Agricultural land-use from space

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Talk Outline

Legend for land use/timing classes

- ■ Pasture - irrigated
- ■ Pasture - dryland (and newly-planted pasture)
- ■ Crop planted early autumn (e.g. grain; or brassica/grass/clover seed)
- ■ Crop planted late autumn (e.g. grain crop or grass seed)
- ■ Crop planted winter (e.g. grain crop)
- ■ Crop planted spring (e.g. grain, peas, brassica seed)
- ■ Crop planted summer, short peak (e.g. potatoes)
- ■ Crop planted summer, long peak (e.g. maize for silage)
- ■ Winter livestock forage - just planted Nov-Dec
- ■ Bare soil (Nov-Jan)
- ■ Unknown
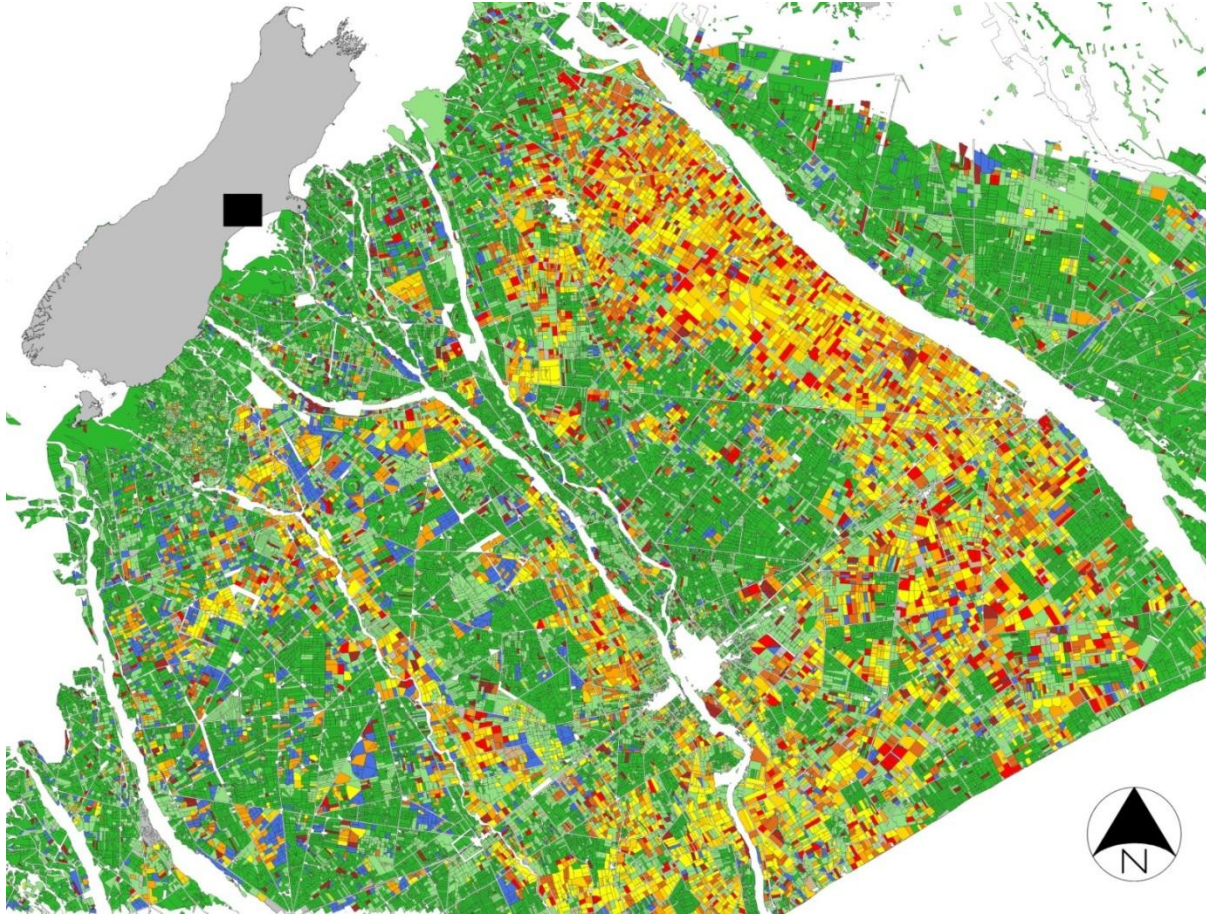
Kilometres

5   0

- Motivation
- Challenges
- Different approach
- Paddock boundaries
- Classifications
- Examples
- Accuracy
- Issues
- Data sources
- Future possibilities

Motivation

Environmental modelling

Regional patterns
- Satellite imagery

Agricultural impacts
- Not just cover

Farming practices
- Irrigation, cultivation, fallow, grazing

Regular / routine
- Minimum fieldwork

Changing patterns
- Accuracy at region

Remote sensing classification - components

- **Classification of content to a set of classes**
  - often pixels
  - paddocks better

- **Analysis of image features**
  - spectral characteristics
  - but also texture, context, shape

- **Using a set of rules**
  - often statistical model

- **Training**
  - Individual images, spectral libraries, rule libraries
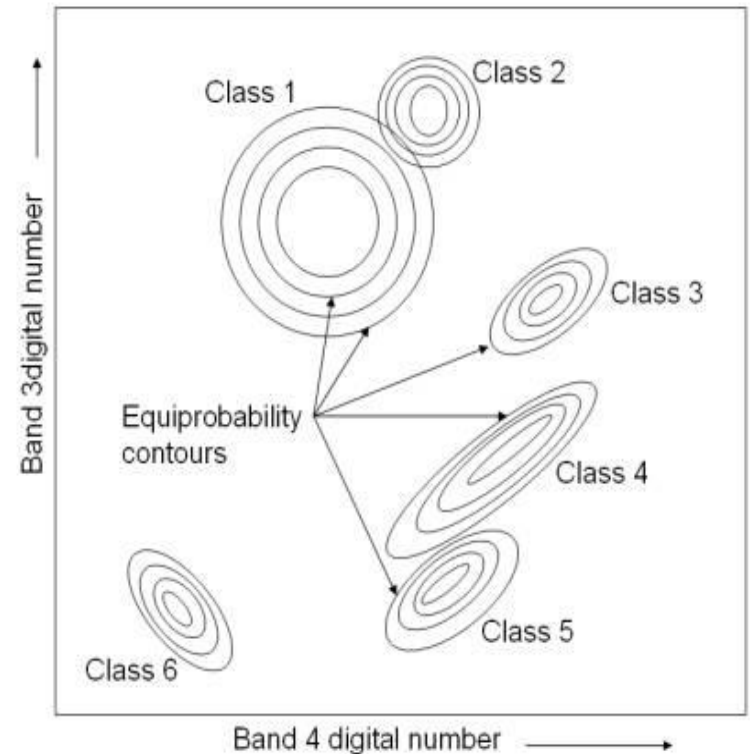
Challenge - variety of crops including…

- Barley
- Borage
- Carrots
- Clover
- Grass
- Kale
- Lucerne
- Oats
- Onions

- Peas
- Potatoes
- Radish
- Rapeseed
- Ryecorn
- Triticale
- Turnips
- Wheat

Most of these crops have multiple uses, e.g.

Grass – pasture, seed
Oats – grain, winter forage
Carrots – fresh, seed
Kale – winter forage, seed

Potatoes, turnips, pasture, clover, and lucerne are not spectrally separable at some stages of their growth cycles
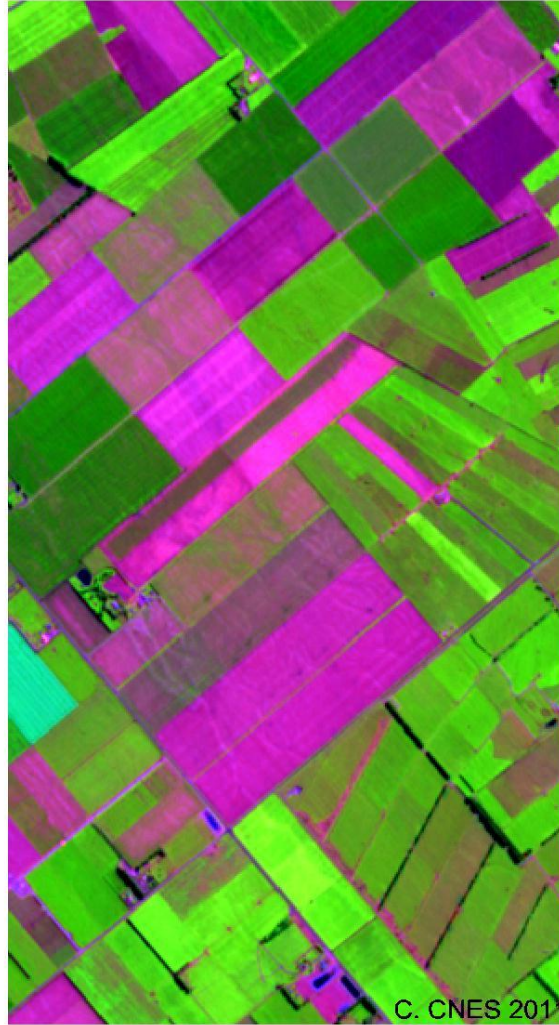
Potatoes can look very different at various stages through their growth cycle

Time series of satellite images

22-August-2011   17-October-2011   25-December-2011

C. CNES 2011   C. CNES 2011   C. CNES 2011

Time series of satellite images

22-August-2011   17-October-2011   25-December-2011

Cropping paddocks

Dairy paddocks

C. CNES 2011
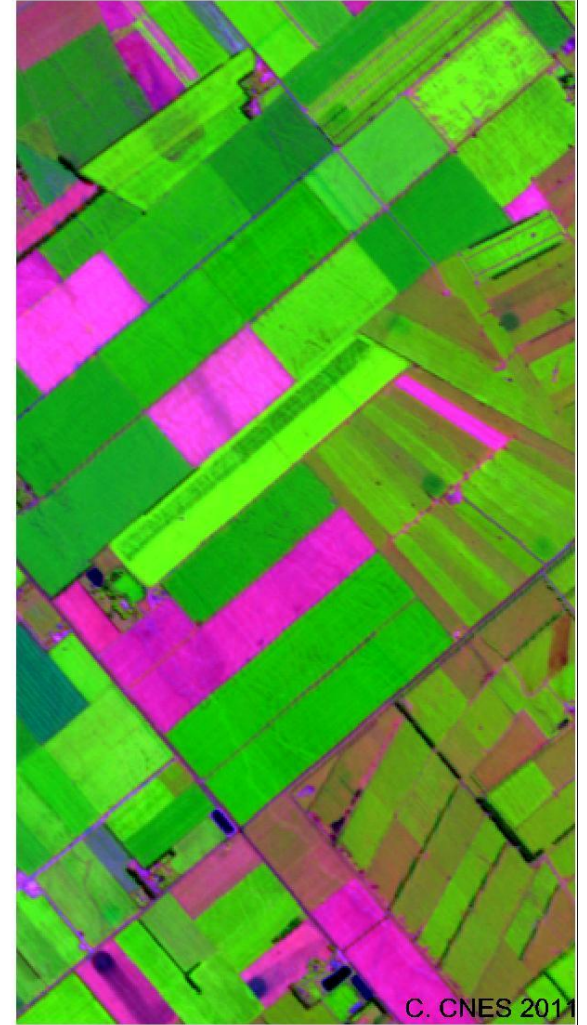
Paddock boundary detection

22-August-2011   17-October-2011   25-December-2011
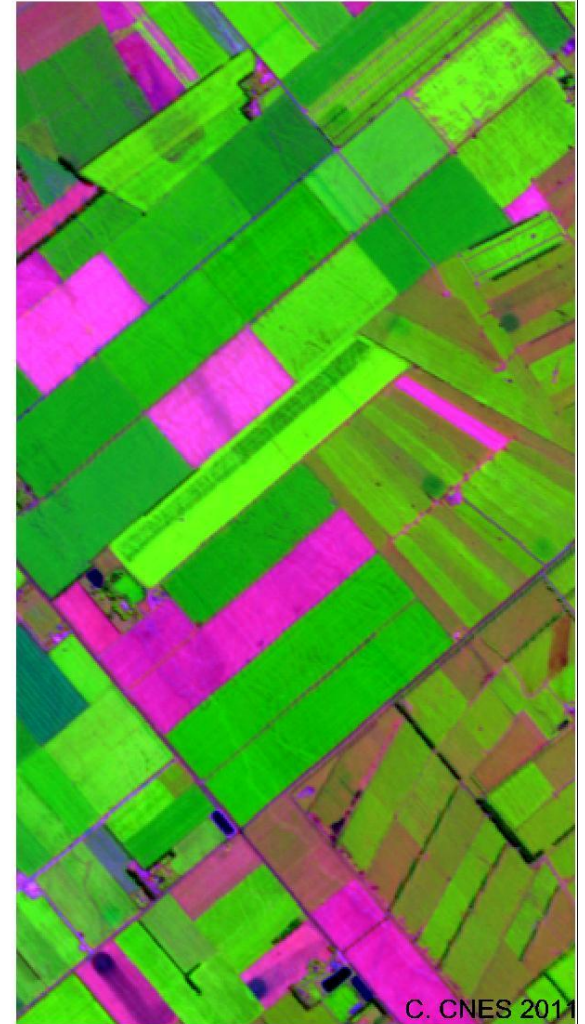
Paddock boundary detection
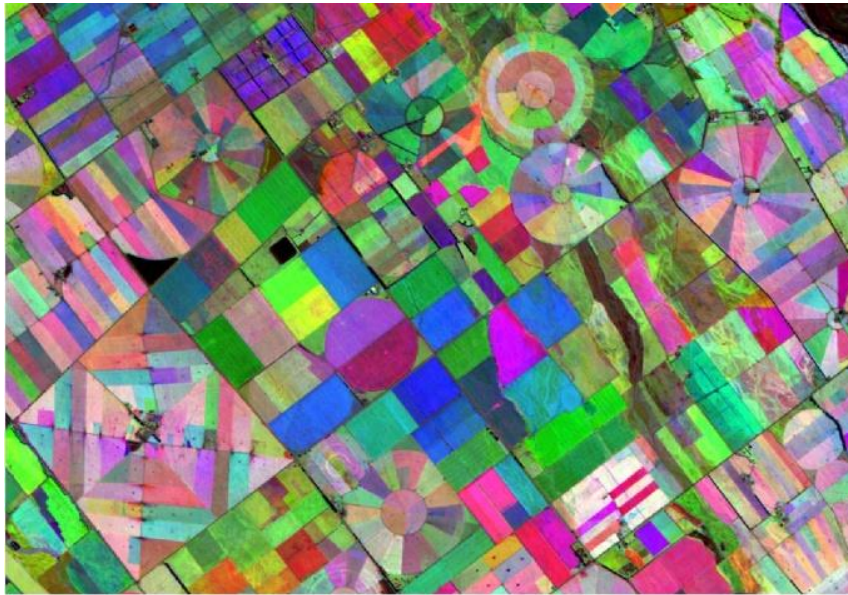
SPOT-5: NIR bands from three image dates
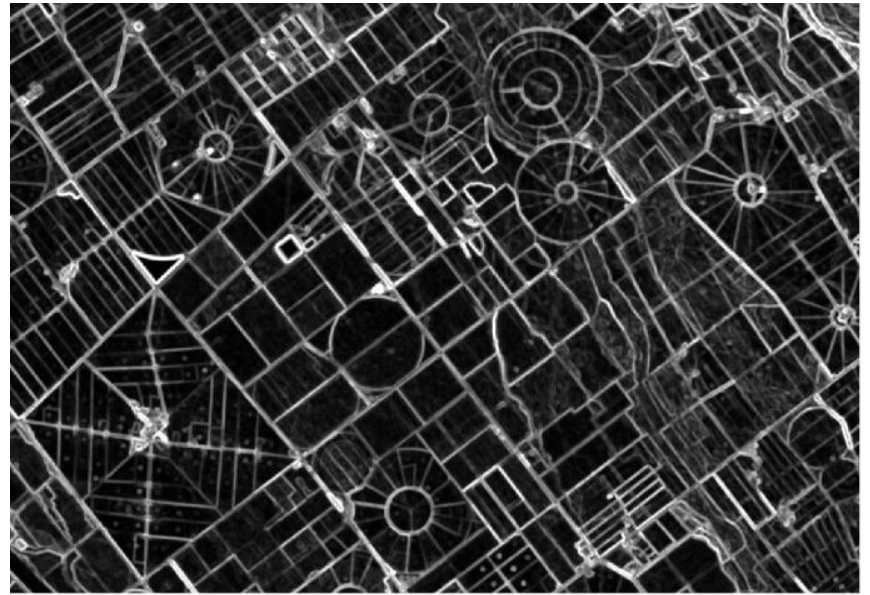
SPOT-5: Average SD of three dates in (a)

Stack of 3-9 images throughout period of interest

Standard deviation enhances boundaries

Polygon coverage and cleaning
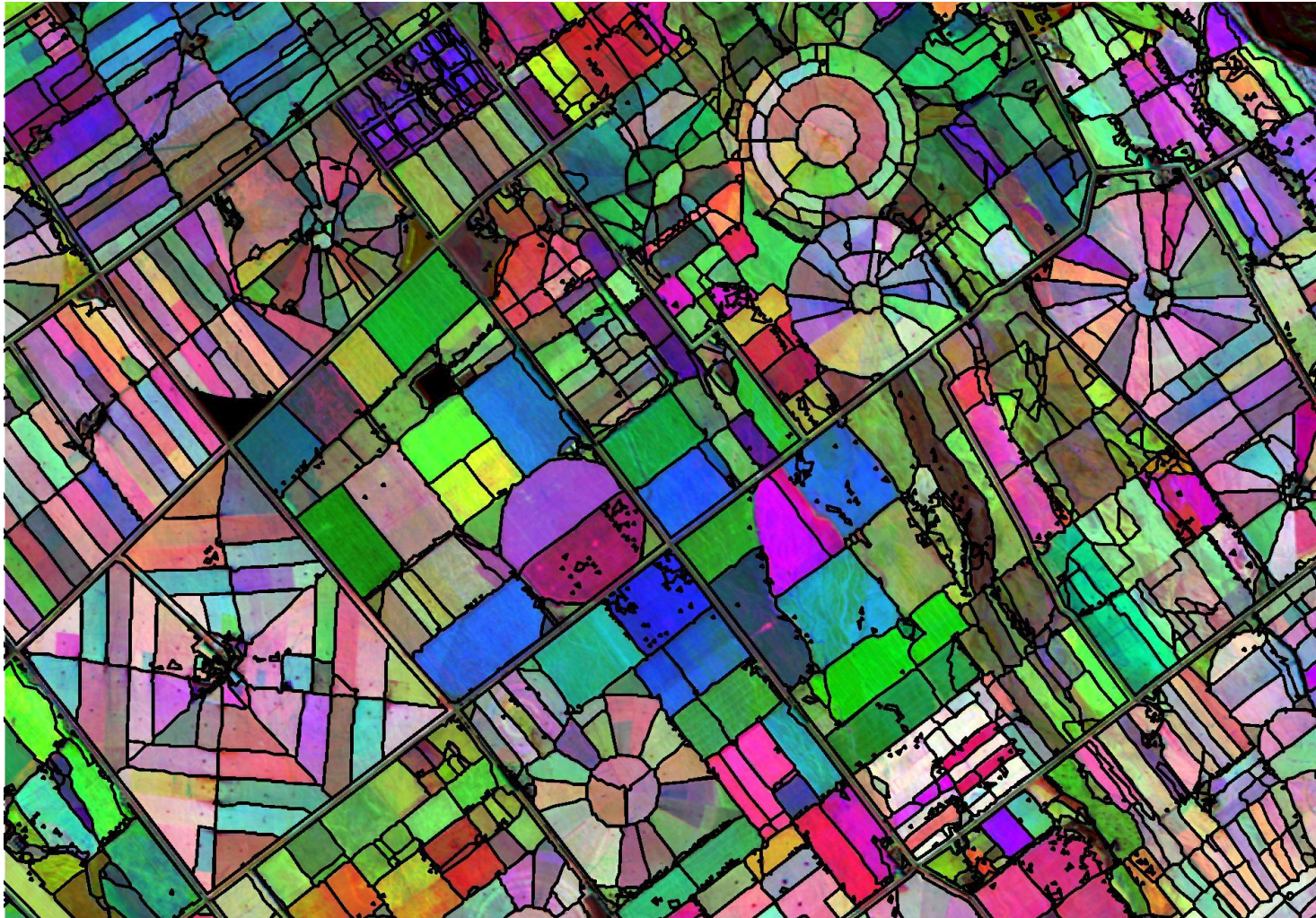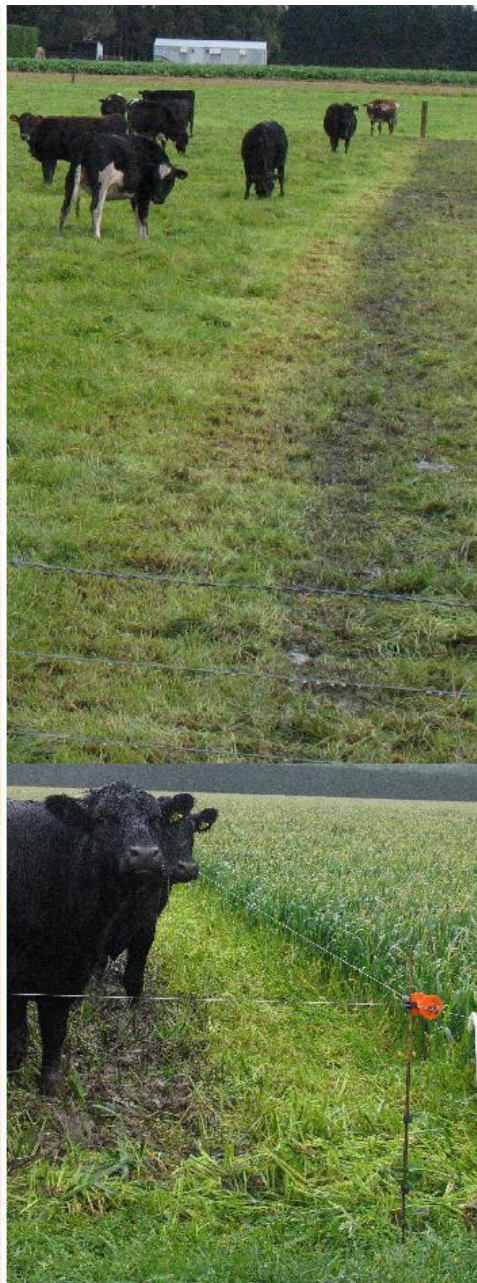
Broad land use types for summer classification (16-Dec)
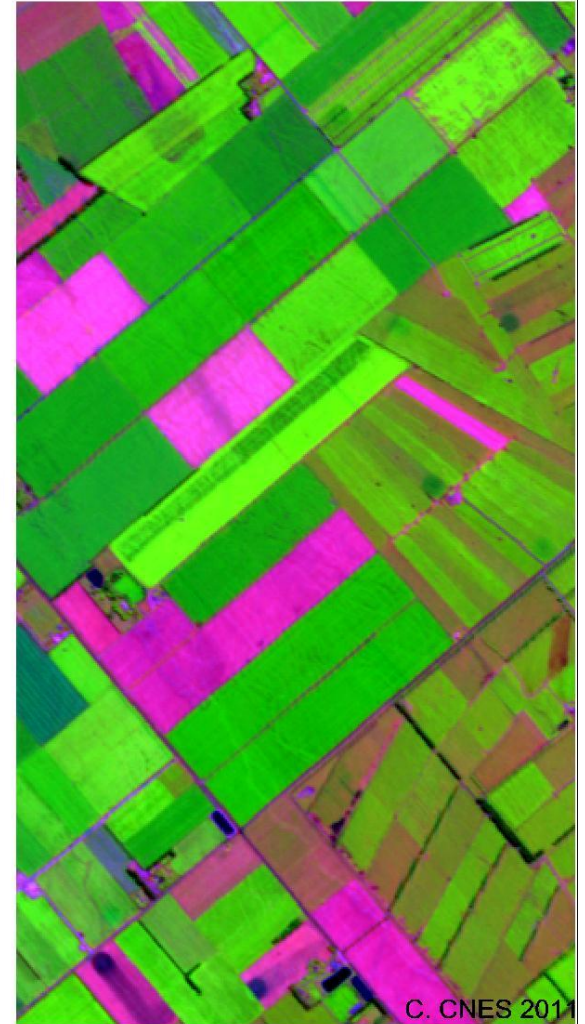
- Uses images from 12 months before to 9 months after classification date
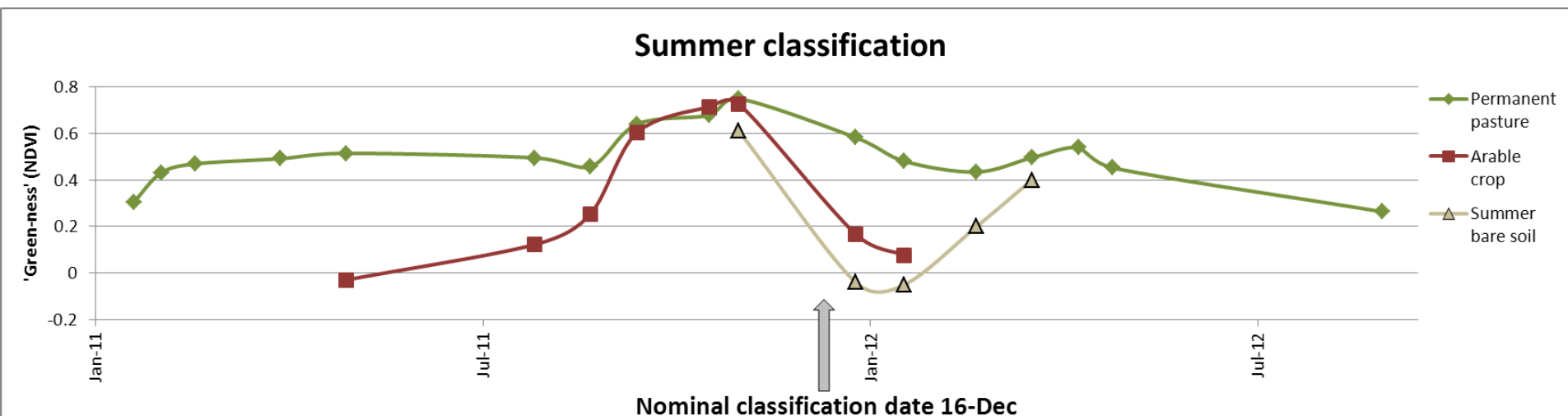
- Graph shows examples of real paddocks in these classes
- Each graph point is extracted from a satellite image at the given date
- Expressed as 'green-ness' of paddock (Normalised Difference Vegetation Index)

Broad land use types for winter classification (16-Jun)

- Uses images from 8 months before to 12 months after classification date
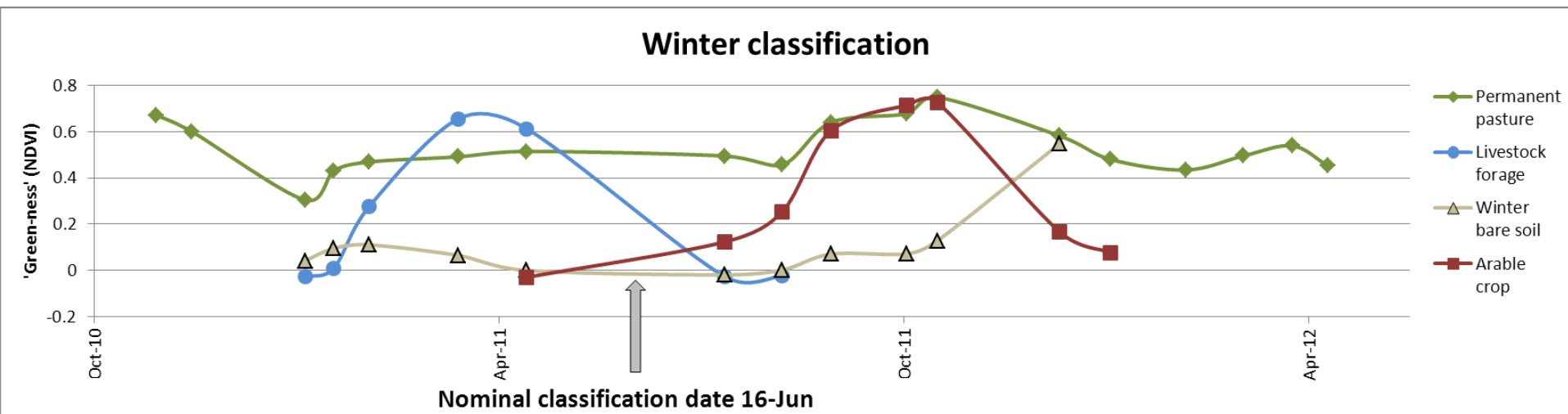
- Graph shows examples of real paddocks in these classes
- Graph points extracted from a time-series satellite images
- Expressed as 'green-ness' (NDVI)

Wheat - planted 2011
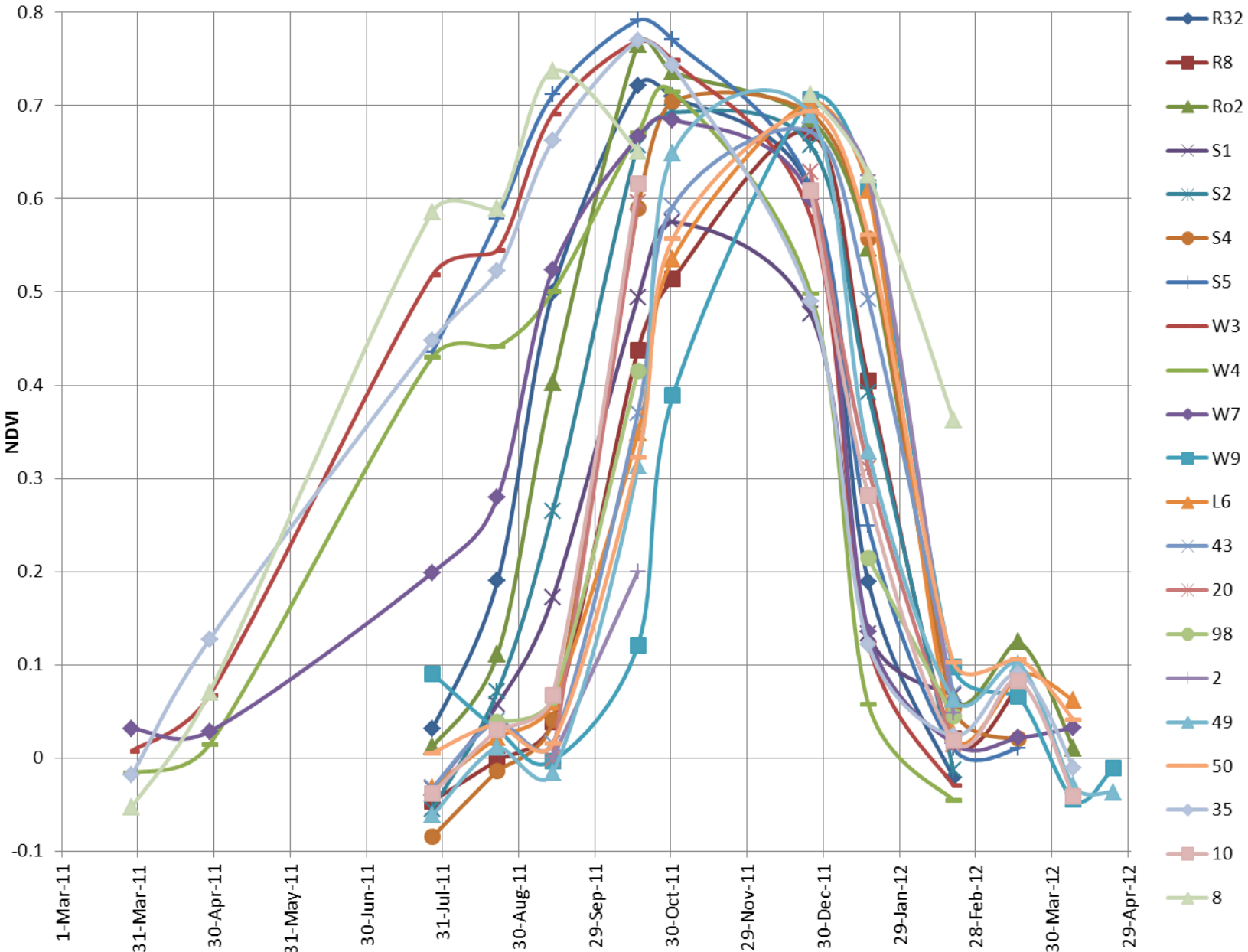
Model curves for crops planted in early autumn
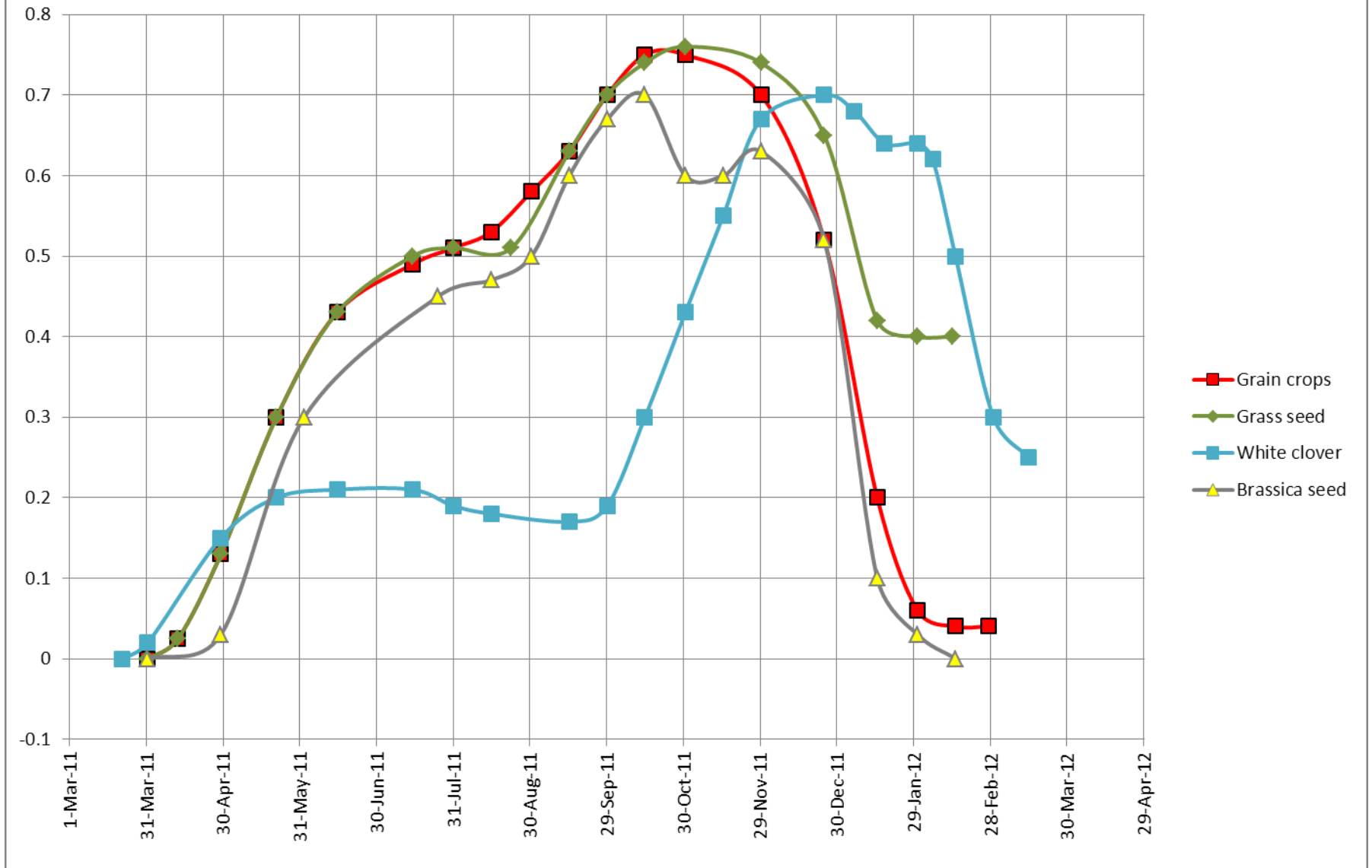
Model curves for crops planted in early autumn
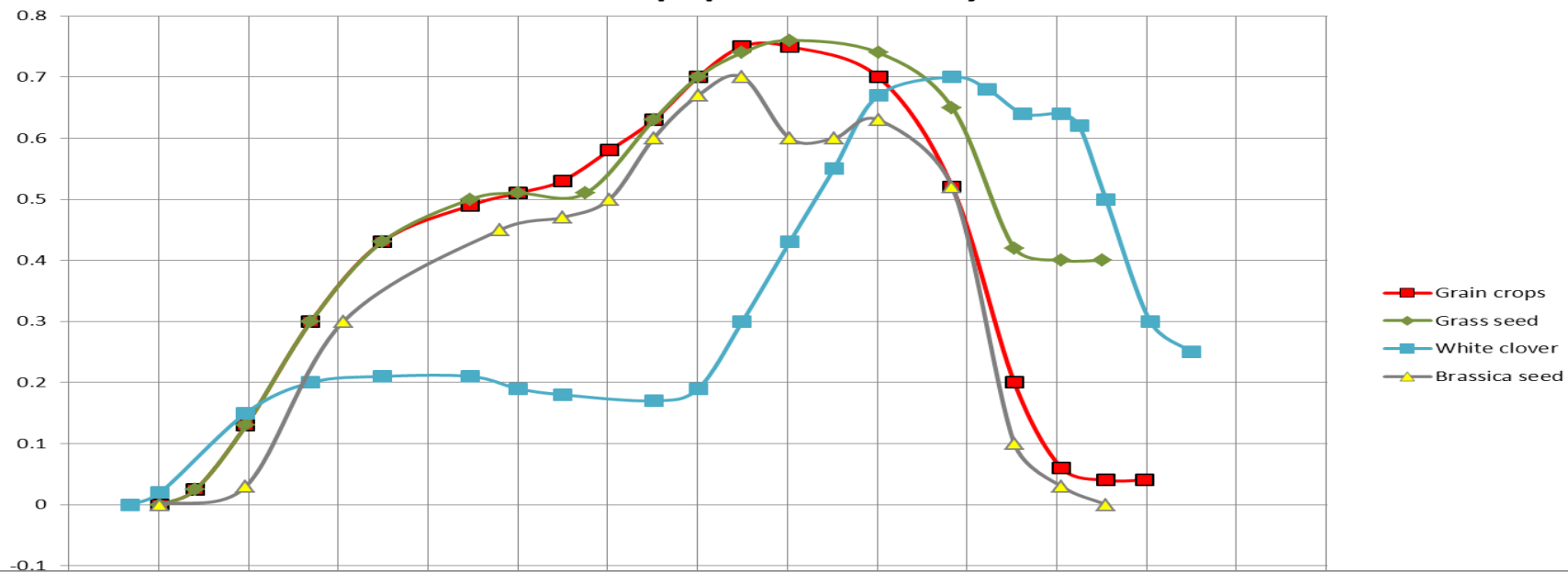
Model curves for crops planted in late autumn

Model curves for crops planted in early autumn

Legend:
- Grain crops
- Grass seed
- White clover
- Brassica seed
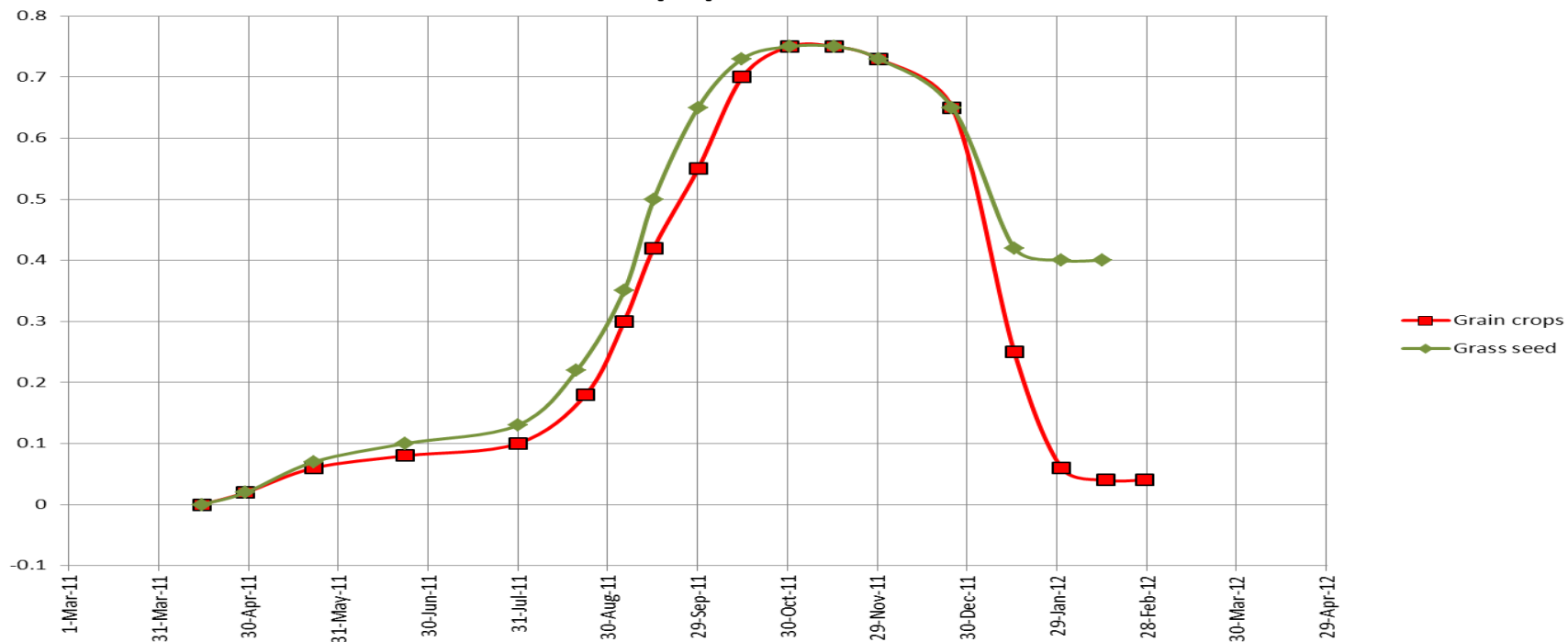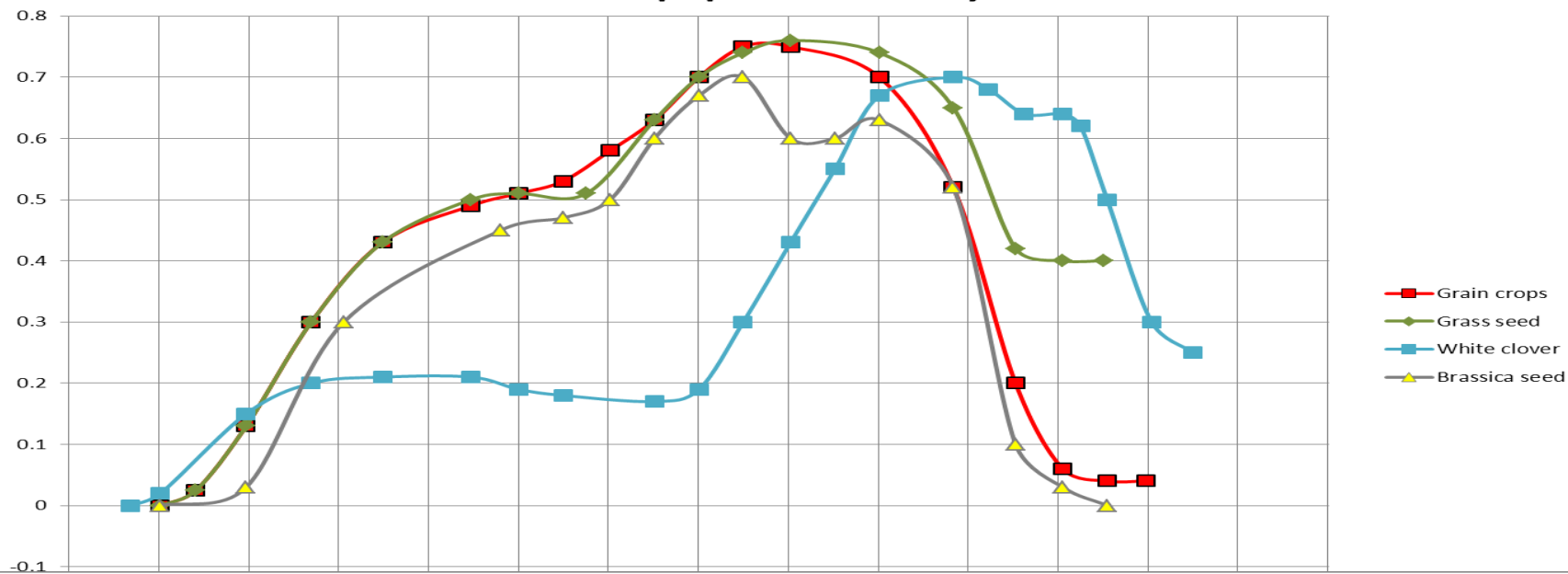
Model curves for crops planted in spring

Legend:
- Grain crops
- Process peas
- Radish/brassica seed
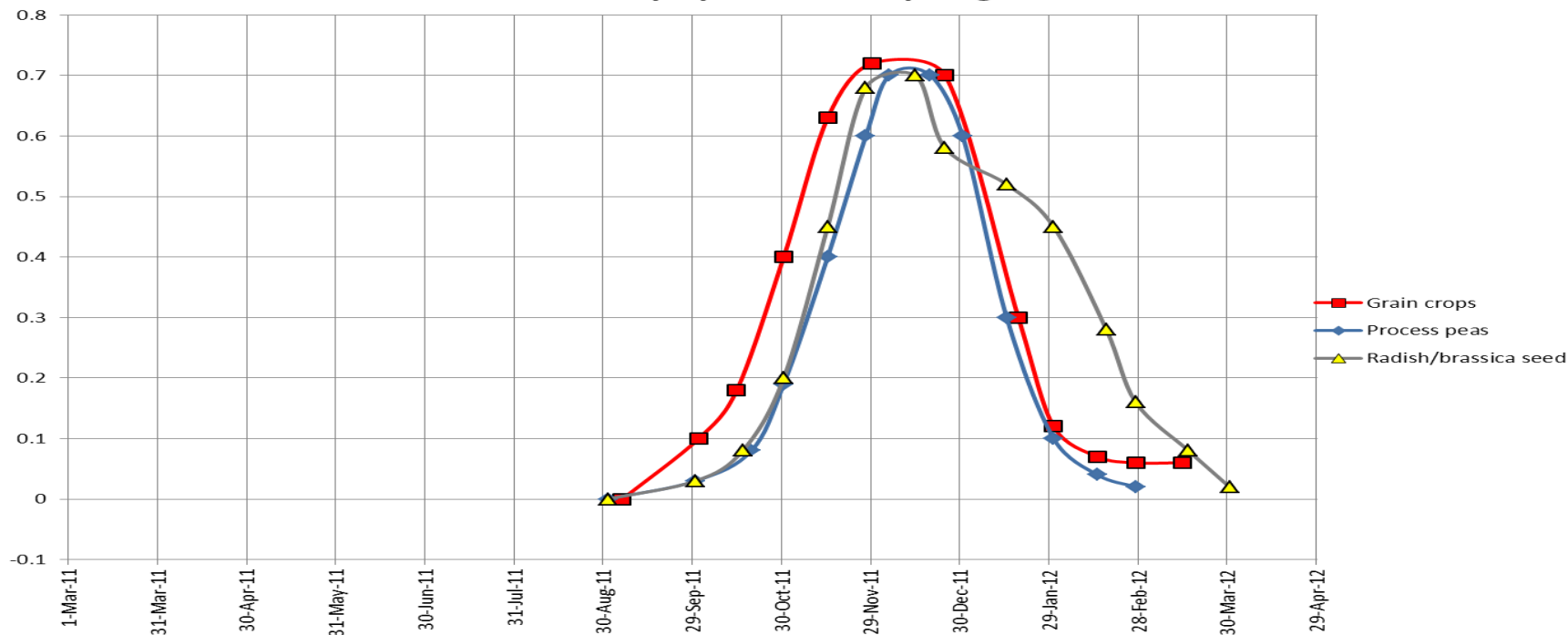
Spectral means for crops
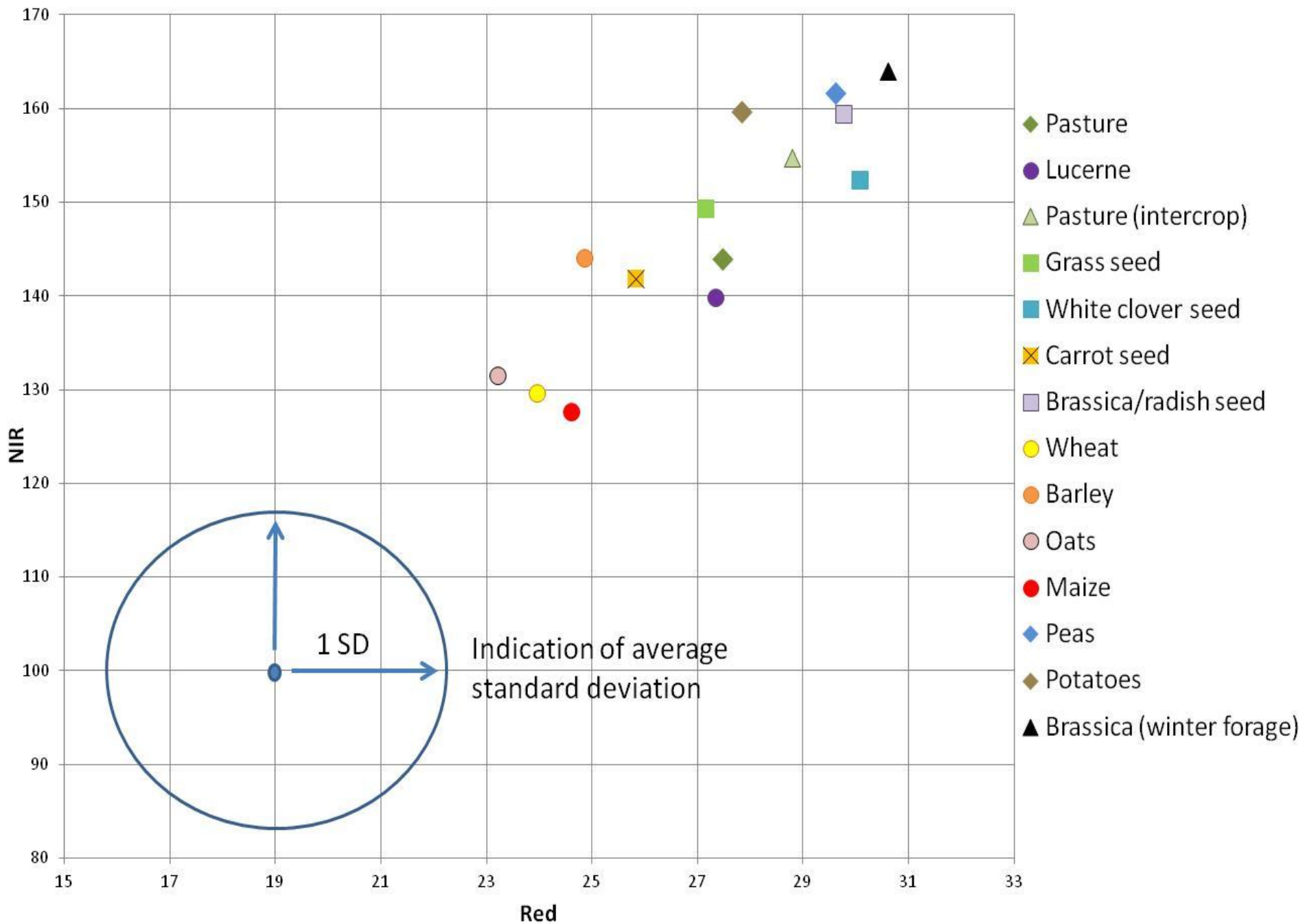
Classification steps

- Identify paddocks

- Match paddock temporal profiles to model curves

- Spectral classification at NDVI peak (crop groups)

Timing and crop type information produced by summer classification

Legend for land use/timing classes

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- Crop planted winter (e.g. grain crop)
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- Crop planted summer, short peak (e.g. potatoes)
- Crop planted summer, long peak (e.g. maize for silage)
- Winter livestock forage - just planted Nov-Dec
- Bare soil (Nov-Jan)
- Unknown

Kilometres

5   0

Legend for crop group classes

- Pasture (or lucerne)
- Grain (wheat, oats, or barley)
- Grass seed or barley
- Maize (silage)
- White clover seed
- Peas or brassica/radish seed
- Potatoes (or carrot seed)
- Brassica (winter livestock forage)
- Pasture (lower probability)
- Unknown crop (lower probability)
- Bare soil
- Unknown
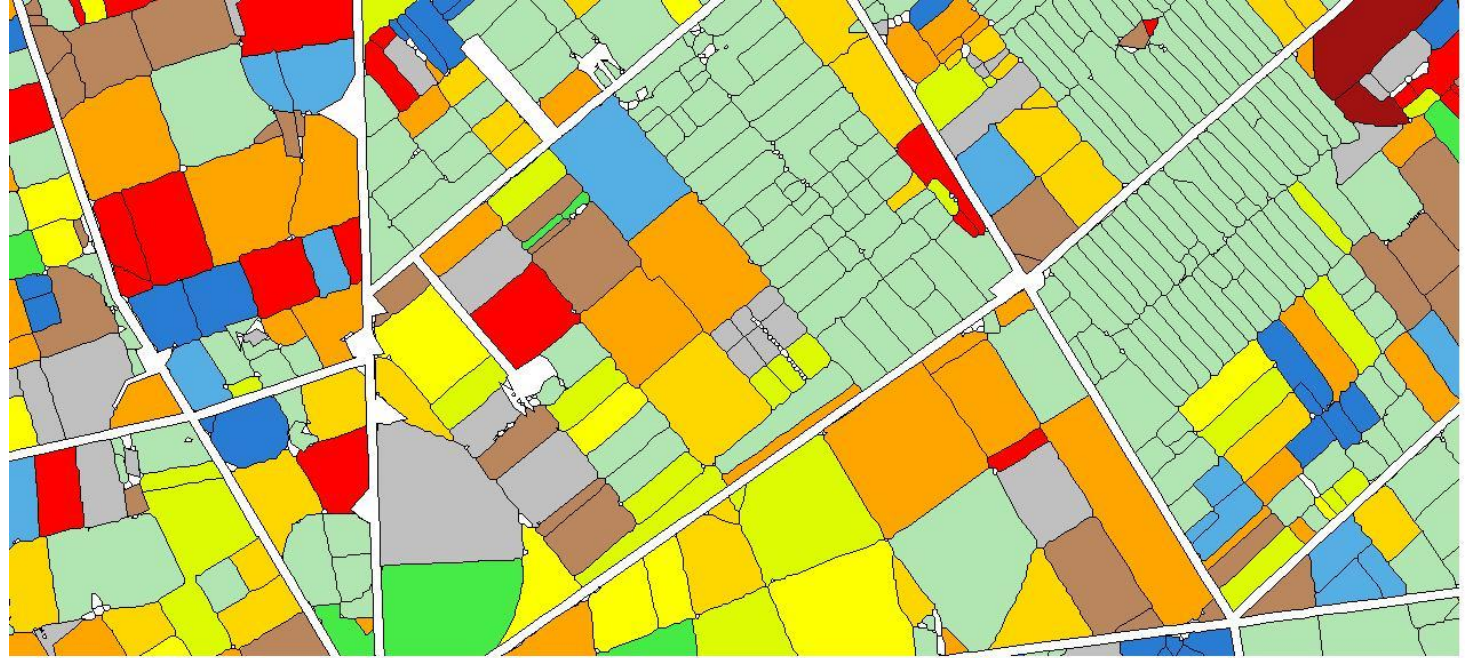
Timing and crop-type information produced by the winter classification

Pasture (or lucerne)

Short-term pasture (between crops)

Winter forage planted Nov-Dec, grazed out by end-July (brassica)

Winter forage planted Nov-Dec, grazed out by end-July (oats)

Winter forage planted Jan-Feb, grazed out by end-July (brassica)

Winter forage planted Jan-Feb, grazed out by end-July (oats)

Winter forage planted Jan-Feb, grazed later (brassica)

Winter forage planted Jan-Feb, grazed later (oats)

Was maize for silage, likely stubble remaining after harvest

Unknown summer-planted crop (likely including further winter forage)

Autumn-planted crop (likely white clover)

Autumn-planted crop (likely brassica for seed)

Early-autumn-planted crop (likely grass for seed or grain)

Late-autumn-planted crop (likely grass for seed or grain)

Bare soil/fallow (April-July)

Unknown

Winter 2011 classification, Mid-Canterbury

Rakaia River

Ashburton

N

Accuracy: broad land use level

		Classified as….						
		Pasture	Summer Crop	Bare Soil	Winter Forage		Number of paddocks correct	105
BROAD LANDUSE: DEC-10								
Field data	Pasture	53	5	0	0		Total number	125
	Summer Crop	10	51	5	0		Percent correct	84%
	Bare Soil	0	0	0	0			
	Winter Forage	0	0	0	1			

ACCURACY FOR THE 3 CLASSIFICATION DATES

Dec-10	84%	
Jun-11	82%	
Dec-11	92%	

Accuracy: planting date level

		Classified as….								
		Early autumn	Late autumn	Winter	Spring	Early summer (short)	Early summer (long)			
PLANTING DATE: DEC-10								Number of paddocks correct		34
Field data	Early autumn	8	0	1	2	0	0	Total number		42
	Late autumn	0	2	0	0	0	0	Percent correct		81%
	Winter	0	0	5	1	0	0			
	Spring	0	0	2	14	0	1			
	Early summer (s)	0	0	0	0	0	0			
	Early summer (l)	1	0	0	0	0	5			

ACCURACY FOR THE 3 CLASSIFICATION DATES

	Dec-10	81%
	Jun-11	69%
	Dec-11	56%

Accuracy: mapped crop group

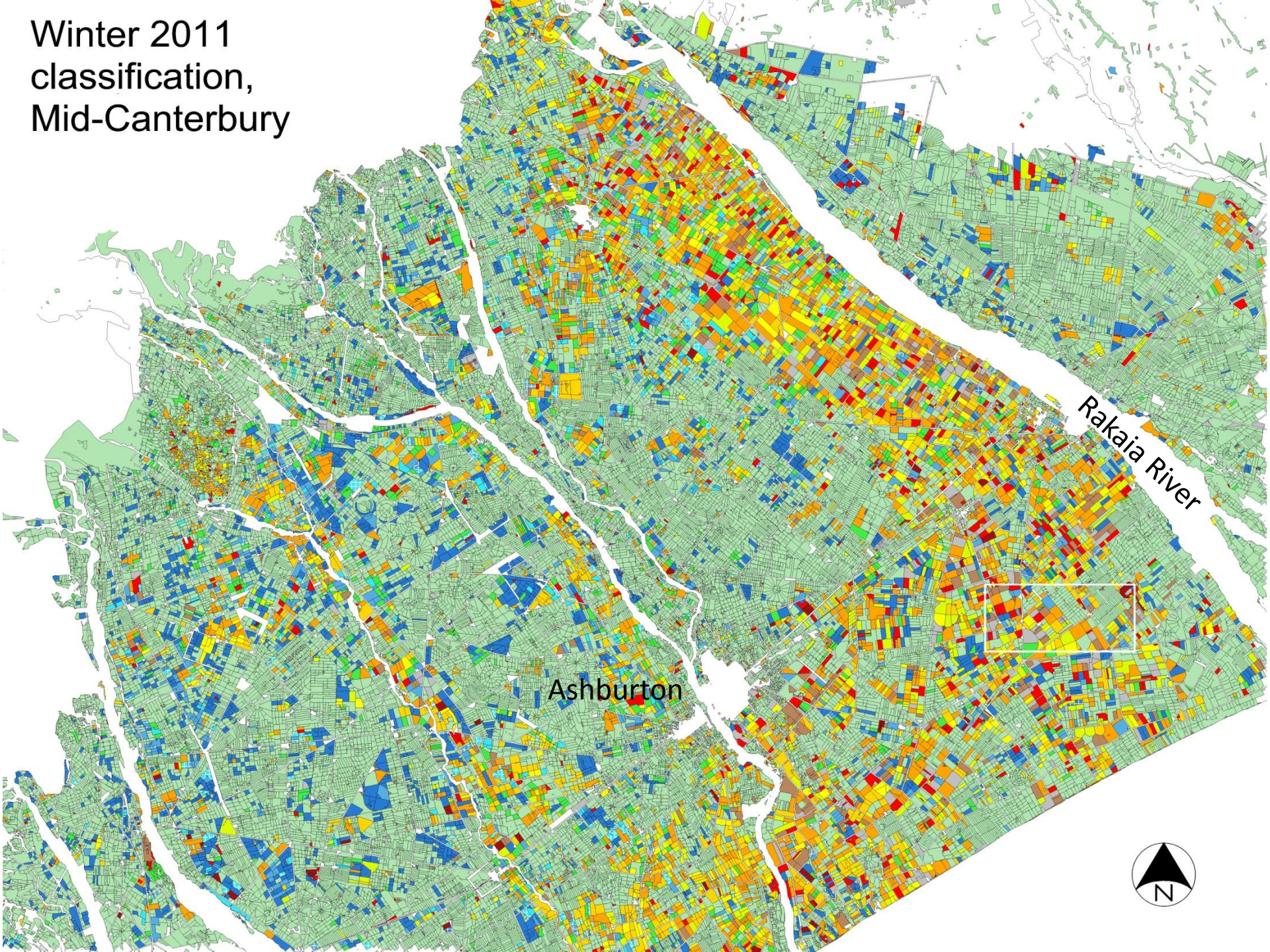**Mapped in crop group….**

MAP SYMBOLOGY: DEC-10	Pasture (or lucerne)	Grain (wheat, oats, or barley)	Grass seed or barley	Maize (silage)	White clover seed	Peas or brassica/ radish seed	Potatoes (or carrot seed)	Brassica (winter livestock forage)	Pasture (lower probability)	Unknown crop (lower probability)	Bare soil
Field data Wheat	1	16	0	0	0	0	0	0	0	5	0
Barley	1	5	0	0	0	0	0	0	0	0	0
Other/unknown grain crop	0	4	0	0	0	0	0	0	0	0	0
Peas	0	1	0	0	0	2	0	0	1	0	0
Radish seed	0	0	0	0	0	1	0	0	0	0	0
Rape seed	0	0	0	0	0	3	0	0	0	0	0
Other/unknown brassica seed	0	0	0	0	0	0	0	0	0	1	0
Brassica - winter forage	0	0	0	0	0	0	0	3	0	0	3
Grass seed	3	2	5	0	1	1	0	0	0	0	0
Pasture	52	0	2	0	2	0	0	0	0	1	0
Lucerne	0	0	1	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	1	0	0	0	0
Maize	0	0	0	4	1	0	0	0	0	0	0
White clover seed	0	0	0	0	0	0	0	0	0	0	0
Bare soil	0	0	0	0	0	0	0	0	0	0	0

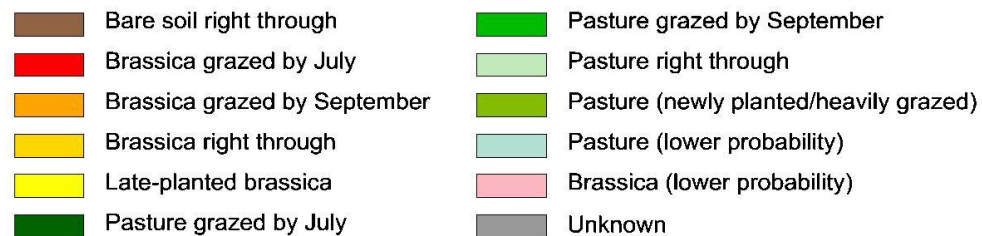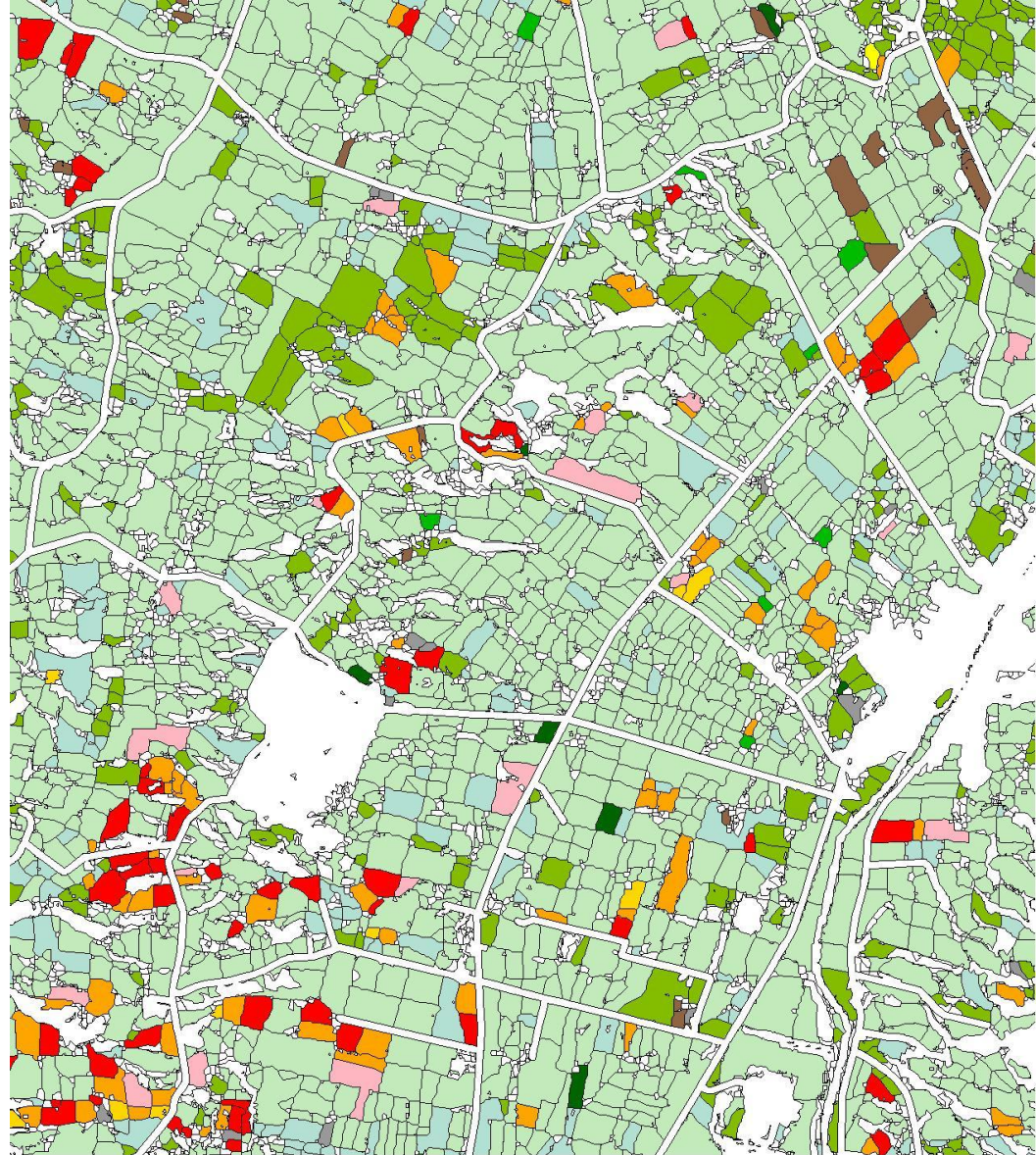|			
Number of paddocks correct	102	**MAP SYMBOLOGY: DEC-11**	83%
Total number	123	**FOUR INDIVIDUAL CROPS: JUN-11**	81%
Percent correct	83%		

Remaining issues

-   Difficulty separating grass seed crop from pasture

-   Irrigated vs dryland pasture accuracy

-   Further crops and timing classes

-   Cross-region

Southland winter forage

- Winter forage classification only

- Simpler set of classes

- Challenges: winter images (low sun angles) and hilly terrain

Legend:
- Bare soil right through
- Brassica grazed by July
- Brassica grazed by September
- Brassica right through
- Late-planted brassica
- Pasture grazed by July
- Pasture grazed by September
- Pasture right through
- Pasture (newly planted/heavily grazed)
- Pasture (lower probability)
- Brassica (lower probability)
- Unknown

Imagery outlook/trends

- More satellites
  - aimed at different markets, pricing and access models
- Improved resolution (spatial)
- Constellations (improved temporal resolution)
- More/better pre-processing
  - geometric orthorectification
  - calibration
  - higher level image products – e.g. cloud masks
- Global monitoring
  - cheap / free
  - improved spectral resolution

Examples

- ## Landsat 8 (Feb 2013)
  - – 11 bands (from 8 on L7), 30m, 185km swath, 16 day repeat
  - – Free online, orthorectified

- ## Sentinel 2 (Apr 2015)
  - – 13 spectral bands, 10m, 290km swath, 5 day repeat
  - – two satellite constellation
  - – Free online, orthorectified

- ## ALOS-3 (2015)
  - – AVNIR-2;   4 band, 5m, 90km swath
  - – HISUI;   57 band, 30m, 30km swath
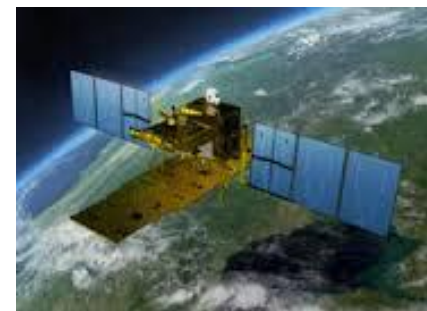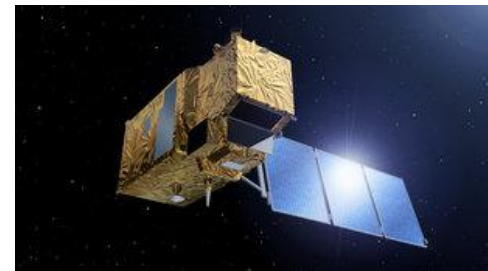
Computing and workflows

- High Performance Computing
- Currently processing all Landsat-8 (339 to date)
  - 1571 Landsat-4,5,7,8 processed to date (4.8 TB)
  - Includes rectification, pan-sharpening, terrain correction, cloud-masking
- Extend to SPOT, and others as available
- Timed mosaics – based on 4-5 month period
- Enables temporal analysis

Other uses

- Better classification of crops, land use, practice
  - Improved information for modelling
- Assist in statistical collection
  - Add value to farmer surveys?
- In season yield forecasting?
- Improve land cover mapping (LCDB)
  - Extension to national land-use map?

Summary

- New method to map land use
  - Whole paddocks, regional coverage
  - Temporal profiles from time series of satellite images

- Provide deep information on land use and farming practice to assess environmental impacts

- We expect this approach to become increasingly practical
  - New satellites
  - High performance computing

Questions?