

# How to translate narrative scenarios in landscape dynamics

Application to the introduction of irrigation in vineyards





Context

Application to mediterranean watershed

Conclusion and perspectives





## Context

Evolution of mediterranean vineyards

Climate change and their consequences

On the use of geopropective to derive spatial land use/cover maps

## Application to mediterranean watershed

La Peyne watershed

Analysis of trends and their driving forces

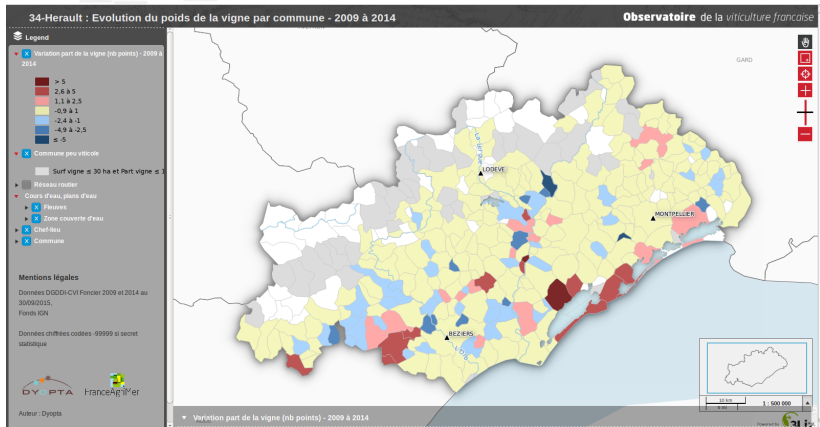
Future landscapes

Model construction and implementation

## Conclusion and perspectives



# Vineyards crises



Observatoire de la viticulture française, powered by 3Liz using QGIS server





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# Ecosystem services provided by vineyard landscapes

## Soil and water preservation

- ▶ Inondations
- ▶ Soil erosion
- ▶ Drought



Le Monde, 2015



Cévenol episode, Olivier Huttel 2014



# Ecosystem services provided by vineyard landscapes



PNAS

## Climate change, wine, and conservation

Lee Hannah<sup>1,2</sup>, Patrick R. Roehrdanz<sup>3</sup>, Makihiko Ikegami<sup>4</sup>, Anderson V. Shepard<sup>5,6</sup>, M. Rebecca Shaw<sup>7</sup>, Gary Tabor<sup>8</sup>, Lu Zhi<sup>9</sup>, Pablo A. Marquet<sup>10,11</sup>, and Robert J. Hijmans<sup>12</sup>

<sup>1</sup>The Betty and Gordon Moore Center for Ecosystem Science and Economics, Conservation International, Arlington VA 22202; <sup>2</sup>Iverson School of Environmental Science and Management, University of California, Santa Barbara, CA 93106; <sup>3</sup>Environmental Defense Fund, San Francisco CA 94105; <sup>4</sup>Center for Large Landscape Conservation, Bozeman, MT 59717; <sup>5</sup>Center for Nature and Society, School of Life Sciences, Peking University, Beijing 100871, China; <sup>6</sup>Departamento de Ecología, Pontificia Universidad Católica de Chile, Alameda 340, Santiago, Chile; <sup>7</sup>Terra Pa Institute, Santa Fe, NM 87505; <sup>8</sup>Instituto de Ecología y Biología, Pontificia Universidad Católica de Chile, Alameda 340, Santiago, Chile; <sup>9</sup>Laboratorio Internacional de Cambio Global, Pontificia Universidad Católica de Chile, Alameda 340, Santiago, Chile; and <sup>10-12</sup>Department of Environmental Science and Policy, University of California, Davis, CA 95616

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## Vineyard production

- ▶ Shift of cultivated area
- ▶ Adaptation of agriculture

Hannah et al 2013, PNAS

...BUT...

LETTER

Why climate change will not dramatically decrease viticultural suitability in main wine-producing areas by 2050

Leeuwen et al 2013, PNAS





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# Geoprosective

**Step 1**

**SYSTEM ANALYSIS**

- Trends analysis
- Driving forces
- Seeds of future changes

**Step 2**

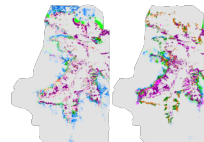
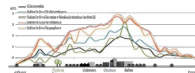
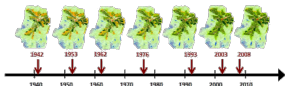
**SCENARIO ELABORATION**

- Definition of scenario assumptions
- Modelling landscape futures

**Step .3**

**SCENARIO ASSESSMENT**

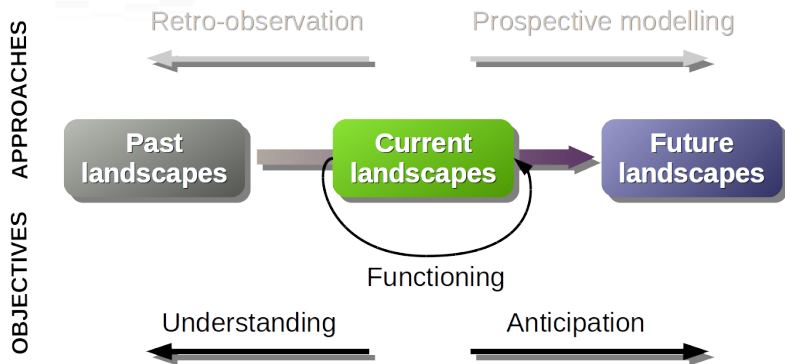
- Environmental assessment
- Stakeholders' assessment



Houet 2010



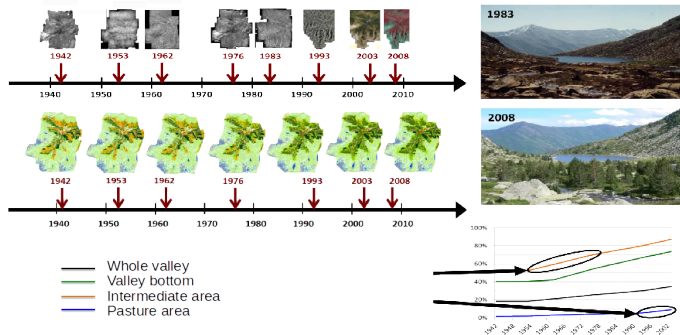
# A method based on landscape observation



Houet 2010



# System analysis of past trends



Characterizing trends and driving forces for extrapolation

Houet 2010





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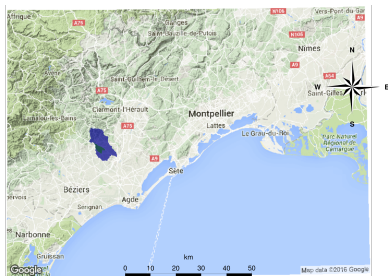
## Conclusion and perspectives



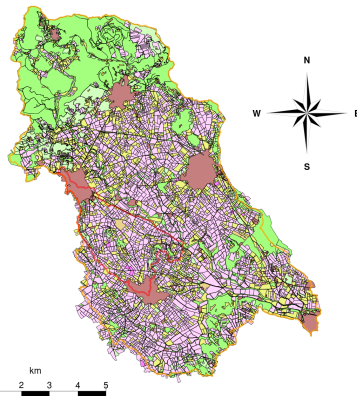
# The diachronic dataset

## Description of the zone

- ▶ A 80 km<sup>2</sup> watershed
- ▶ approximately 8000 fields in 2012
- ▶ A majority of vineyards



Google map view



- Urbanized areas
- Other arable lands
- Transitional vineyard
- Gobelet vineyard
- Aligned vineyard
- Orchards
- Forests
- Sclerophyllous vegetation



# The diachronic dataset

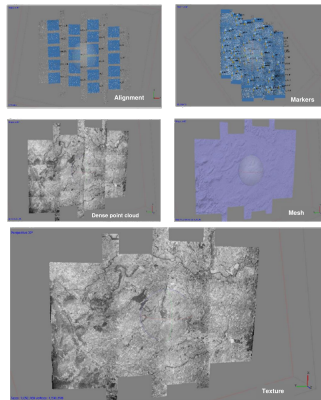


## Orthorectification procedure

- ▶ Aerial campaigns downloaded from IGN (1962-2001)
- ▶ Image alignment
- ▶ Markers pinpointing
- ▶ Meshing and texture draping
- ▶ Creation of the orthophoto

## Satellite images

- ▶ Orthophotos from 2003-2012



Photogrammetric analyses



# The diachronic dataset

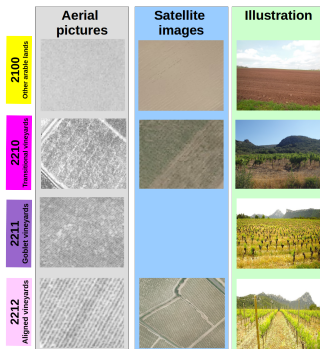
## Land use/cover classification

- ▶ Based on Corine Land Cover
- ▶ Supplementary level added for vineyards
  - ▶ Goblet vines
  - ▶ Aligned vines

- Urbanized areas
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Classification levels

Classification for cultivated land uses







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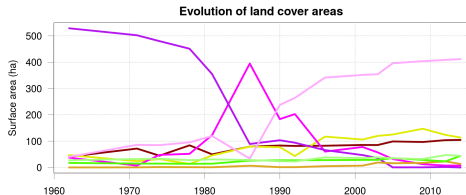
## Conclusion and perspectives



# Mediterranean landscape trends (Past Landscapes)

## A brutal conversion of vineyards

- ▶ Introduction of mechanization
- ▶ Planting new varieties of vines
- ▶ Urban expansion of main towns



Evolution of land uses during the entire period





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# Describing future landscapes using narrative scenarios

## Prospective study

- ▶ Reference scenario : extrapolation of past trends
- ▶ Introduction of irrigation

**Urbanized areas followed its expansion along roads networks whereas vineyards surfaces declined slowly on high slopes for abandoned vines.**

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## Prospective study

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**Vineyards are irrigated on catchment area surrounding water river and according to dam potential. Urbanized areas followed its expansion along roads networks. Other vineyards with low potential are progressively abandoned.**



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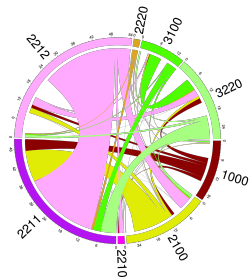
# A model for geopropective



## Narrative scenarios

- ▶ Temporal trends via transition matrices
- ▶ Spatially explicit drivers
- ▶ Field scale

- |                         |                             |
|-------------------------|-----------------------------|
| ■ Urbanized areas       | ■ Orchards                  |
| ■ Other arable lands    | ■ Forests                   |
| ■ Transitional vineyard | ■ Sclerophyllous vegetation |
| ■ Goblet vineyard       |                             |
| ■ Aligned vineyard      |                             |



Simulation of temporal dynamics using markov chains



# A model for geopropective

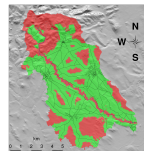


## Narrative scenarios

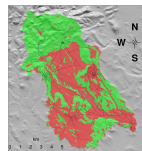
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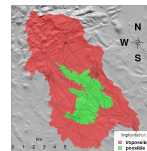
Urbanized areas



Low-potential Vines



Irrigated vines



## Examples of spatially explicit constraints



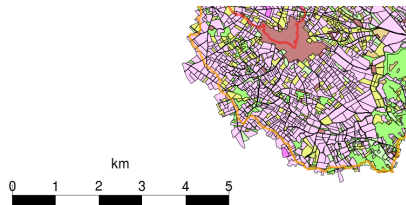


# A model for geopropective

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Zoom to field level



# Application of the model to narrative scenarios



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# Conclusion and perspectives

## Limits of the model and perspectives

- ▶ Simplicity of spatially explicit constraints
- ▶ Number of parameters and equifinality
- ▶ Spatial and temporal variability of trends non implemented
- ▶ Coupling with mechanistic model of landscape functioning : erosion and runoff to quantify impact of land use/cover change on ecosystem services

## Potential of the model

- ▶ Compact representation of narrative scenarios
- ▶ Flexibility and portability of the model (R platform)
- ▶ Introduction of new land uses in response to climate change (drought-resistant varieties, for example)
- ▶ Genericity to other study areas (implementation in progress in Tunisia and Morocco)

