Inferring blue tit reproductive phenology using SPOT4 imagery

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Evolutionary Ecology:
Evolution takes place in an ecological context

How do animals adapt to their environment?

Can birds adapt to a heterogeneous environment?

Process

Habitat heterogeneity
Environmental data, GIS

Climate change
Climatic data

Material for evolution

Genetic Diversity
Next Generation Sequencing

Response

Dispersal?
Pgi gene
Multi-state models

Adaptation?
Genome-wide signatures of selection *Clock*, *Pgi* gen
Quantitative genetics of the timing of breeding

Animal phenology:

- Variable in time & space
- Timed to its ecological environment

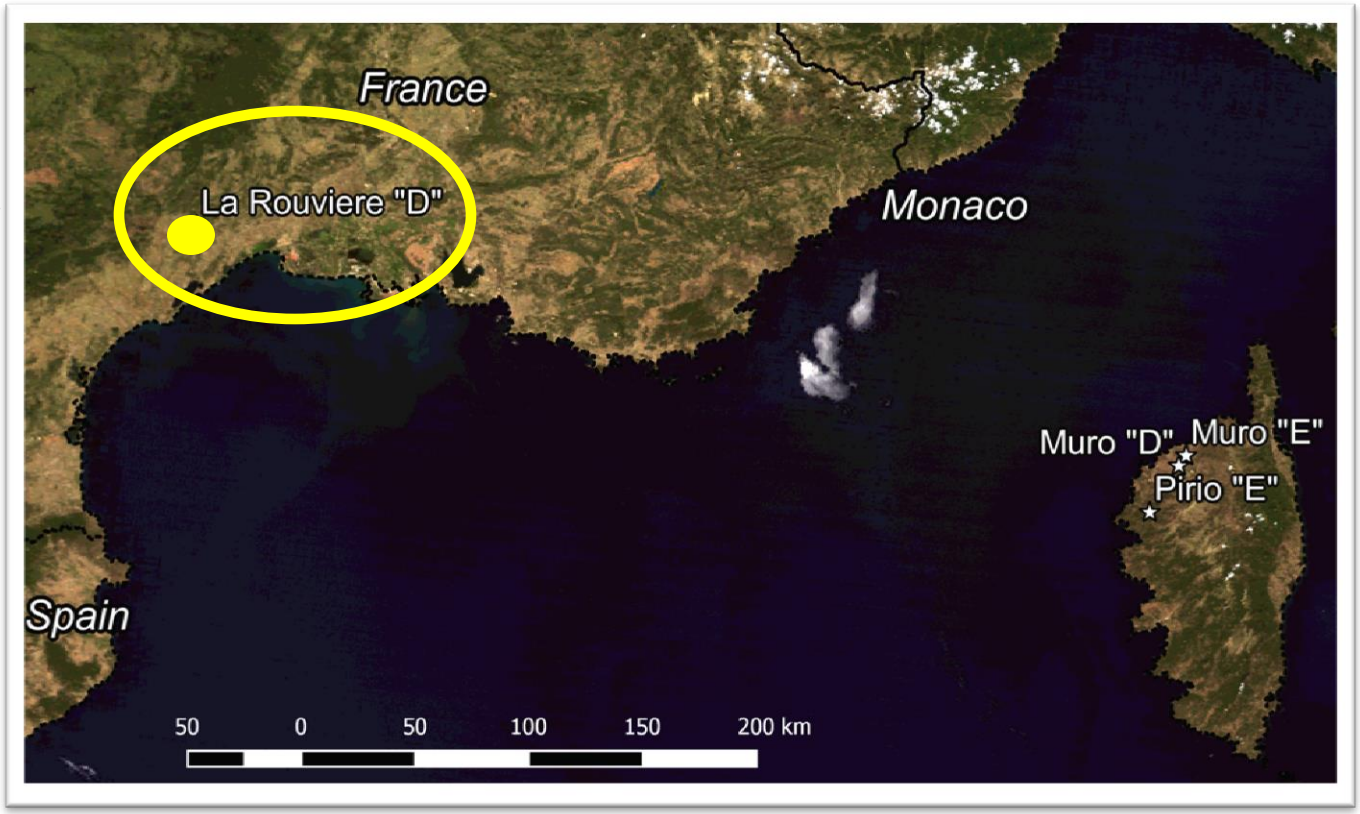
Parallel populations monitored in contrasted habitats

Cyanistes careuleus caeruleus & C. c. ogliastrae

"D" Deciduous: *Downy Oak (Quercus pubescens)*

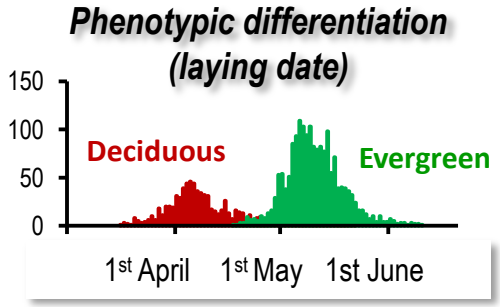
"E" Evergreen: *Holm Oak (Quercus ilex)*

Study sites:

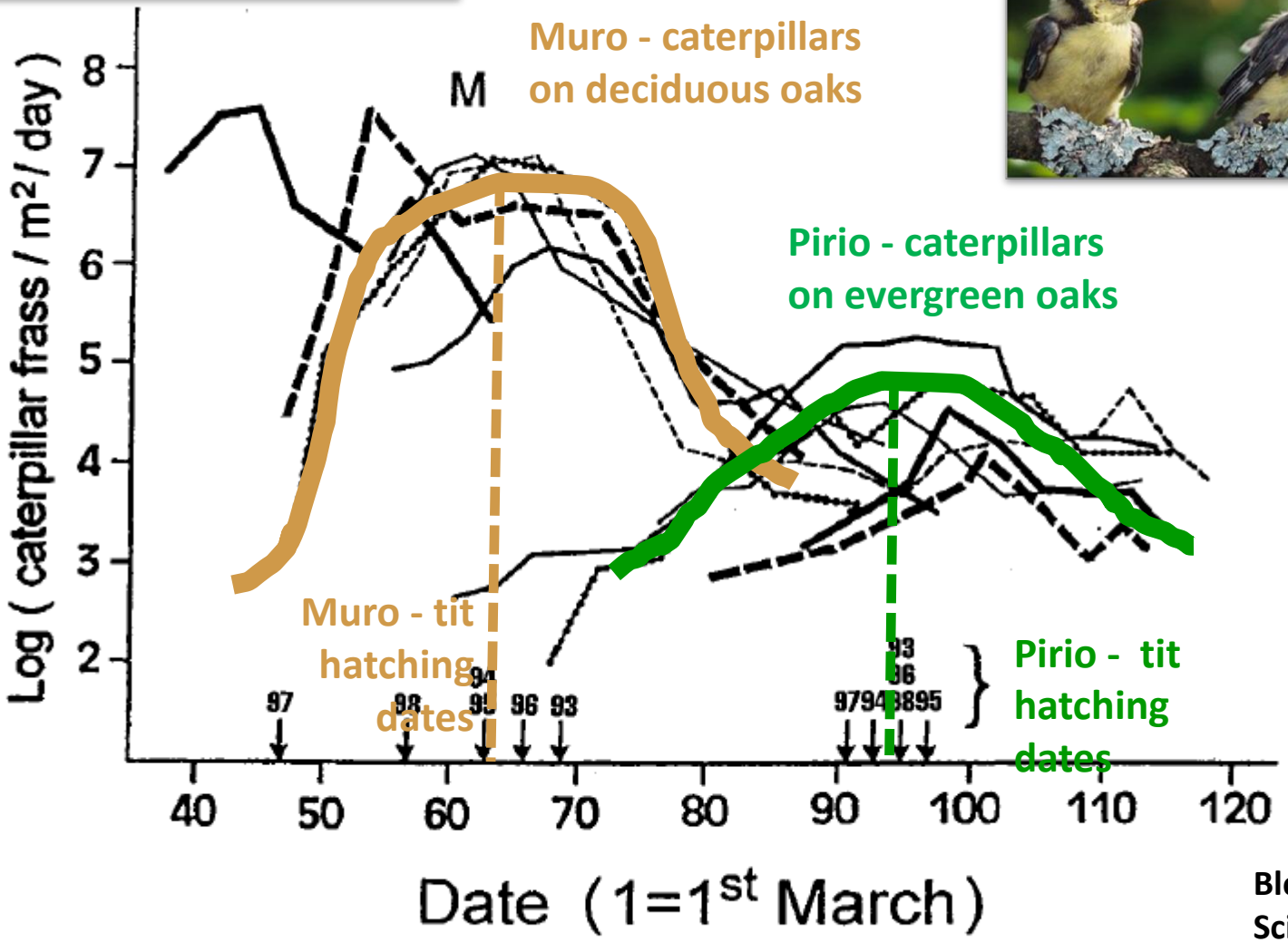


Bird phenotype:

1 month difference in breeding time depending on oakwood morphotype.



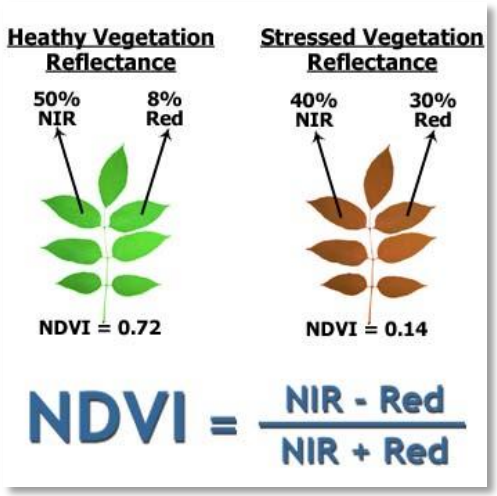
Blue tits match their reproduction to local food peaks



Blondel *et al.* 1999
Science

Blue tit field work

Vegetation Indexes for Remotely Sensed phenology



NDVI: Normalized Difference Vegetation Index

- Measures green plant spectral reflectance using measurements acquired in red and near-infrared (NIR) regions

- **Can we use winter NDVI to differentiate deciduous and evergreen oaks?**
  "La Rouviere" study site: 80% deciduous, 20% evergreen

Research Aims

Can satellite imagery generate biologically relevant information regarding habitat heterogeneity and blue tit phenology?

- Validate satellite imagery with ground data
- Investigate the predictive power of remotely sensed vegetation indexes to explain variation in animal reproductive success

- Explore start of season (SOS) statistics and test their predictive power in explaining:
    - caterpillar peaks
    - blue tit timing of breeding

Collaborators

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Montpellier

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Phenology

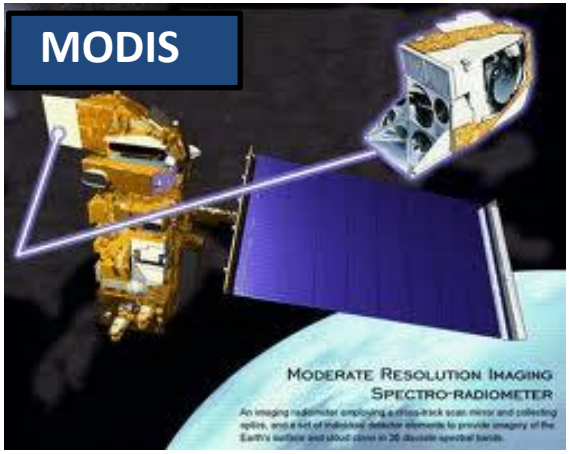
- Leaf Development Index
- Caterpillar biomass / frass

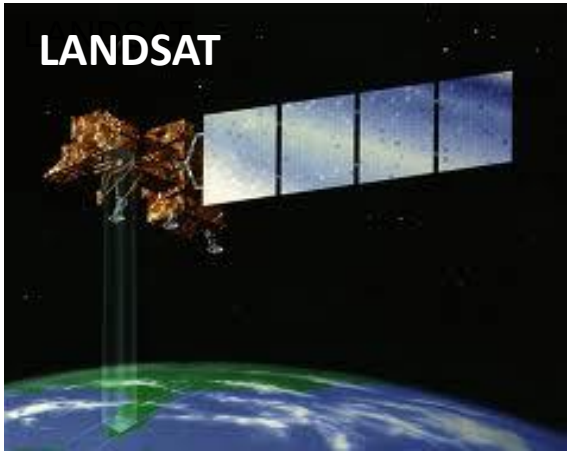
} Data not always available

- Remote sensing of phenology: satellite imagery
  - MODIS – 2000
  - LANDSAT – 1970s
  - AVHRR – 1970s
  - **SPOT 4 (Take 5) - 2013**

} Vegetation indexes based on spectral reflectance

Satellite sensors to monitor phenology

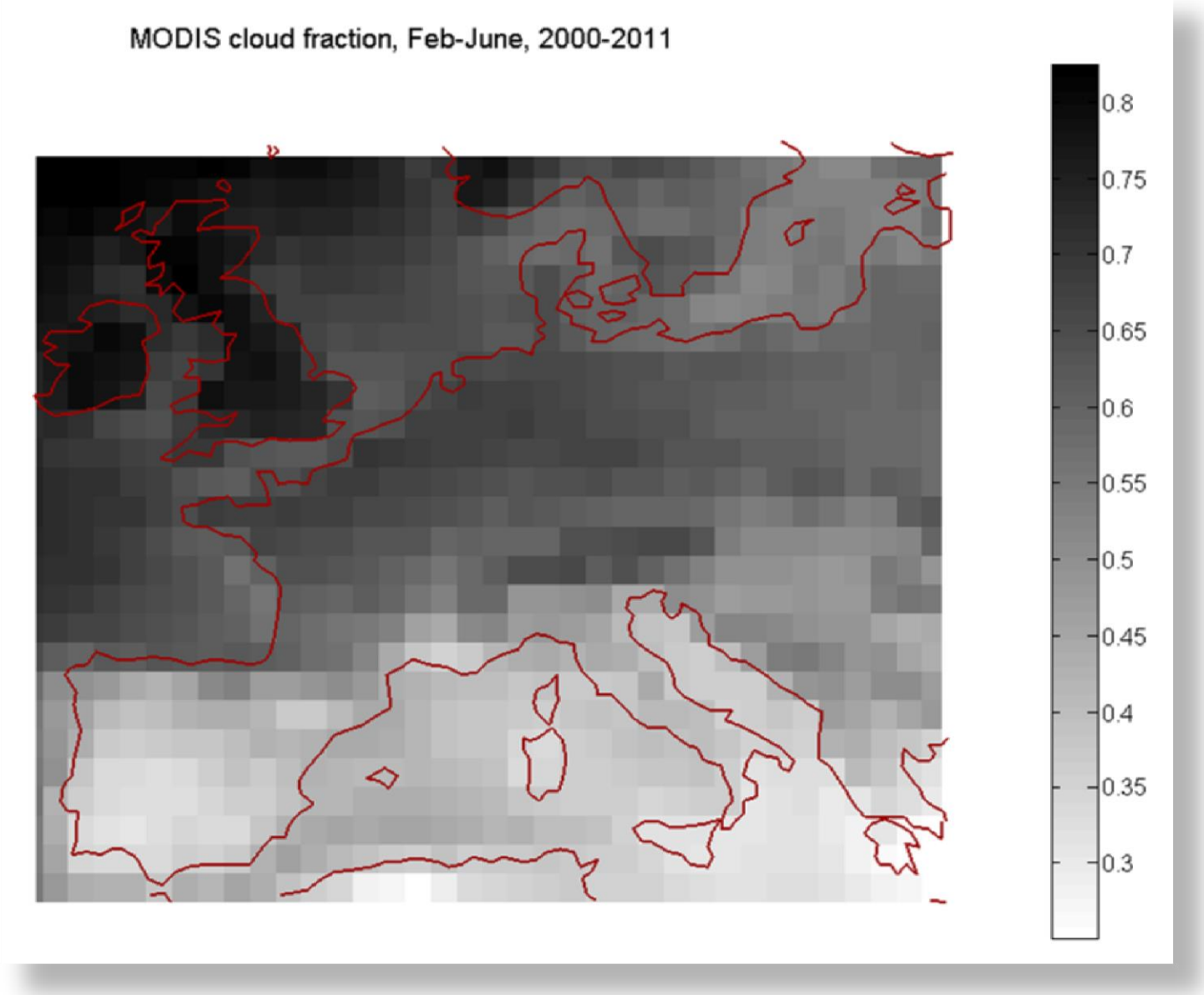




Resolution:	250 m.	30 m.	20 m.
Frequency:	Once a day	Every 16 days	every 5 days

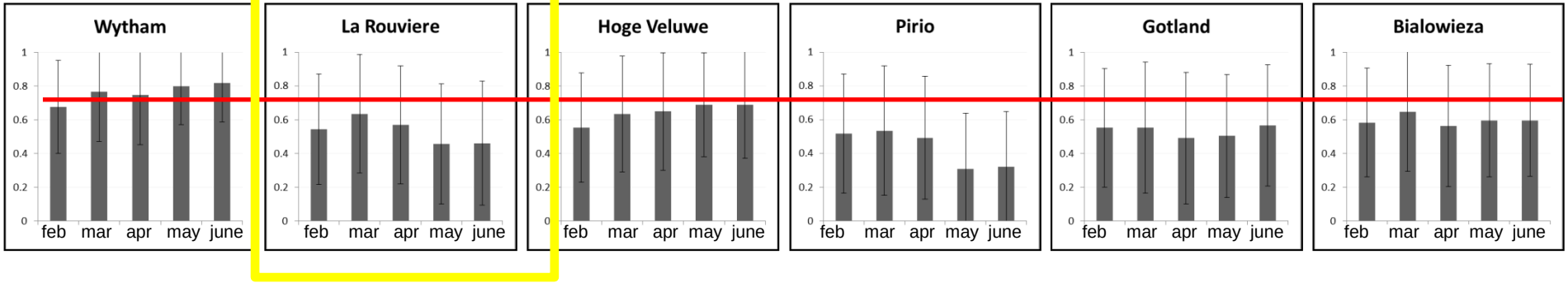
- Resolution vs frequency of image acquisition

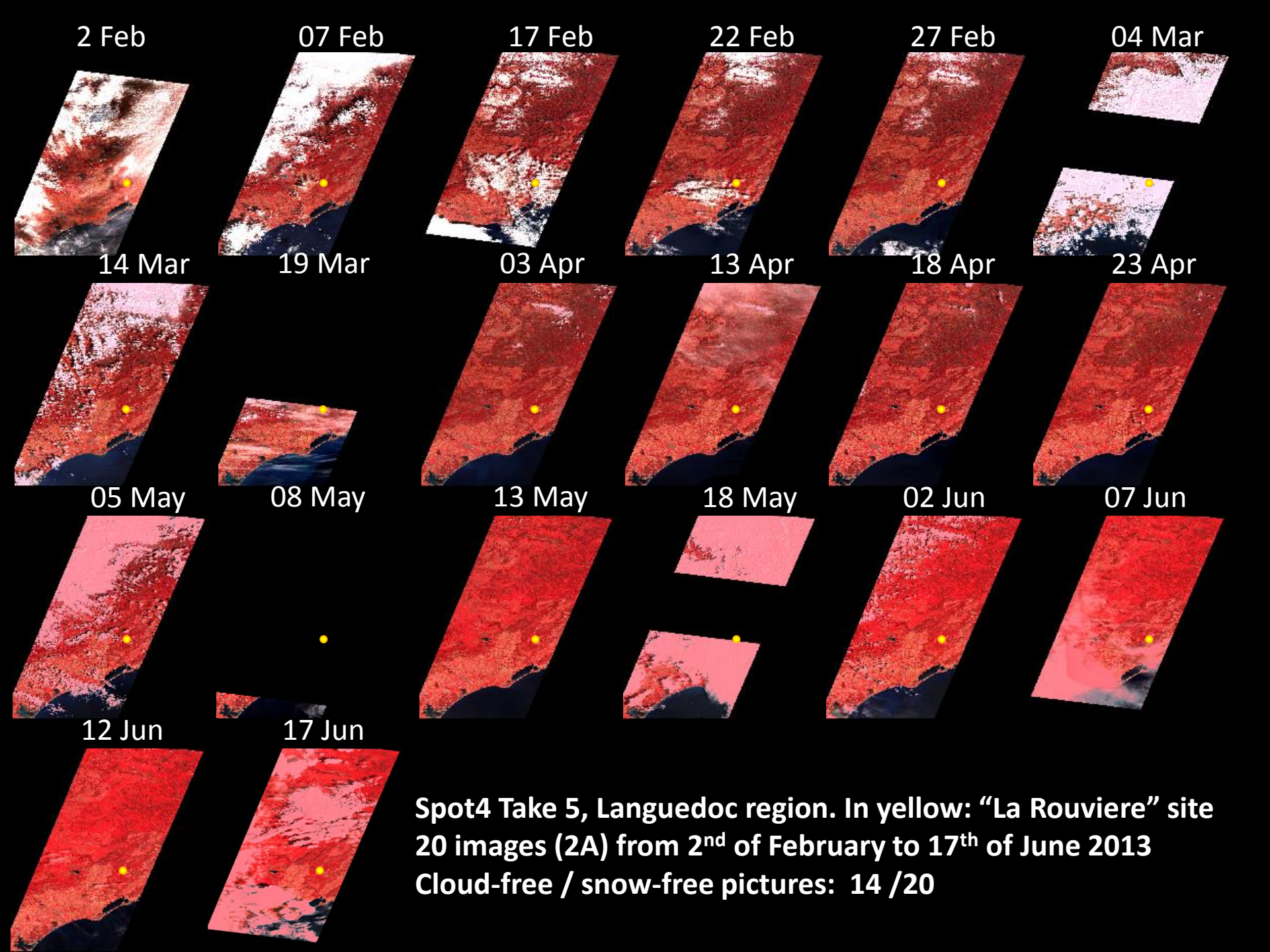
Available satellite data



Cloudiness & bird long-term studies

monthly means & SDs of MODIS-derived cloud fraction (2000-2011):

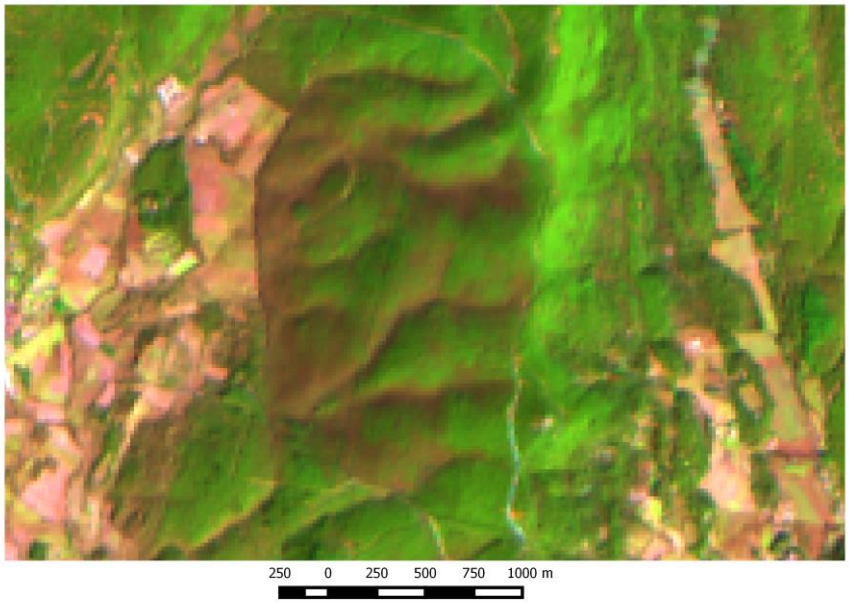




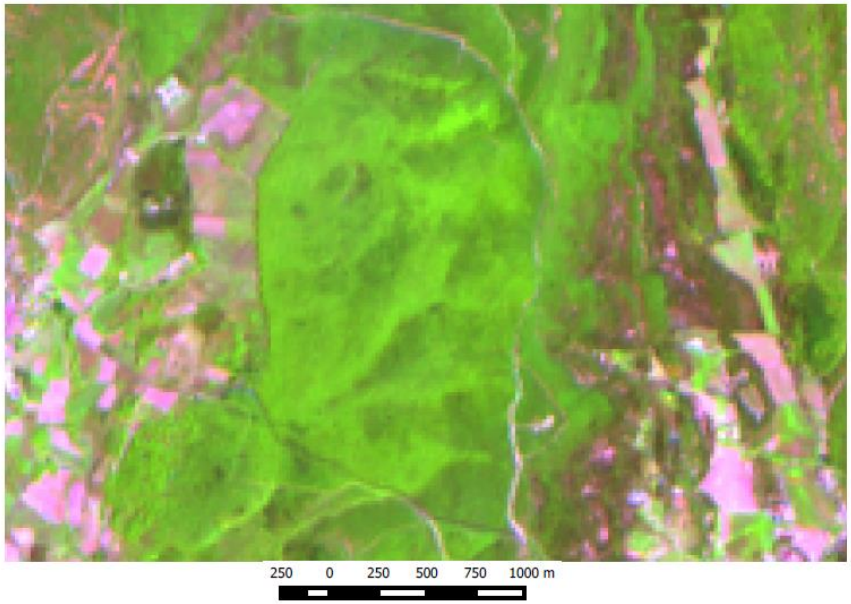
Spot4 Take 5, Languedoc region. In yellow: "La Rouviere" site
20 images (2A) from 2nd of February to 17th of June 2013
Cloud-free / snow-free pictures: 14 /20

SPOT image of the La Rouviere site (1 pixel=20m)

Winter



Summer

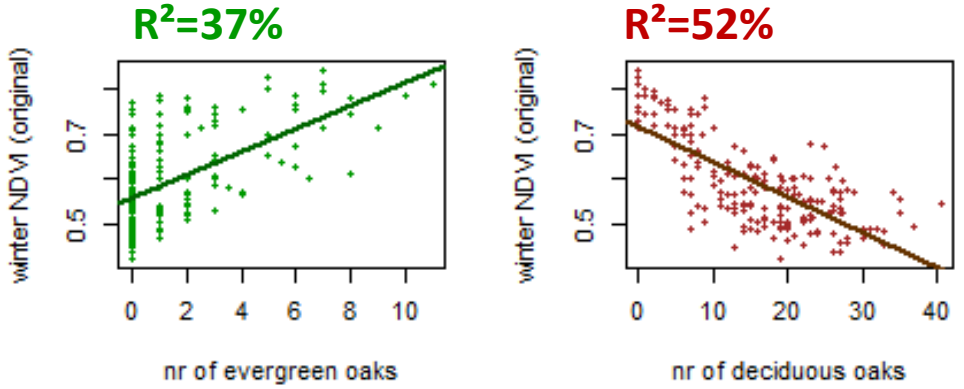


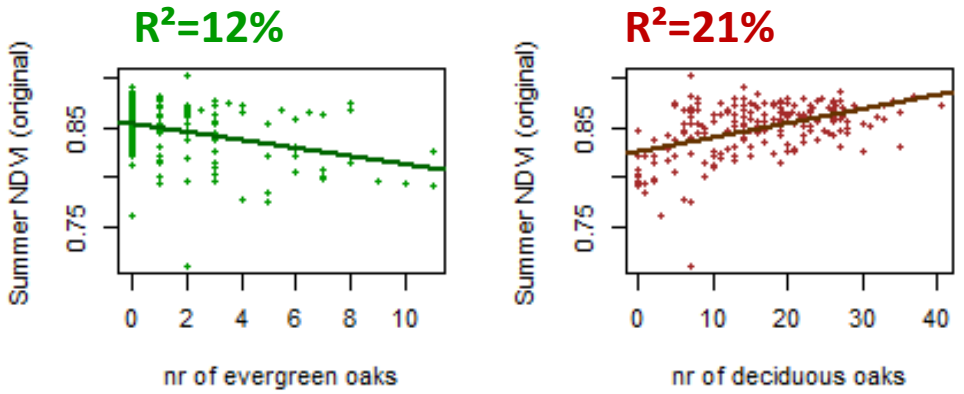
Deciduous oak Evergreen Oak

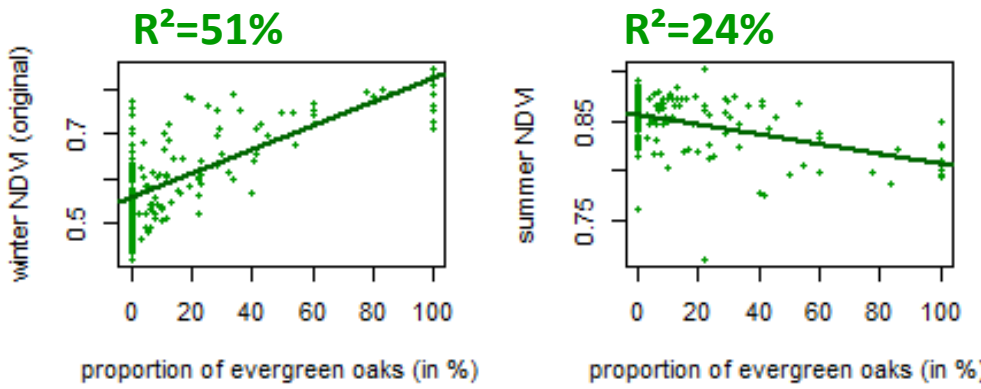
SPOT imagery + 194 nestboxes + 194 oak estimates in 50m radius

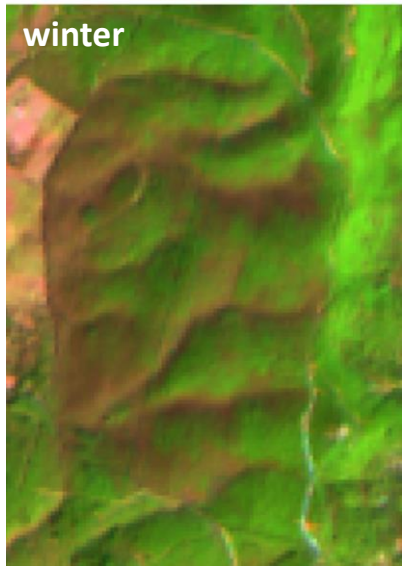
250 0 250 500 750 1000 m

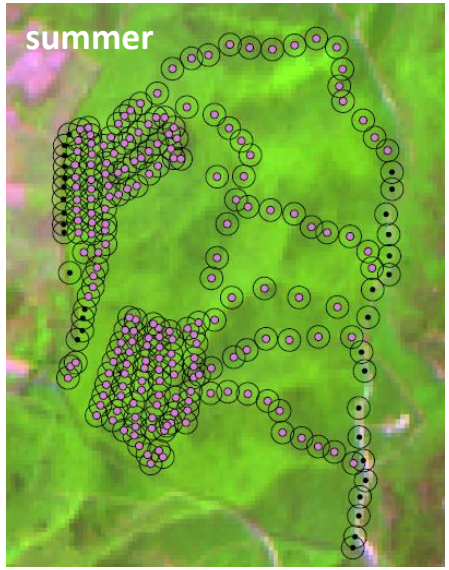
SPOT NDVI & oak ground data







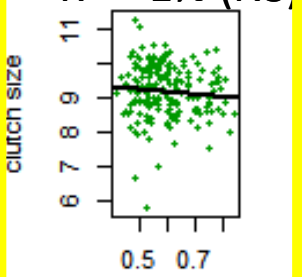




- SPOT imagery explains up to 55% of variance in oak number measured in the field
- Spot imagery in good agreement with ground data

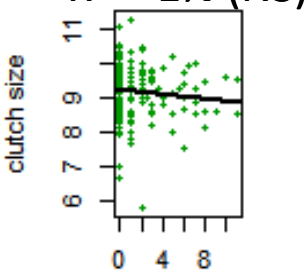
SPOT NDVI & bird reproductive data

R^2=<1% (NS)



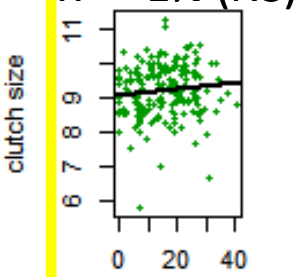
Winter NDVI

R^2=<1% (NS)



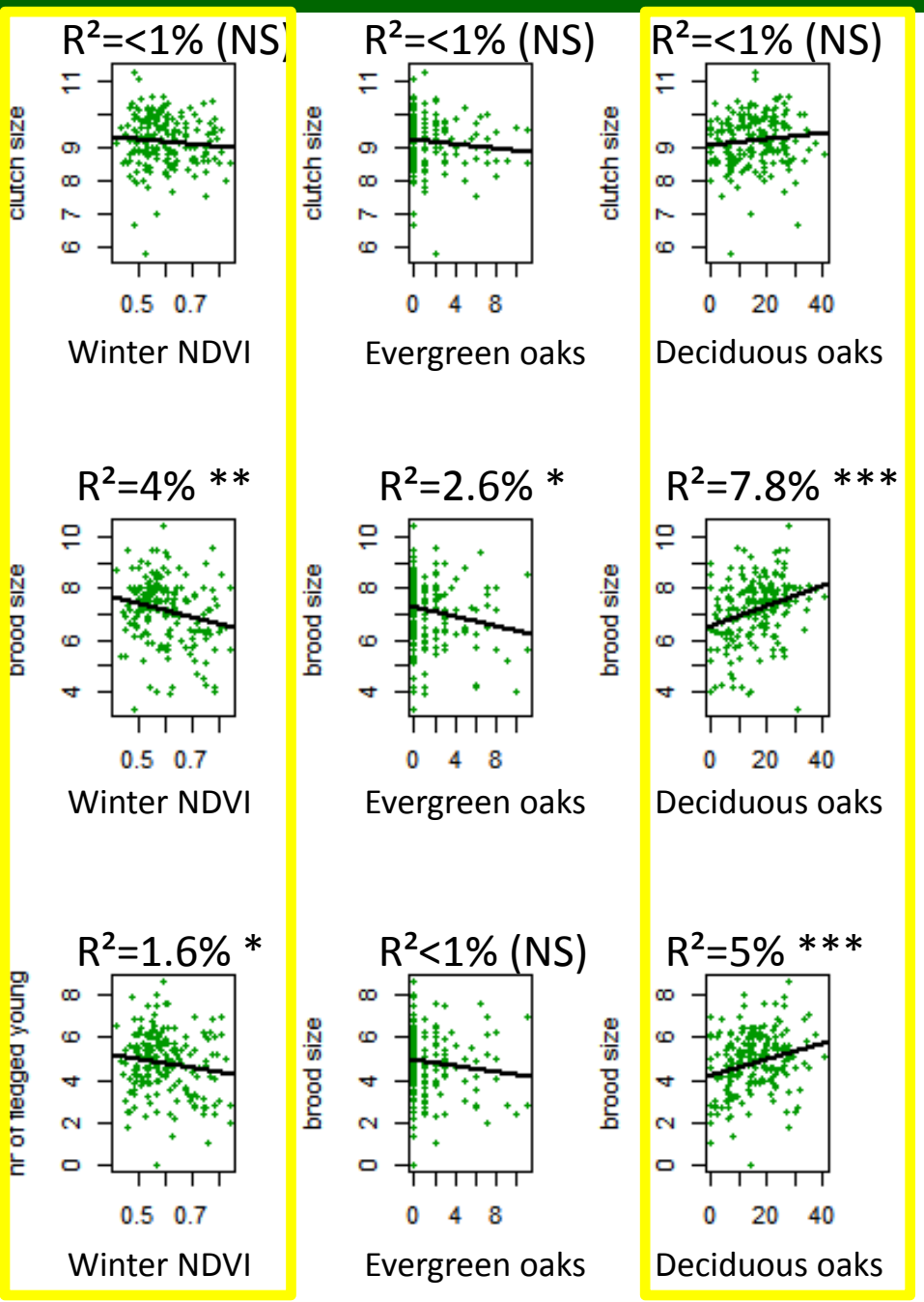
Evergreen oaks

R^2=<1% (NS)



Deciduous oaks

SPOT NDVI & bird reproductive data



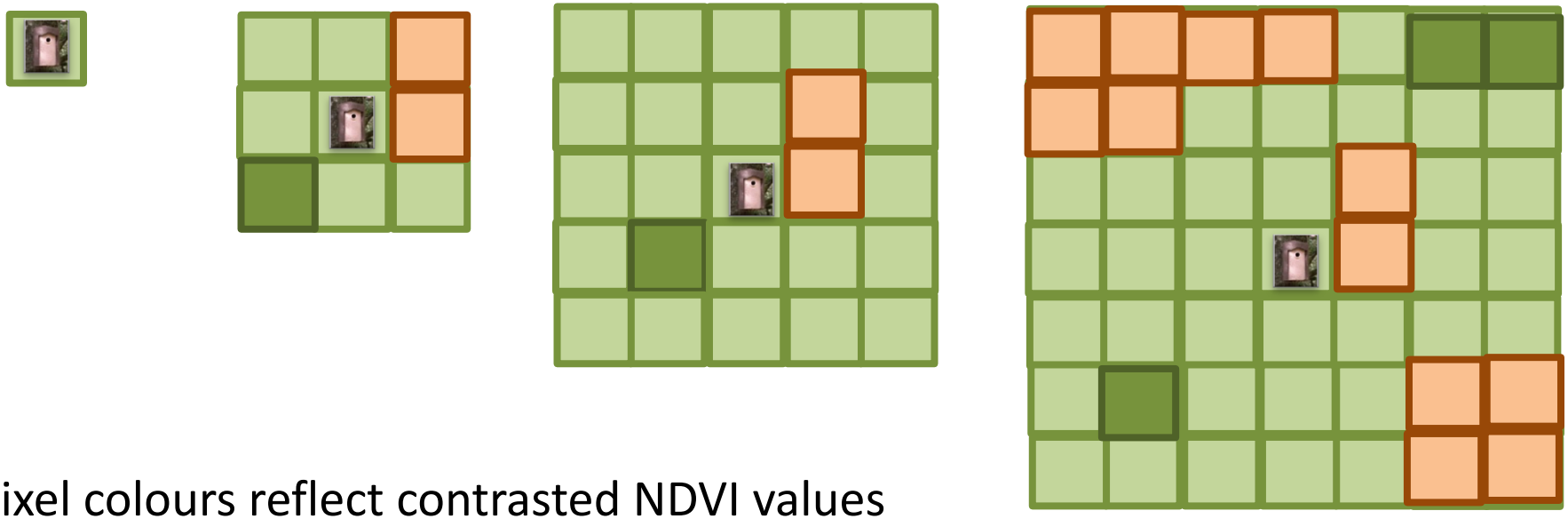
- NDVI explains meaningful variation in bird reproduction
- It is a valuable proxy when ground vegetation data is not available

SPOT NDVI filter size

- How many pixels to sample around the nestbox to best capture biologically relevant ecological and reproductive data?

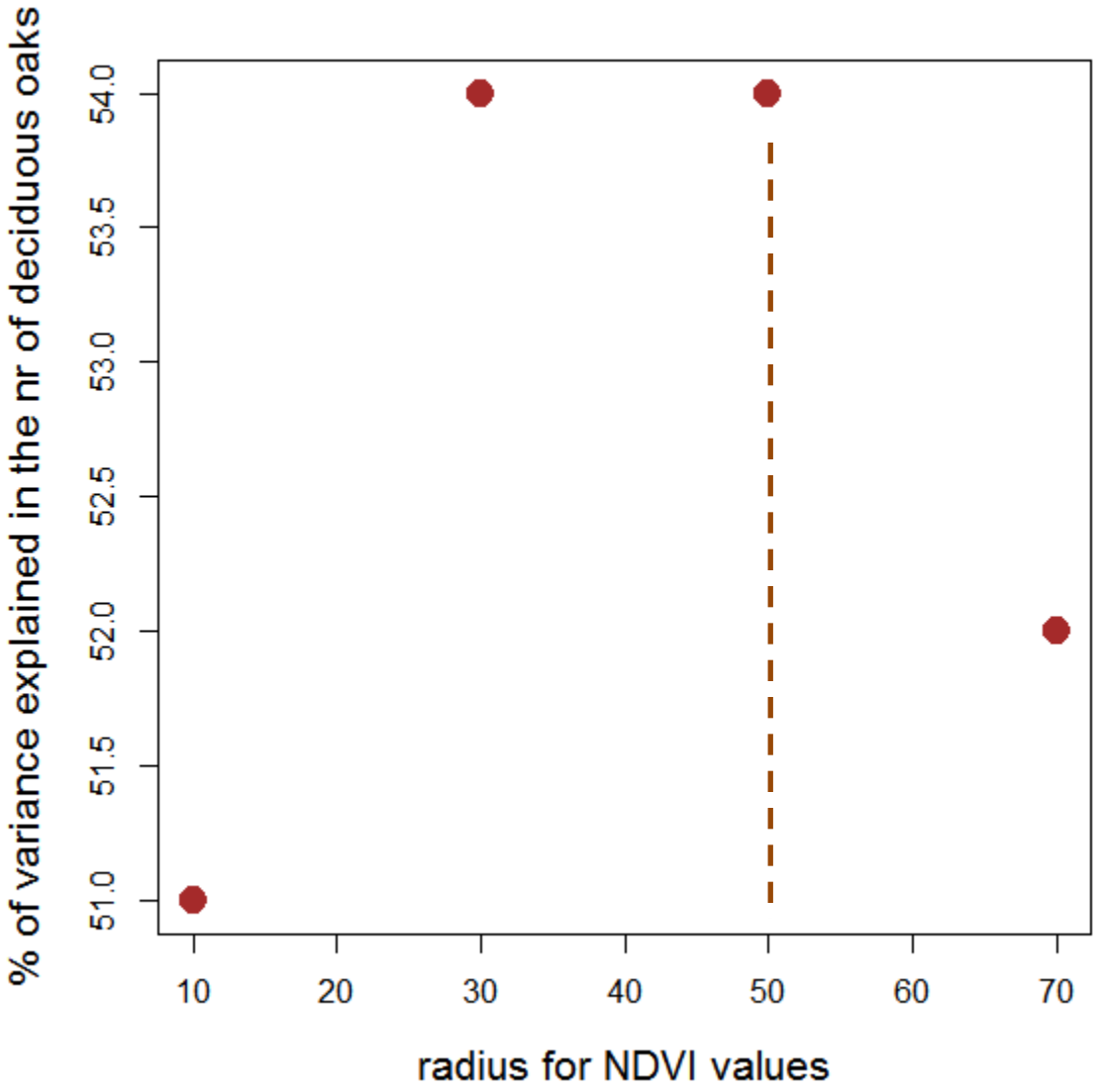
Filter size:

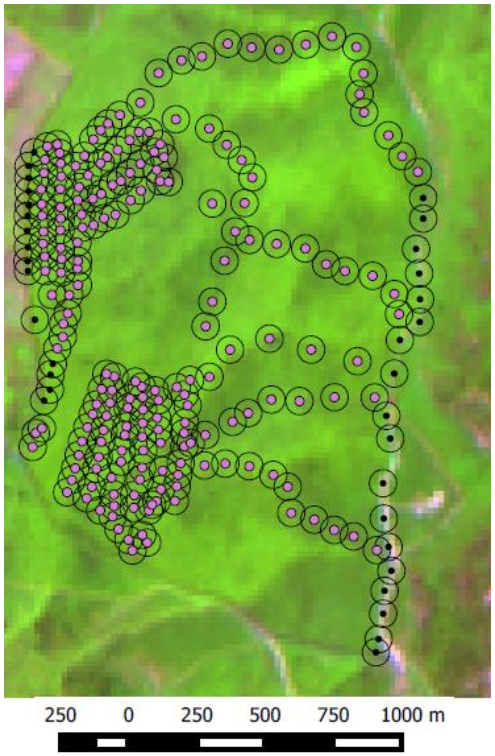
1*1 pixel (10m radius) **3*3pixels (30m radius)** **5*5 pixels (50m radius)** **7*7 pixels (70m radius)**



- Pixel colours reflect contrasted NDVI values

SPOT NDVI as a proxy for oak ground data in 50m radius from nestbox

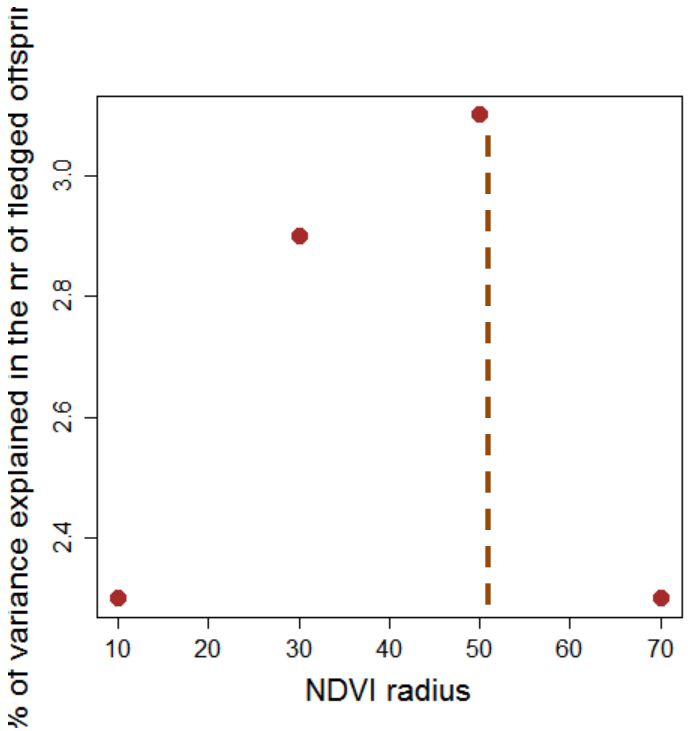




- NDVI filters between 30 and 50 meter radius best explain variance in the number of oaks as measured on the ground in a 50m radius

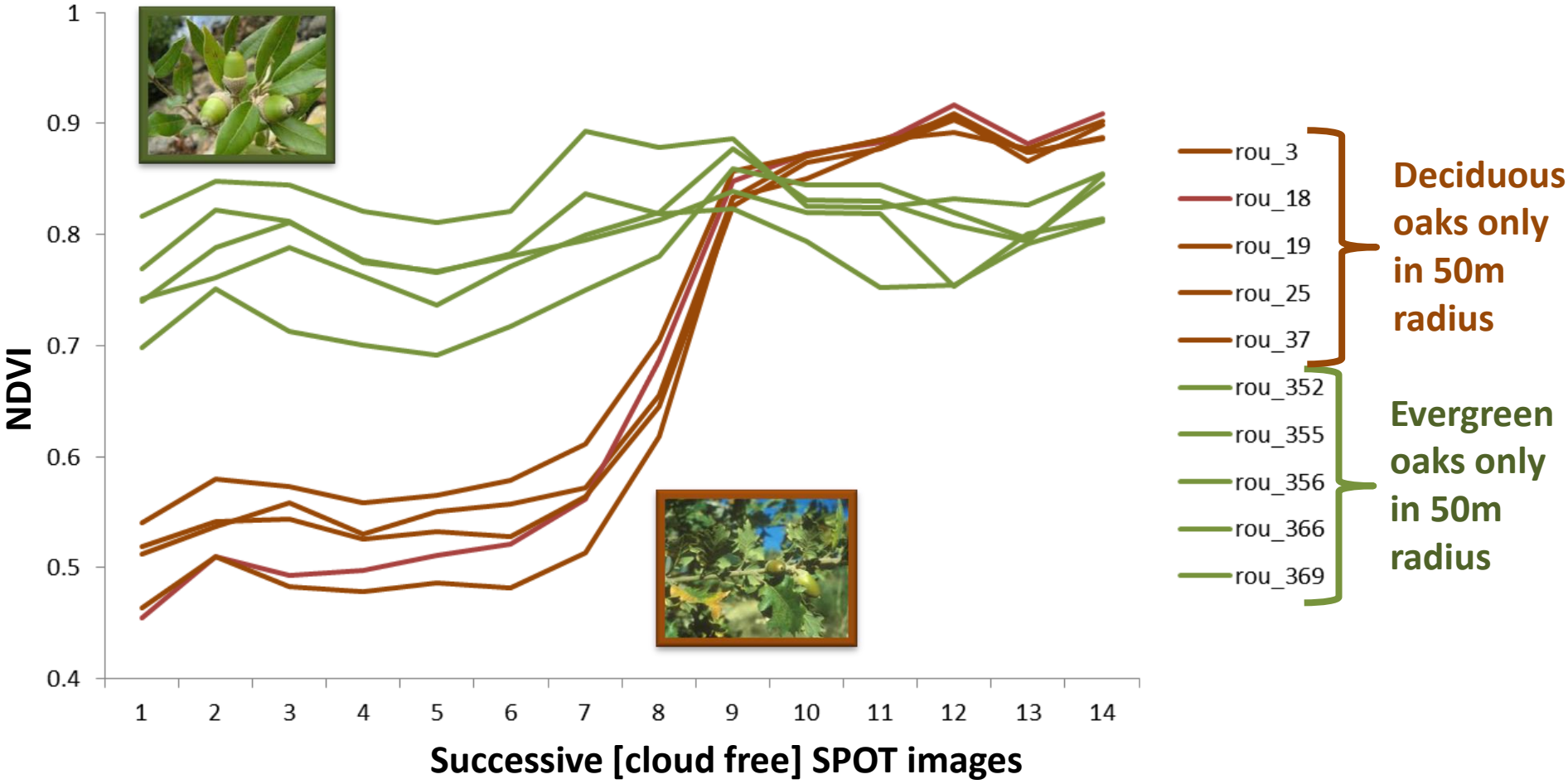
SPOT NDVI to infer bird foraging distance

Can we use NDVI filters of increasing size to infer realised blue tit foraging distance when feeding offspring in the nest?



NDVI radius important at the fledging stage peaks at 50m

SPOT NDVI time series



- SPOT imagery accurately predicts NDVI signatures of deciduous and evergreen oaks along the season
- MODIS analyses are scheduled to infer pixel-based start of season statistics across several phenological cycles

Summary

- SPOT imagery explains up to 55% of variance in [deciduous] oak number as measured in the field and is thus in good agreement with ground data

- It is a valuable proxy when ground vegetation data is not available

THANK YOU!!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MARIE CURIE ACTIONS