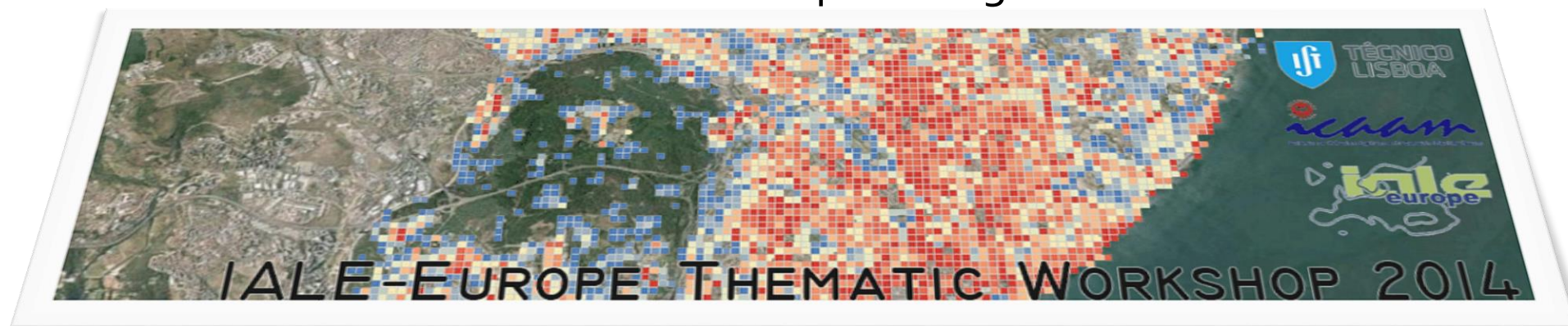


AGRICULTURAL LANDSCAPE SEGMENTATION

a stochastic method to map heterogeneous variables



Research group

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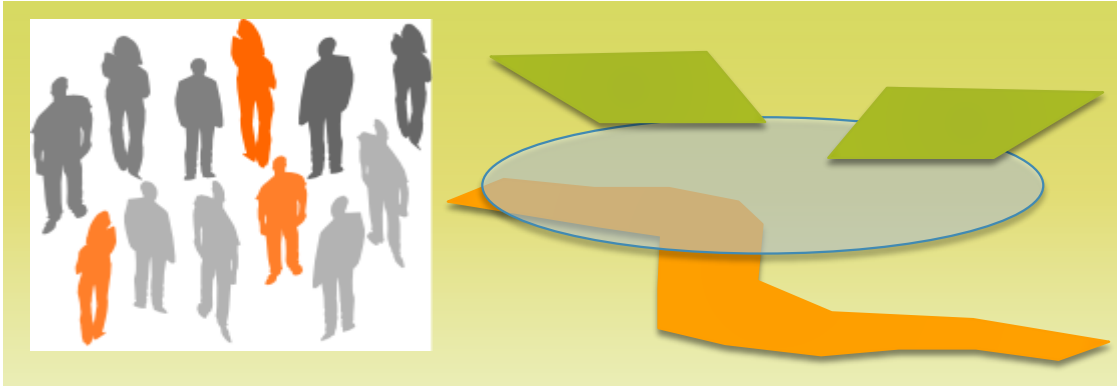
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Introduction #1 | Agricultural landscape management

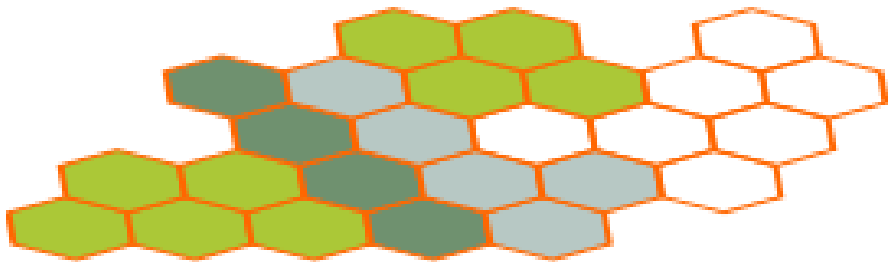


Agricultural landscapes are composed of many land management units.



Involved stakeholders or specific research foci can define these units differently

Straume, 2014
Zanten et al., 2013

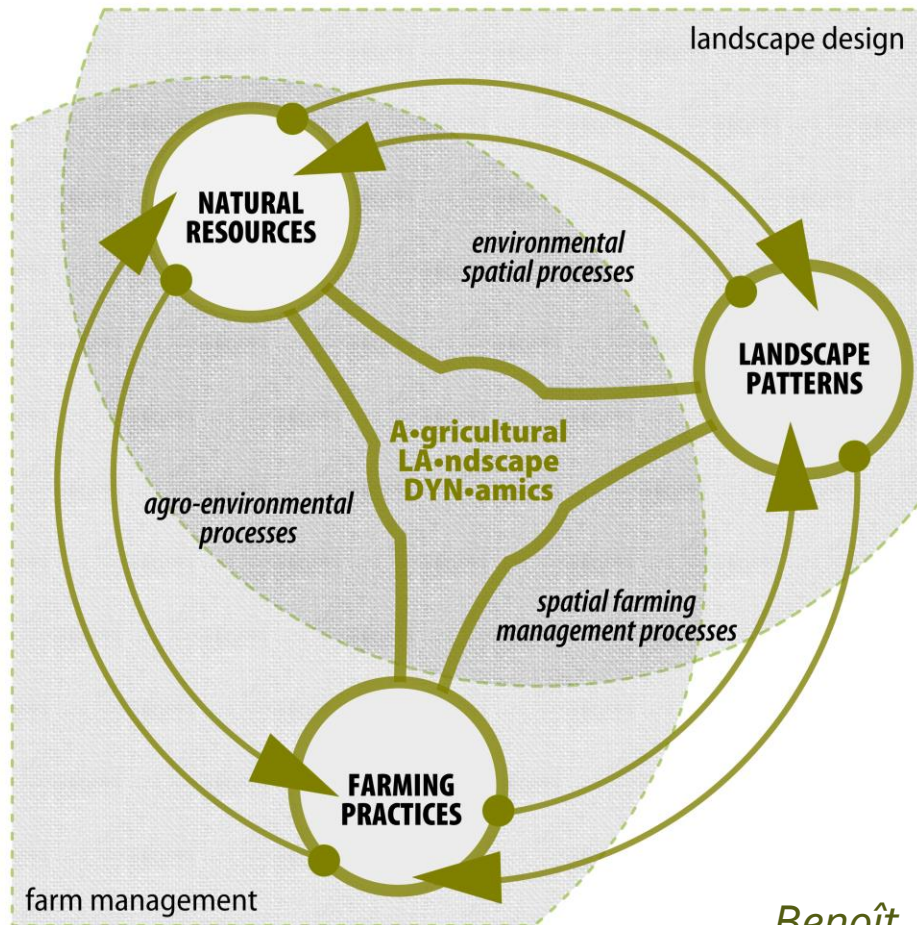


Innovative approaches to address temporal and spatial dynamics using multiple data sources

Brown et al., 2013
Rizzo et al., 2013

biblio at <http://bit.ly/IALE2014>

Introduction #2 | Landscape agronomy



Agricultural land uses:
randomly distributed among fields
managed by farmers ?

Understanding how
spatial organization & temporal evolution
of farming practices
reveal logical processes and driving forces

a major challenge for landscape agronomists

Benoît, Rizzo et al., 2012

biblio at <http://bit.ly/IALE2014>

Aim | context-wise landscape segmentation

Temporospatial method...

Mari et al. 2013

Arpentage is a HMM based software specifically developed to perform (un)supervised segmentations of agricultural landscapes

Mignolet 2008

Developed to map **crop sequences** as support to evaluate agricultural impact on water quality and on biodiversity

Lazrak et al. 2009

...to map landscape regularities

Test this method in new contexts with an explicit landscape agronomic approach

Profile of **heterogeneous spatial data** instead of (crop) time sequences

Focus on abandoned areas in a Mediterranean terraced landscape dominated by olive groves

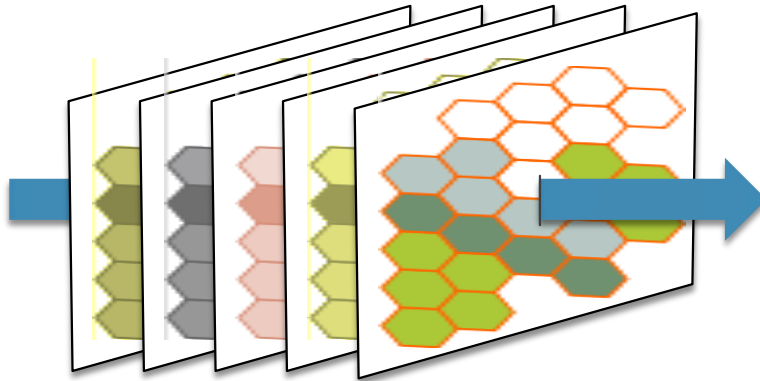
HMM = Hidden Markov Model

biblio at <http://bit.ly/IALE2014>

Methods #1 | Landscape segmentation

**Space
dominant**

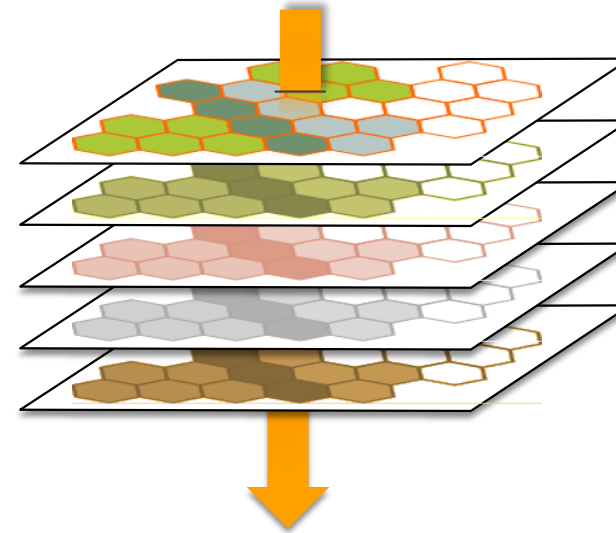
*sequence of
images*



Software for LUCC analysis generally implement unsupervised clustering on spatial entities based on space-dominant attributes

**Time
dominant**

*image of
sequences*



Data mining approaches involving clustering of sequences allowed knowledge extraction to get a landscape description in terms of land-use patterns

Mari et al. 2013, EMS • Lazrak et al. 2009 & Schaller et al. 2012, Lands Ecol

biblio at <http://bit.ly/IALE2014>

Methods #2 | ArpentAge

French acronym for: Landscape Regularities Analysis: Environment, Territory, Agronomy
Arpenter is a French verb meaning *to survey*

It relies on a stochastic principle to model time space landscape regularities on 2 Markovian assumptions

probably the 1st software in the agronomic area implementing a time-dominant model and processing time-space data.

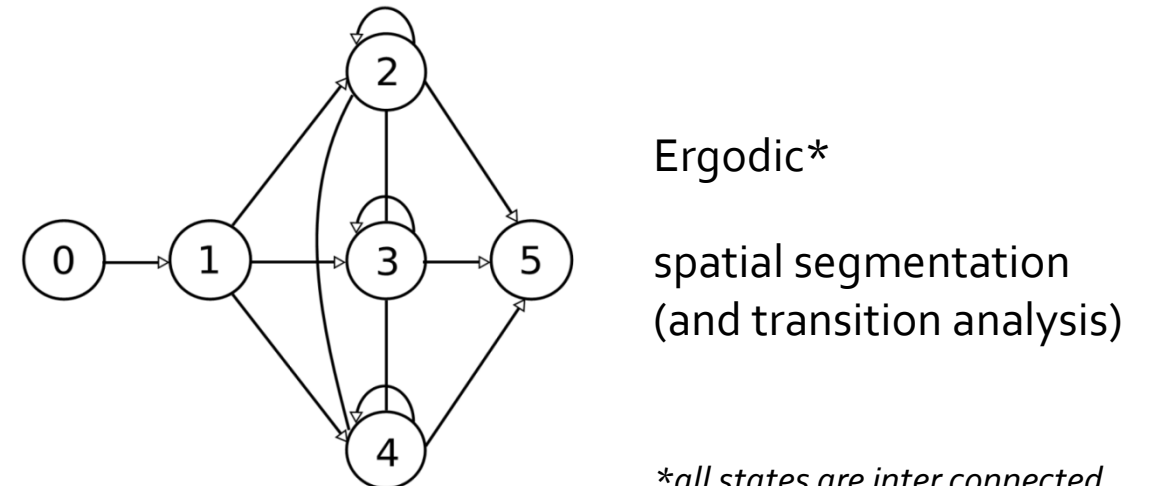
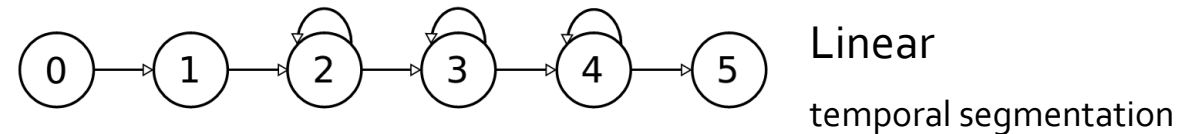
Markov chain

land use of a given field in a year depends only on the land-use of the recent previous years in the same field.

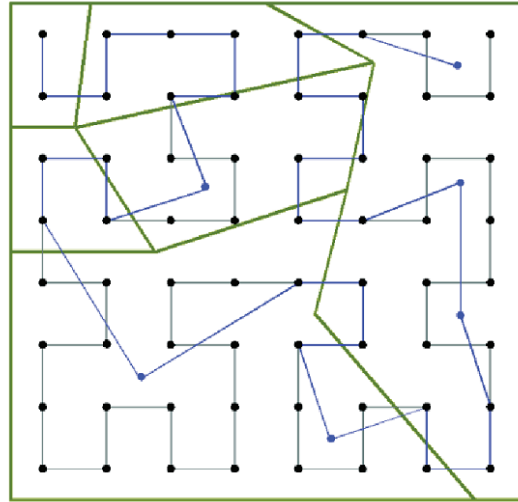
Markov random field

land use of a given field depends only on the land-use of the neighboring fields

free download: <http://www.loria.fr/~jfmari/App>

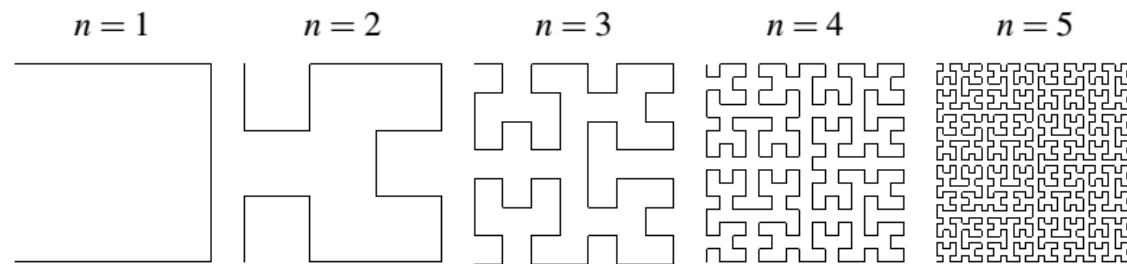


Methods #3 | Approximating a MRF by a HMM



the Hilbert-Peano fractal curve is used to approximate the Markov Random Field (**MRF**) assumption through a Hidden Markov Model (**HMM**)

a space filling curve allows to approximate the 2D as a simple chain



Lazrak 2012, PhD thesis

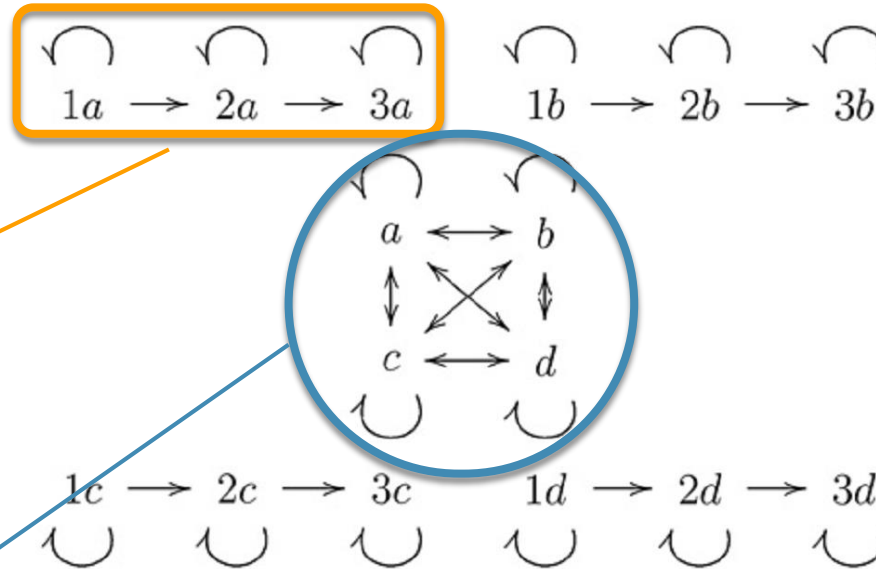
biblio at <http://bit.ly/IALE2014>

Methods #4 | hierarchical model

Two stochastic processes can be represented, the first (hidden) driving the second (known and visible)

Each "super state" of a "super model" is a HMM (generally linear) to describe the (time) sequences

Hierarchical HMM is strictly ergodic to segment the landscape into patches of homogeneous time sequences



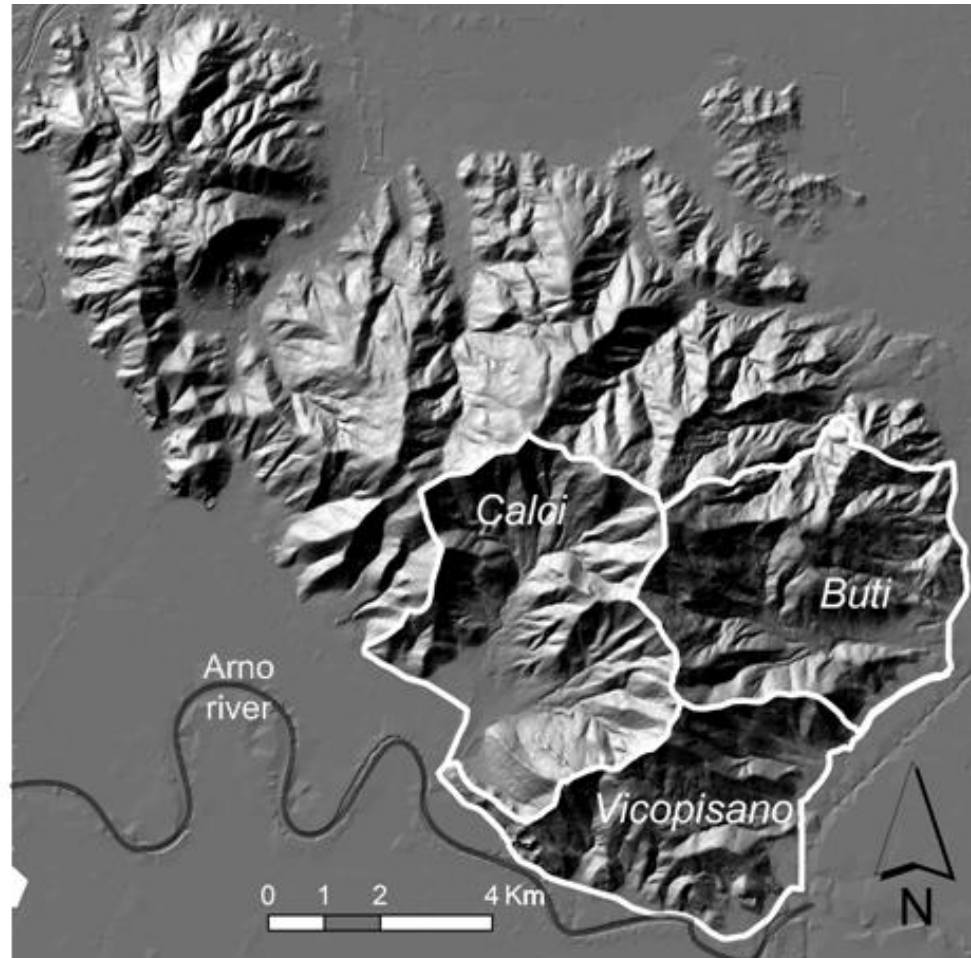
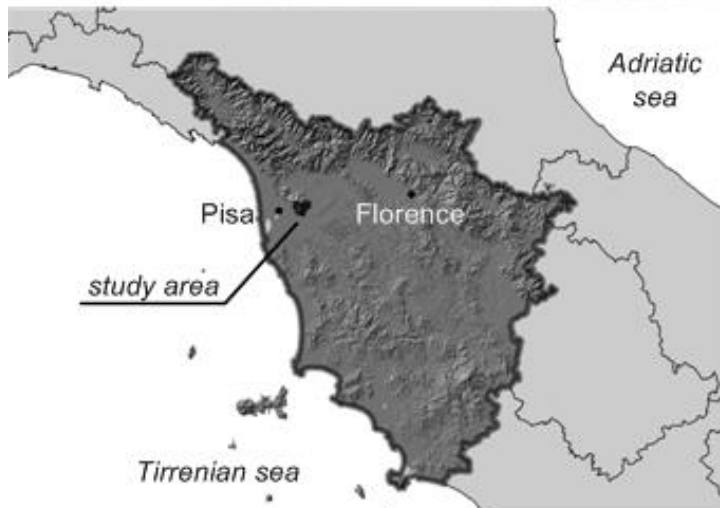
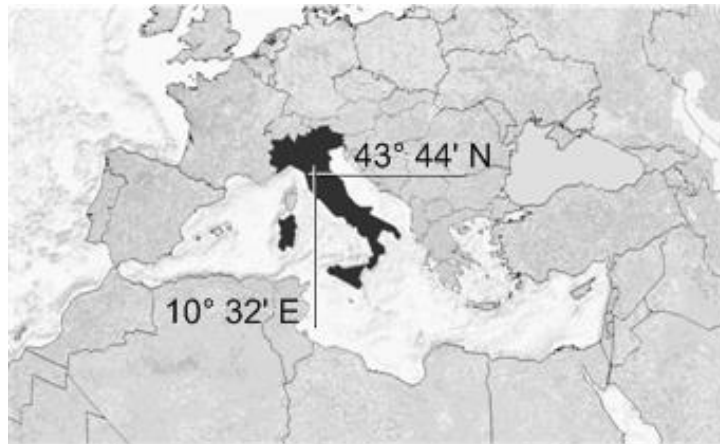
Combining heterogeneous data to deal with drivers of management dynamics (instead of pixels)

ArpentAge instead of clustering because "context-wise" (cf. fractal curve)

Context-wise landscape segmentation focused on management related variables

HMM = Hidden Markov Model

Materials #1 | study area: *Monte Pisano*



Mediterranean terraced olive grove farming system (62 km²)

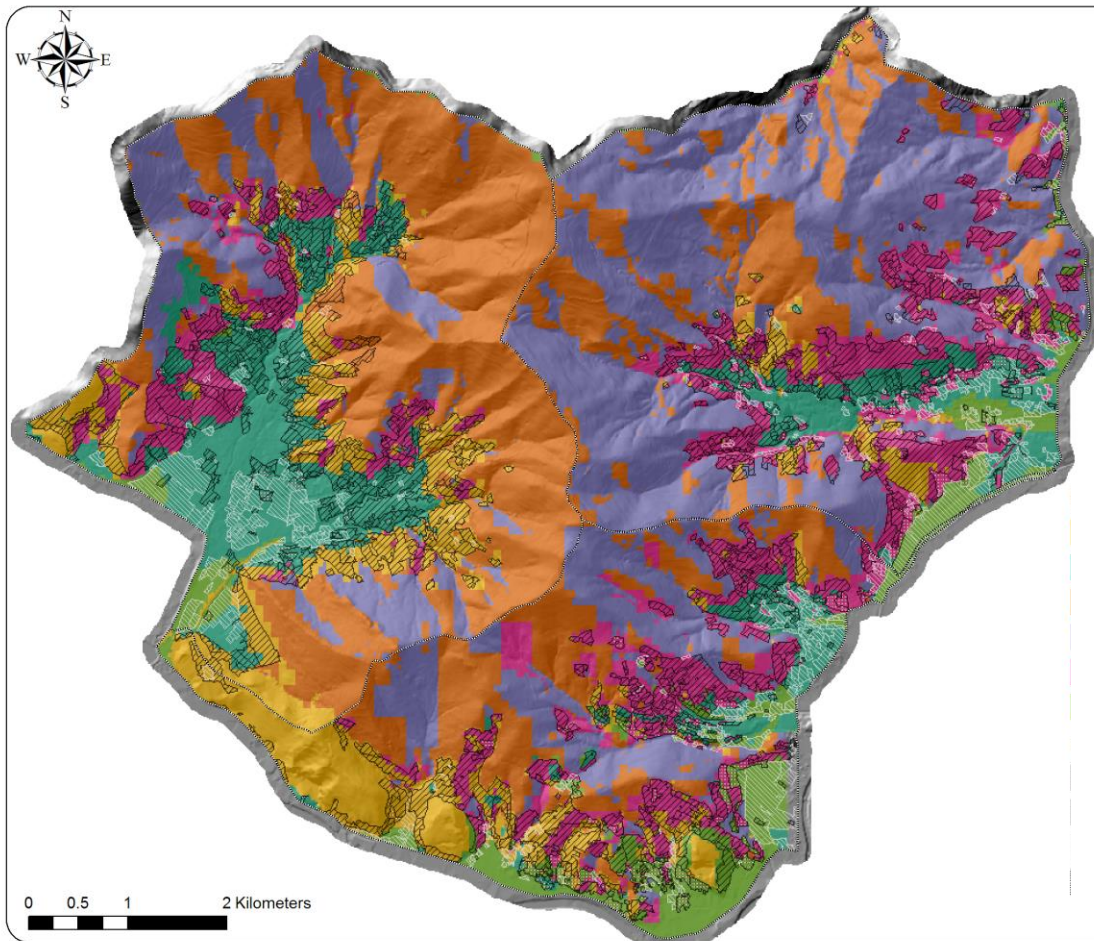
Materials #2 | input data

Geology	5 cl.	• anthropic • alluvial & sand-loam sediments • quartzes • limestone • schist
Orientation	4 cl.	N, S, E, W
Morphology	4 cl.	• Plains • valleys • slopes • ridges
Land cover	14 cl.	• Urban • garden • cultivated olive groves • abandoned olive groves • vineyards • orchards • arable lands • fallows • garigues • outcrops • wetland vegetation • water • pine wood • wood
Terrace type	5 cl.	(bench) terraces • talwegs • pocket terraces • broad field terraces • extensive
Dry-stone wall density	6 cl.	From 0 to 44.5 m/ha (natural breaks)

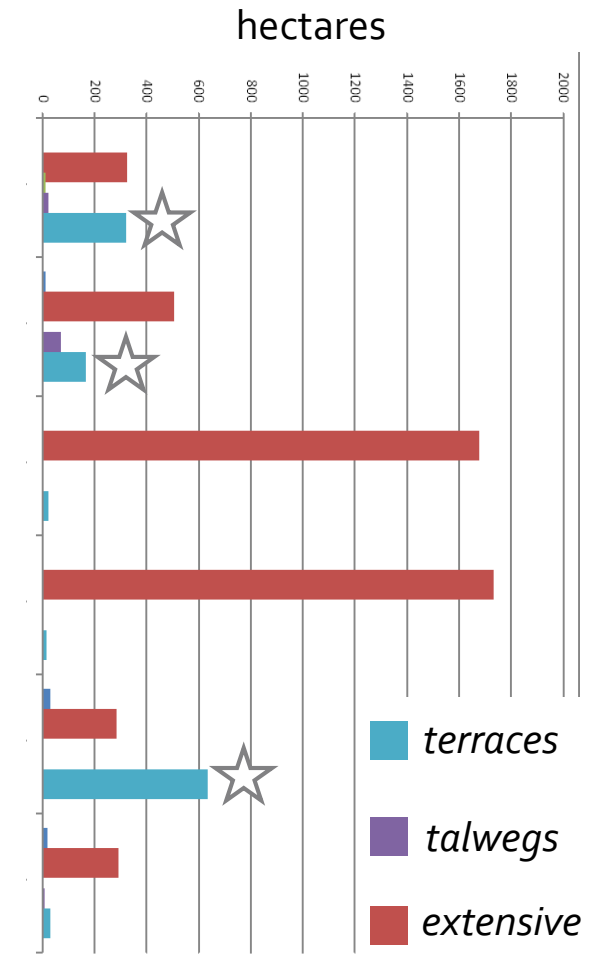
Layers were sampled on a 10m regular point grid

Markov random field approximated to a hidden Markov model using a space-filling curve

Results #1 | an output map

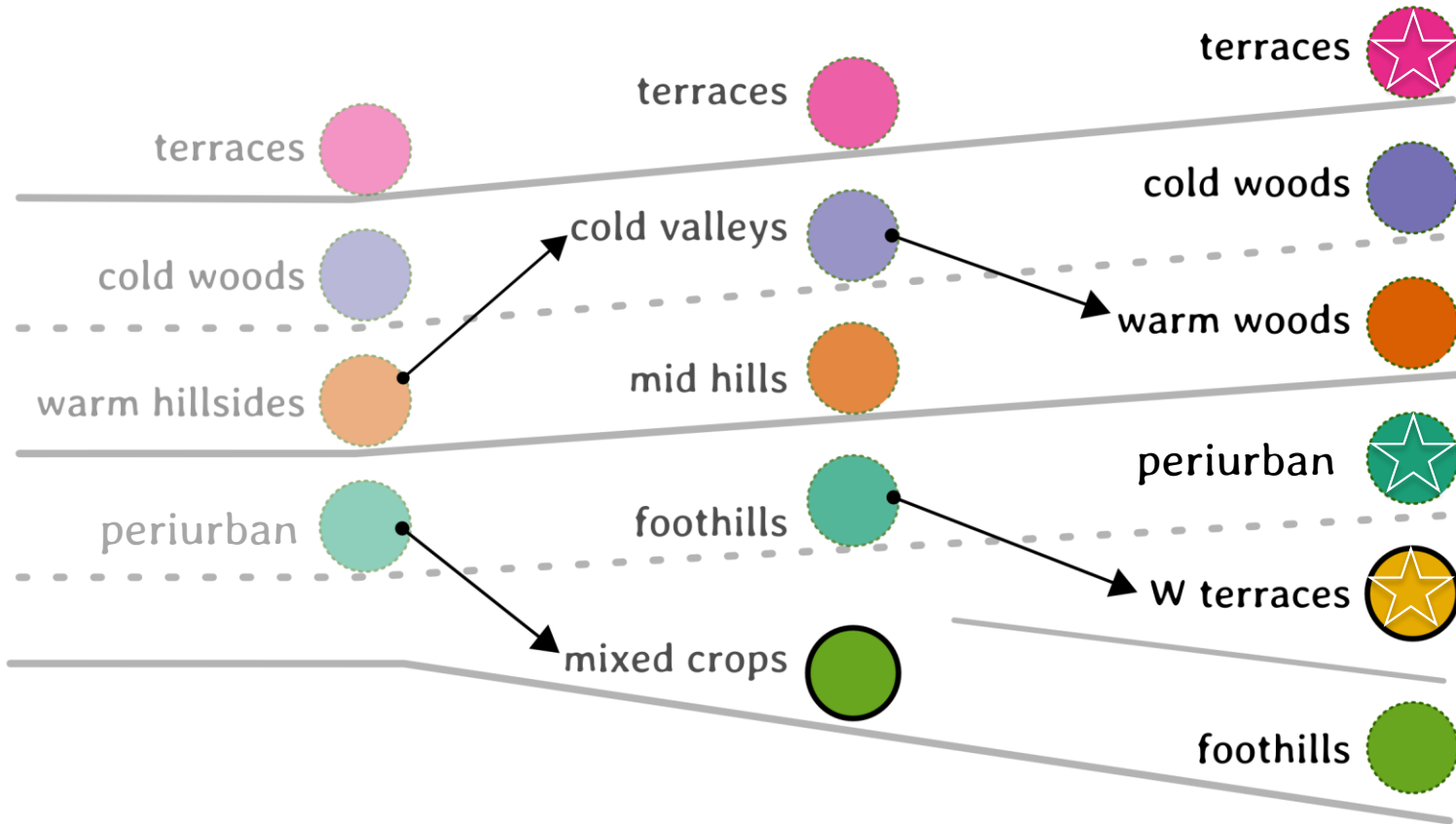


- West exposed terraces
- periurban
- warm woods
- cold woods
- terraced groves
- foothills



Results #2 | variable segmentation

The increasing segmentation allows to define a hierarchy of the variables



Three major management regions:

- Terraced groves
medium-high density DSW on quartz, E-S oriented with some garigues and pine woods

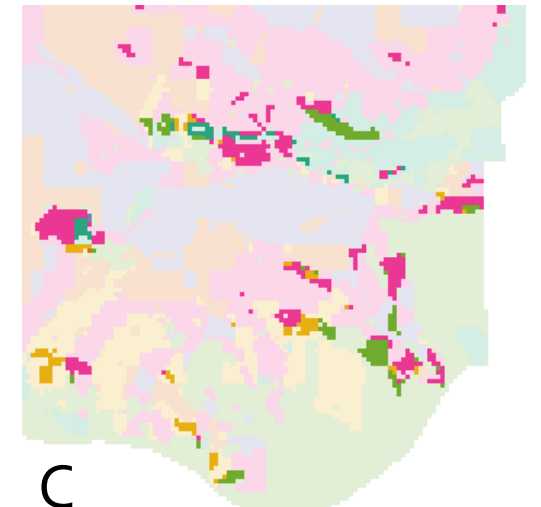
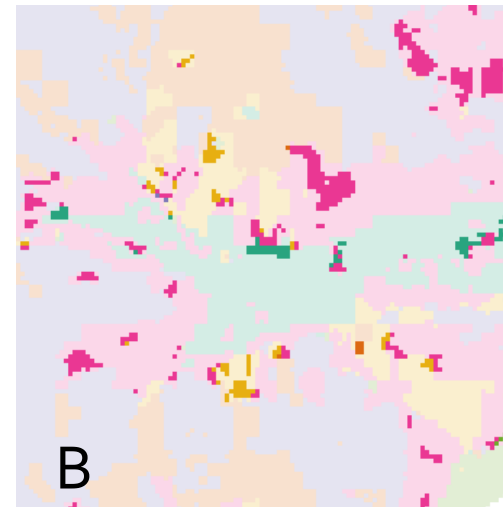
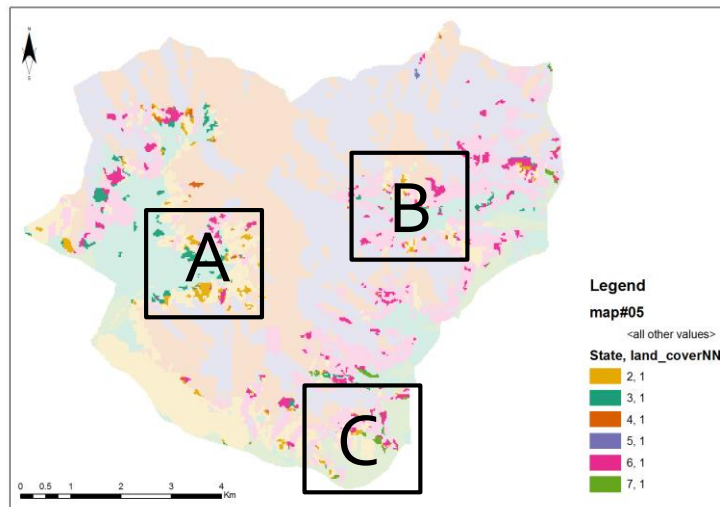
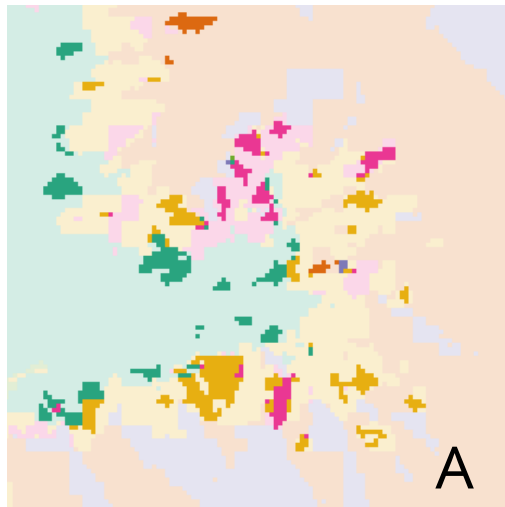
- Woods
may differ for morphology or exposition

- Foothills
may be segmented for specific terrace types, mix with urban land cover or plain morphology



Especially relevant for management issues

Results #3 | location of abandoned olive groves



● West exposed terraces

● periurban

● terraced groves

● foothills

Western side

Eastern side

prevalently associated to the cluster grouping the foothills, with the prevalence of the anthropic bedrock and S-W exposition

prevalently associated to sand-loam sediment area, with low density terraced in valleys.

Conclusions and perspectives

Leverages...

variable choice

e.g., what if we introduce proximity to road?

to
further
explore

input variable **classification**
type and number of classes

variable input **quality**
different geometric scales

HHMM parameterization
space filling curve, number of states

...and potentials

Flexibility of variables treated
remote sensing map, census data, etc.

Flexibility of scale of analysis
potentially no limit if input data are defined coherently to the research question

*Future applications could address the temporospatial characterization of **agricultural practices** at the **watershed scale***

*9th IALE World Congress
July 5-10, 2015
Portland, Oregon*

Participate !

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FERGUSON Rafter Sass,
BENOIT Marc,
PADOA-SCHIOPPA Emilio

Landscape agronomy: advances and challenges of a new field addressing the management of rural land systems

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read more at
http://bit.ly/IALE2015_Symposium_LA

