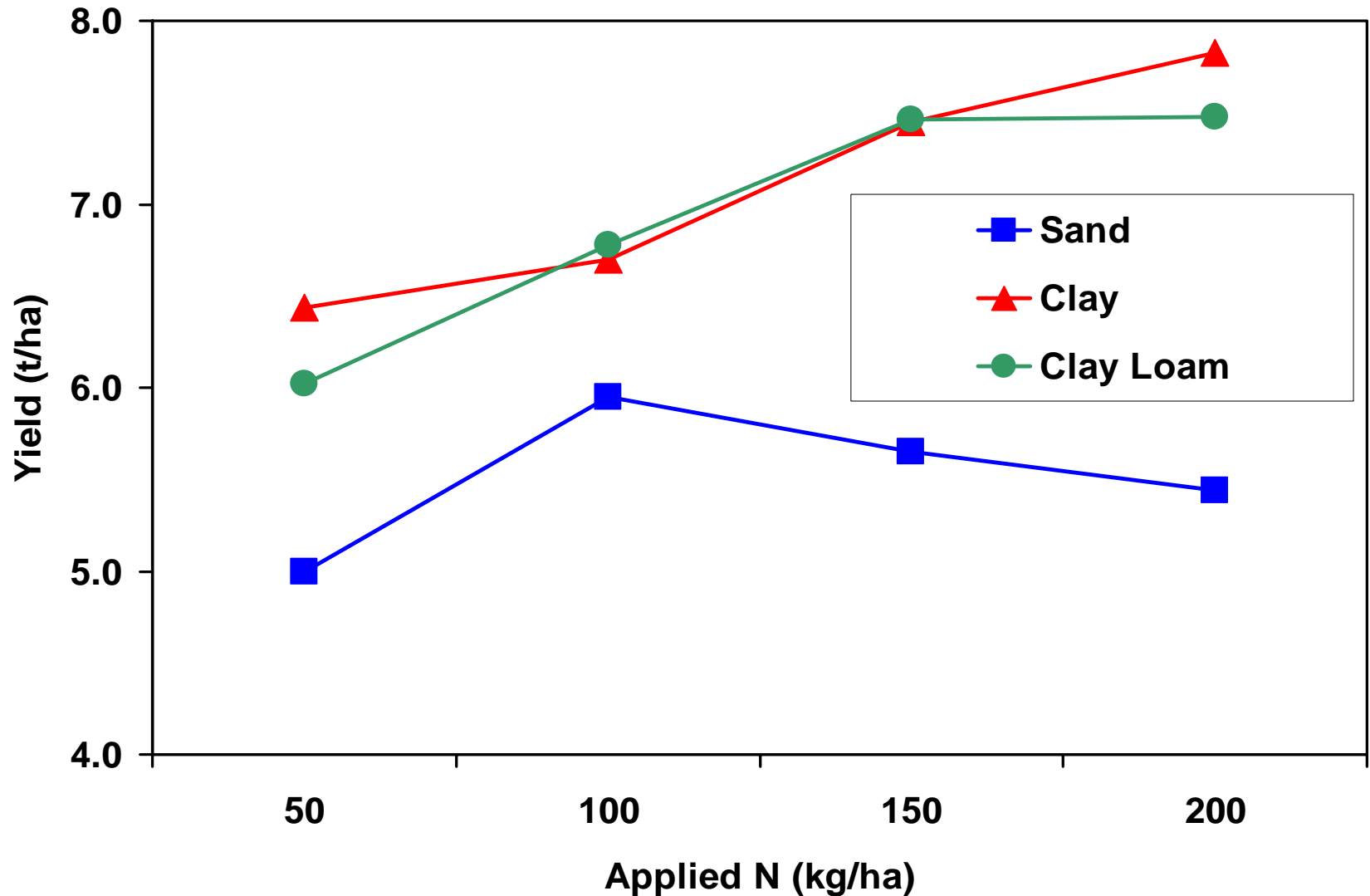
Question

- Do you put more fertilizer on a low yielding area or less?

Answer - It depends!

- If it is limited by fertilizer
 - put on **more** fertilizer
- If it is not limited by fertilizer
 - and you are not going to change the limiting factor
 - put on **less** fertilizer!

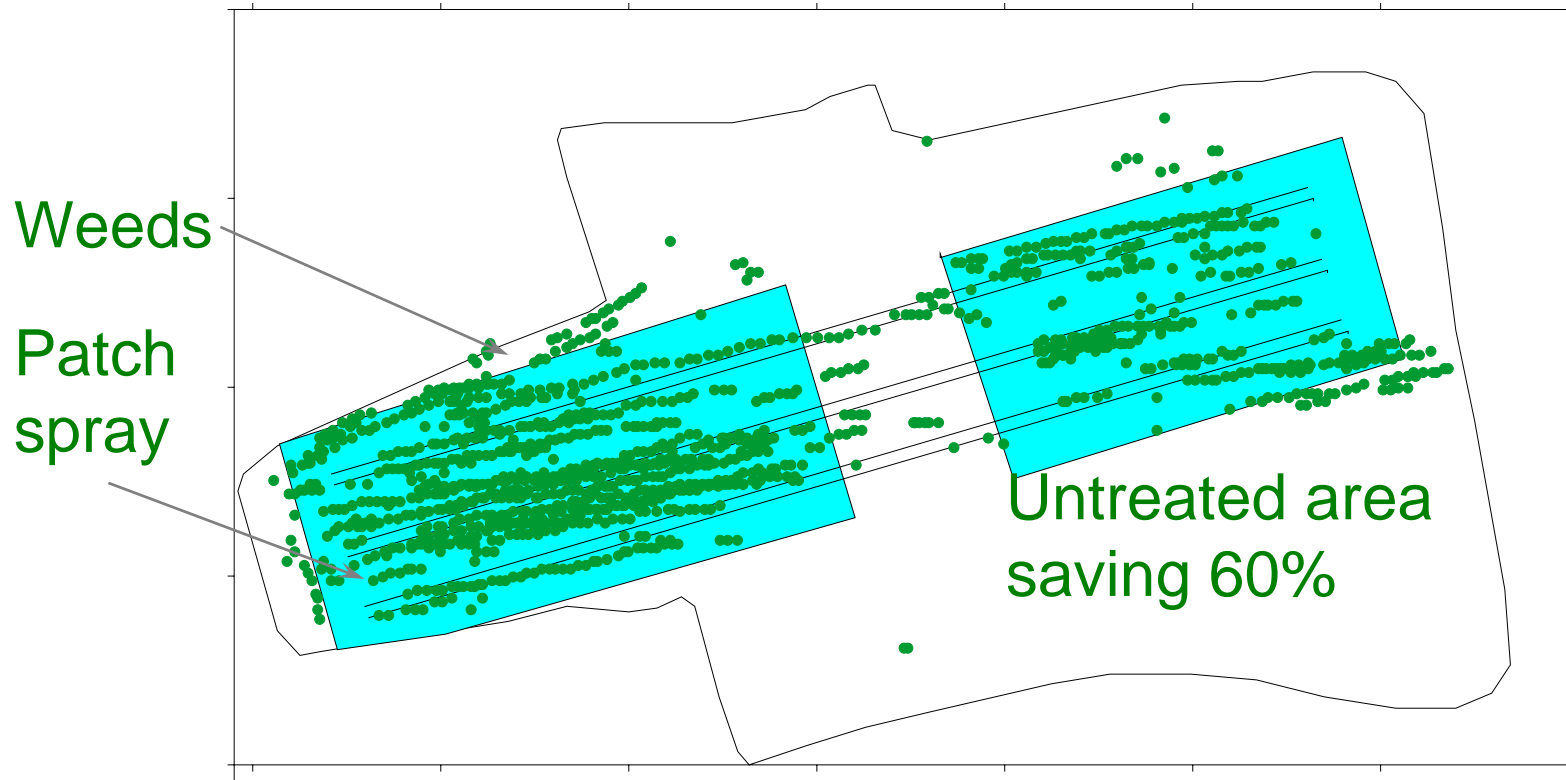
Spatial variation of N response in same field



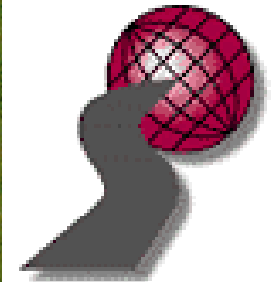
Treatment maps

- The treatment can be anything from fertilizer application to subsoiling depth
- The treatment map defines:
 - The precise *location* of the treatment
 - The precise *quantity* of the treatment
 - The precise *timing* of the treatment
- Each unit can be identified uniquely and treated uniquely.
- The treatment map can be used to show good practice.

Herbicide application map



Silsoe Research Institute patch sprayer



Spatially variable fertiliser distributor



Pneumatic fertiliser spreader



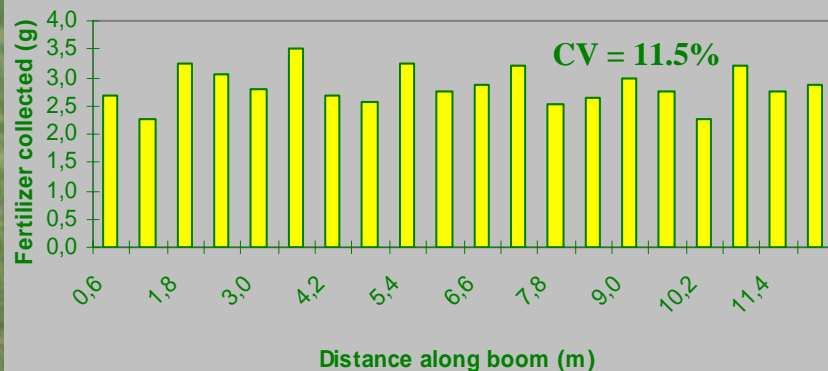
Kuhn 2224 Aero Spreader

Longitudinal

Accuracy of Application (CV%)

Site	Mean	Range
Trent Field, Andover	7.7	2.9 - 11.1
12 Acres, Cirencester	14.2	12.5 - 17.3
Far Sweetbriar, Shuttleworth	8.3	5.5 - 12.8

Kuhn 2224 Aero Spreader
Lateral Fertilizer Distribution (24m configuration)



Spatially variable seed drill and seed density trial results

