

Ecosystem services and land use changes: a case study of forest expansion in a peri-urban area

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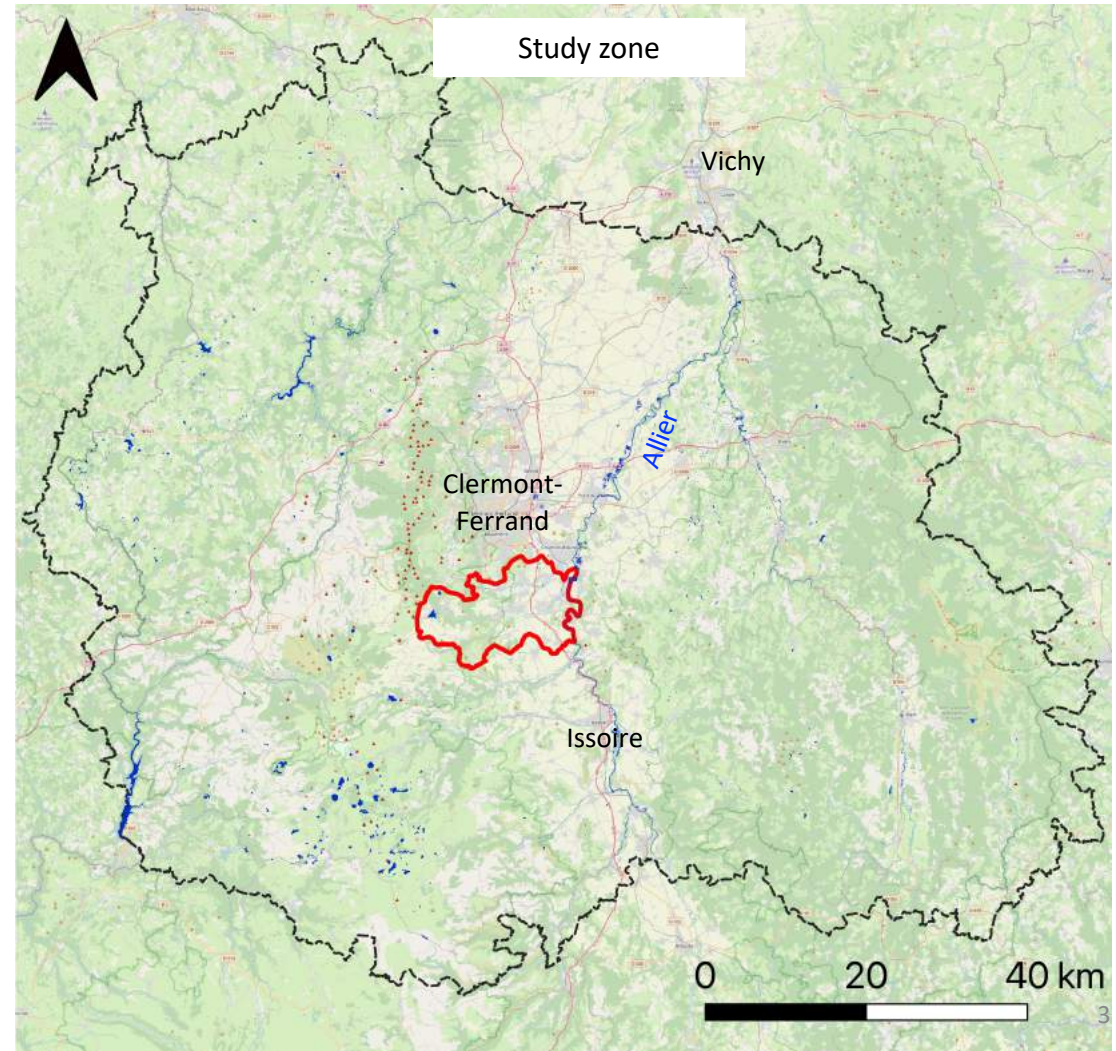
Context and questions

- Land-use and land cover: change over time
 - Driven by anthropogenic factors or non-anthropogenic factors (or both)
 - Modifications of ecosystems conditions
 - Ecosystem services capacity and supply
 - Linked to ecosystems conditions (vegetation, soil)
- ➔ How did LULC change in the last decades ?
- ➔ How do ecosystem services change with LULC ?
- ➔ What drives ES levels ?

Study zone

- 165 km²
- South of an urban area
- Between 400m and 1000m a.s.l.
- Diversified (topography, stakeholders, activities)

Puy-de-Dôme





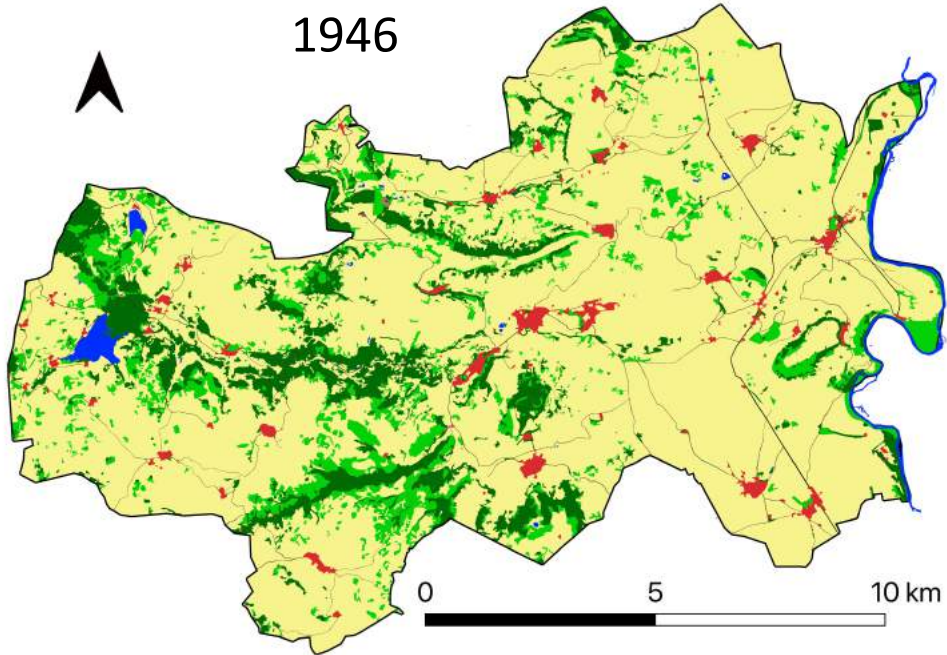
Methods

Land-use and land cover changes

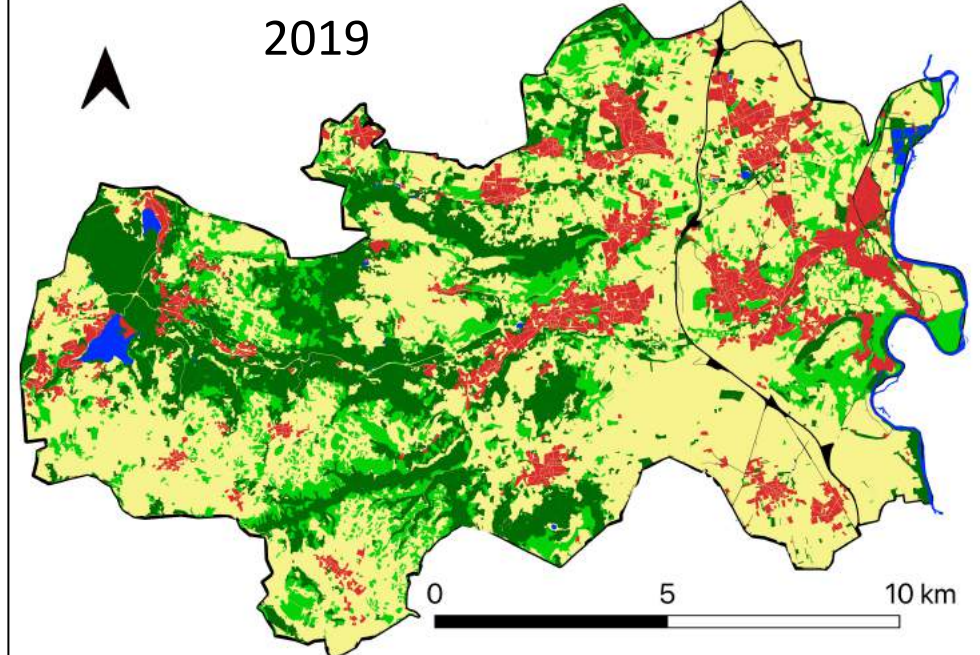
- LULC maps of 1946 and 2019
- Field characterization

Land-use and land cover

1946



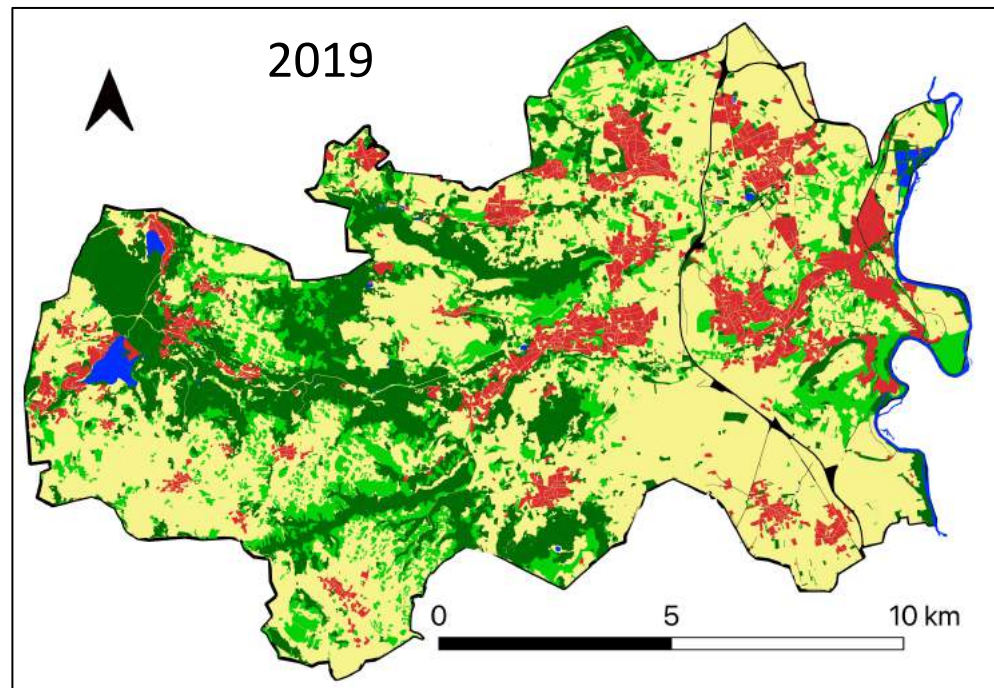
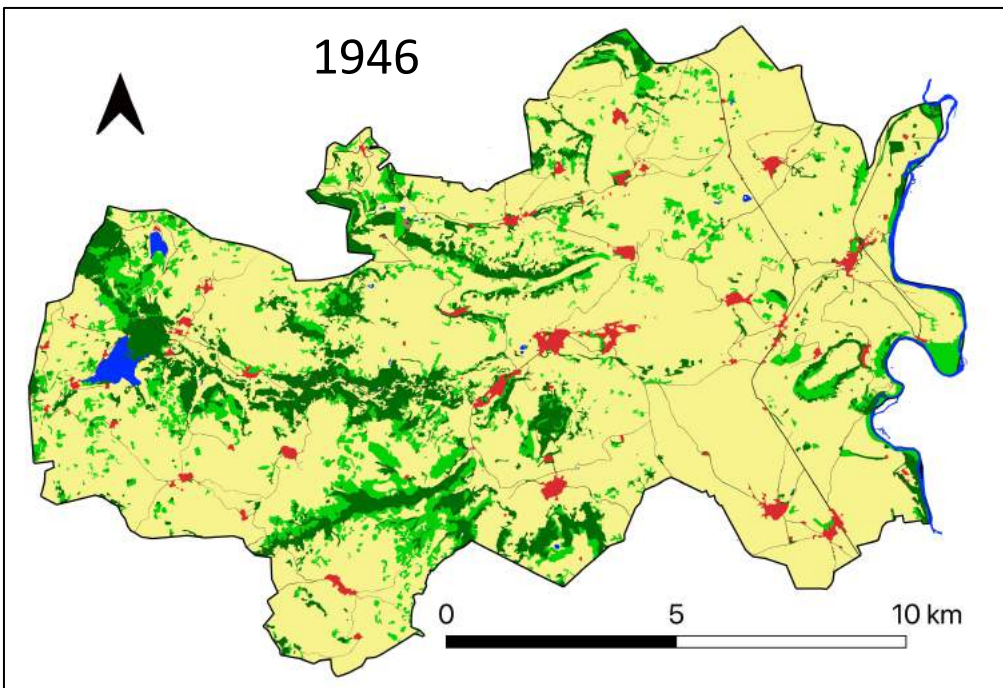
2019



LULC

-  Crops and grasslands
-  Shrublands
-  Woodlands
-  Water
-  Urban areas
-  Main roads

Land-use and land cover



LULC

- Crops and grasslands
- Shrublands
- Woodlands
- Water
- Urban areas
- Main roads

Agricultural abandonment, forest succession and urbanization :

Woodlands x2.2

Shrublands x1.6

Urban areas x5.3

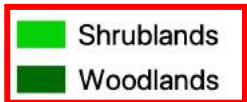
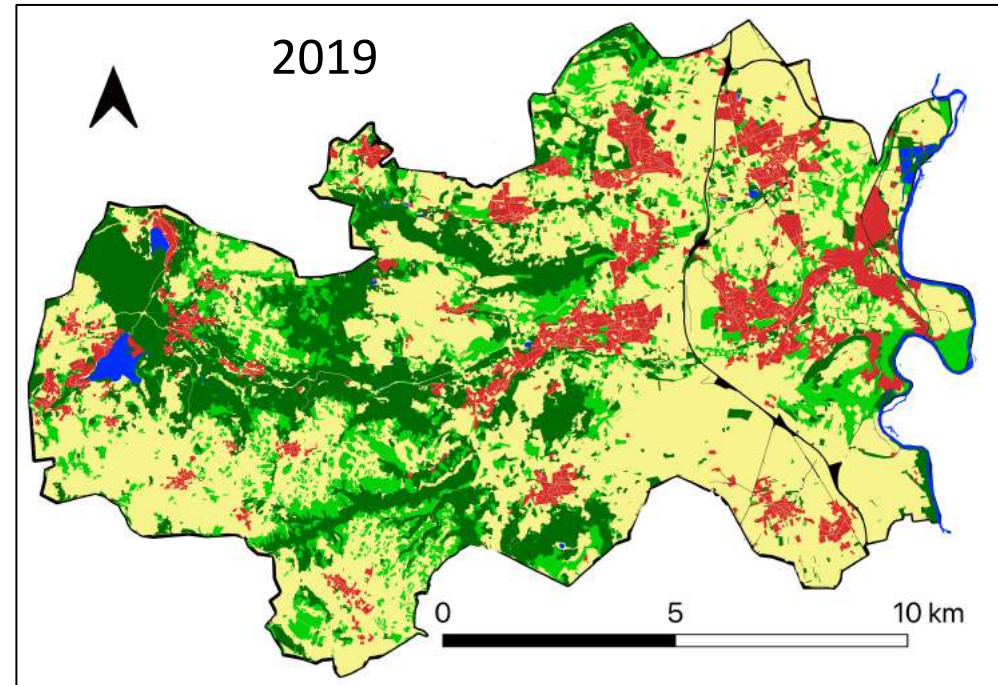
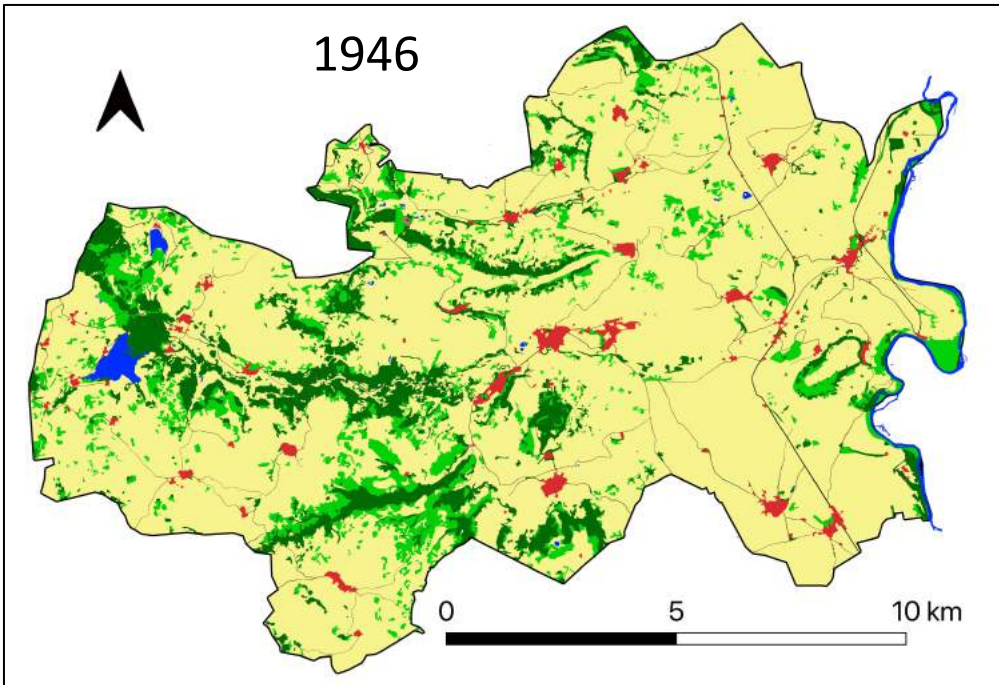
Demography

1946: 9988 inhab.

2016: 26219 inhab.

→ x 2.6 in 70 years

Land-use and land cover

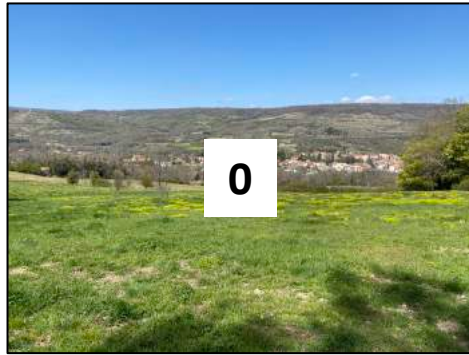


Focus

- ➔ How do ecosystem services change with LULC ?
- ➔ What drives ES levels ? **Forest succession ?**

Land-use and land cover

- 5 post cultural succession stages



0

in use



1



2



3



5



4

Methods

Land-use and land cover changes

- LULC maps of 1946 and 2019
- Field characterization

Ecosystem services measures

- Carbon stock
- Soil sensitivity to erosion
- Maintenance of soil fertility



x5 plots = 25

Carbon stock: methods

- Multiple pools

- Aboveground : grasses, shrubs, trees (living, dead)

- Sampling
- Measures *in situ* + allometric equation

- Belowground : roots

- Ratio

- In the soil

- Sampling
- topsoil, 4 replicates per plot

IPCC, 2006

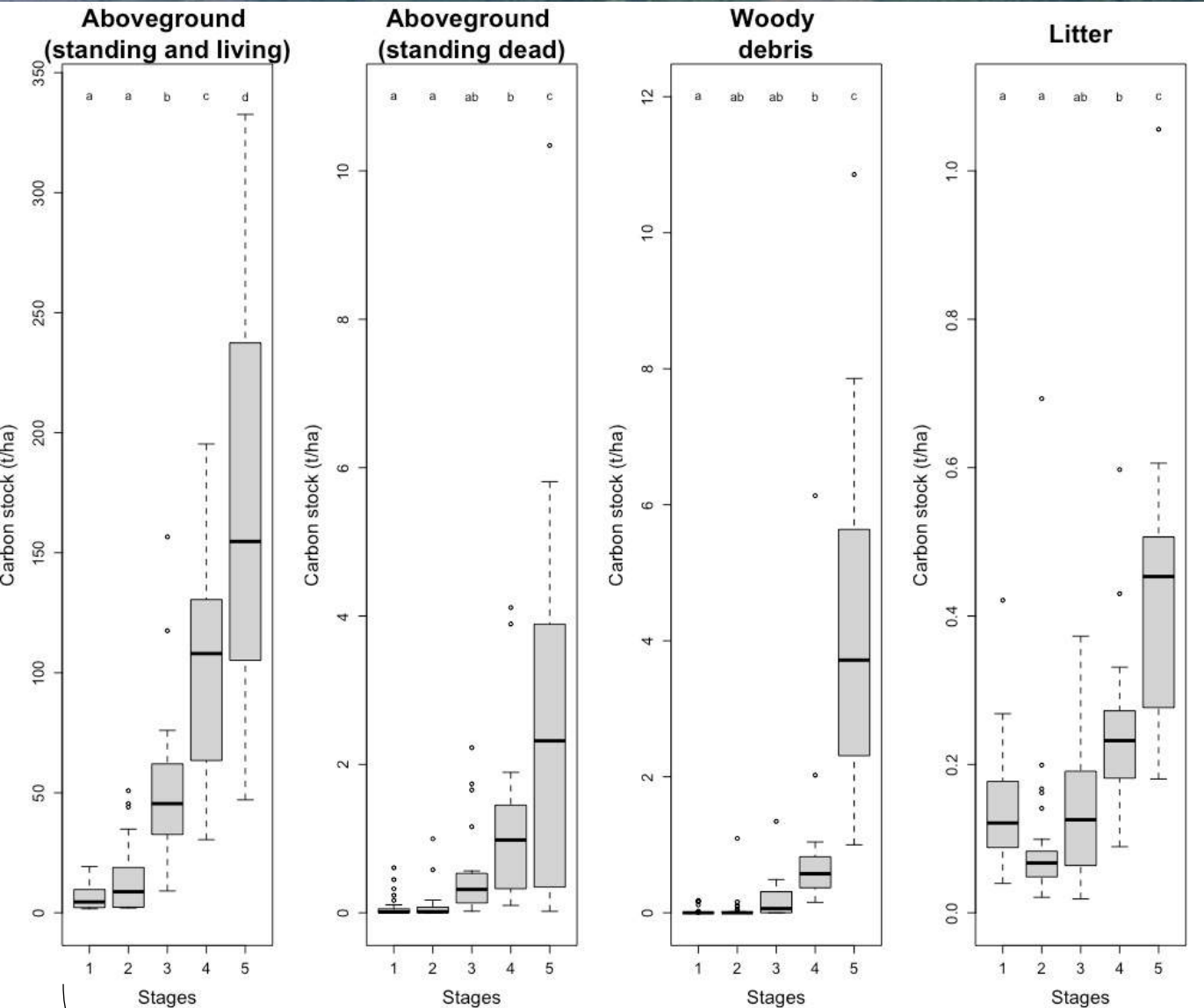
Bartholomé *et al.* 2018

Montero *et al.* 2013

Zianis 2008

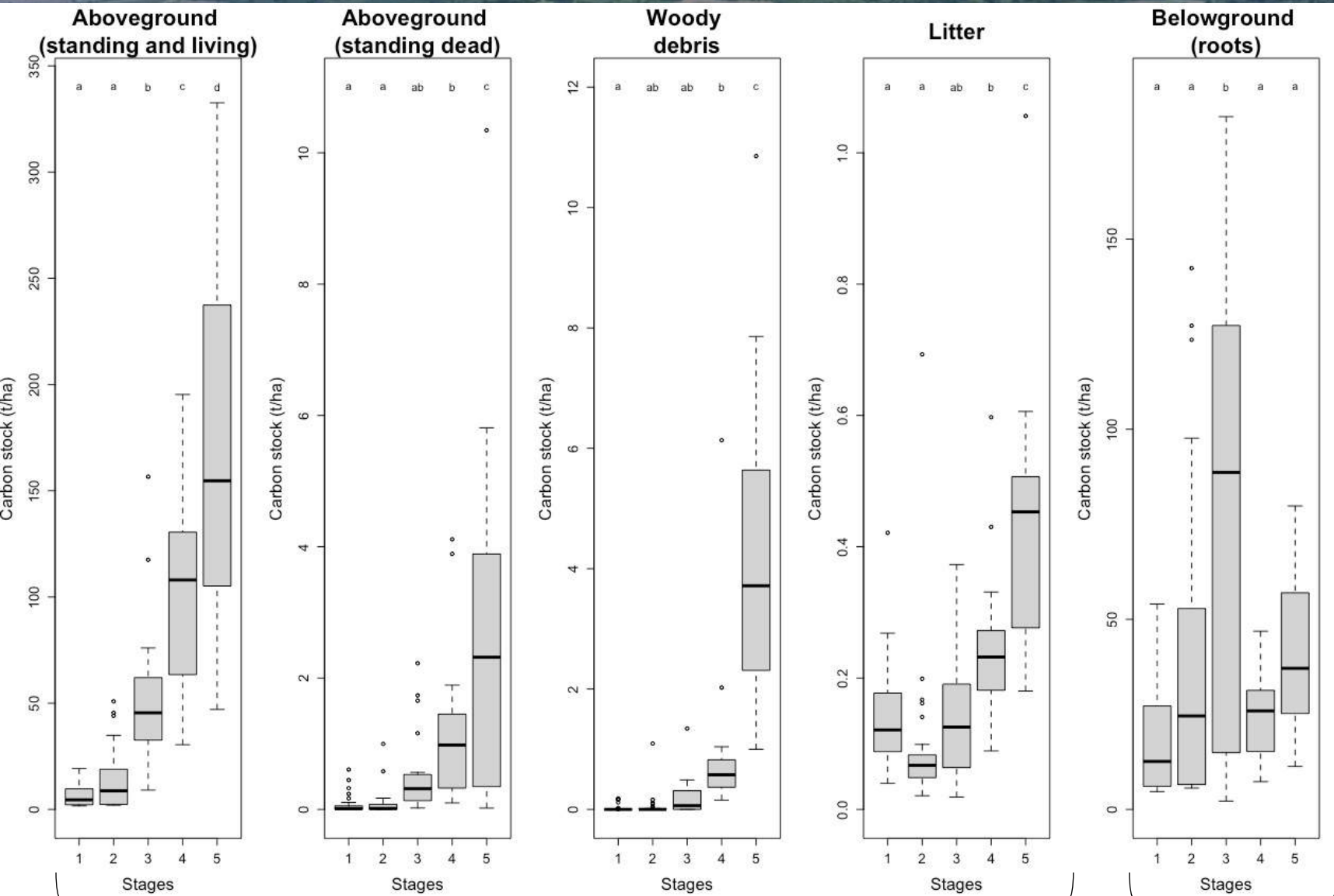
Balloy *et al.* 2017

Carbon stock



C stock increase with succession

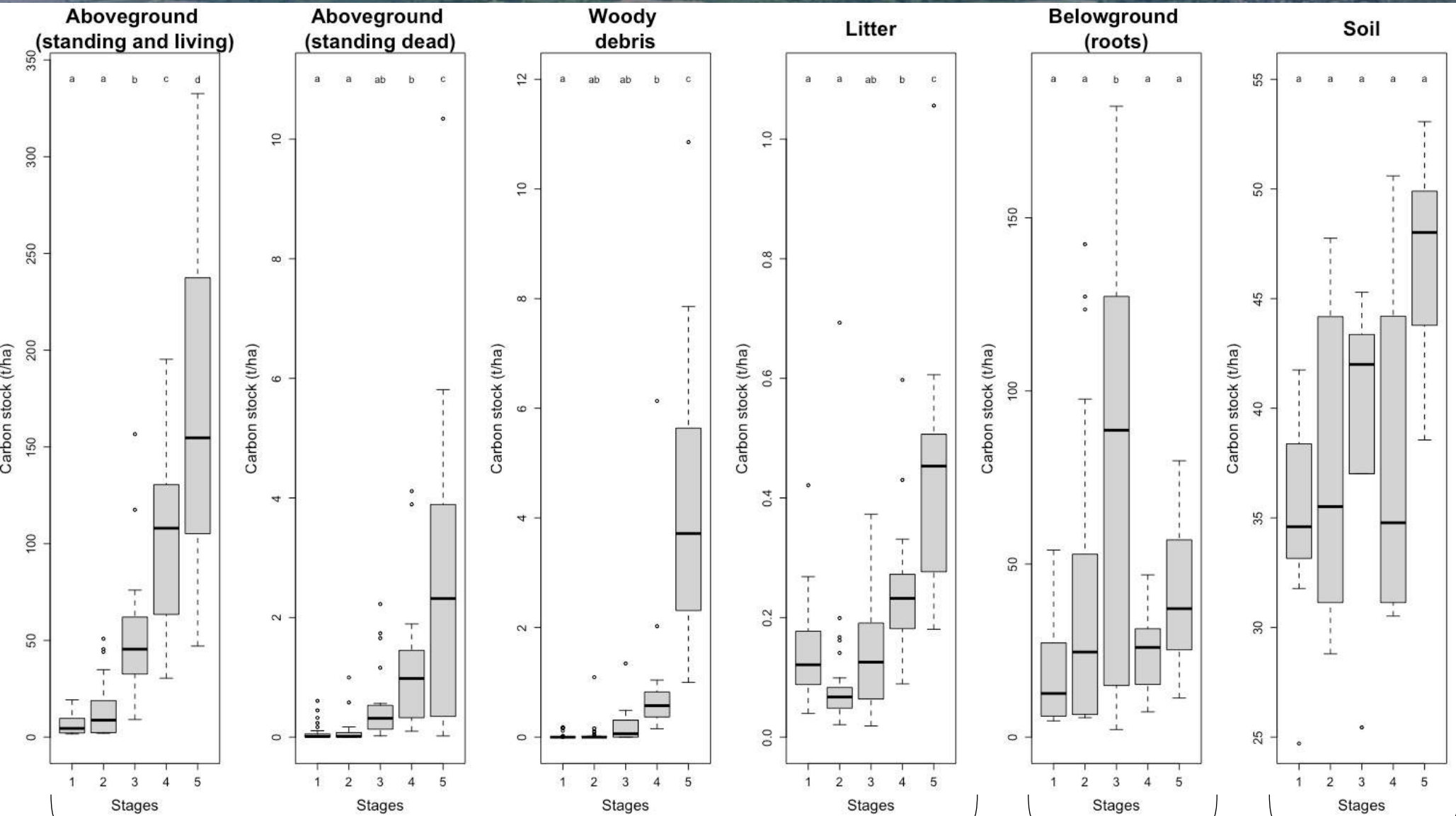
Carbon stock



C stock increase with succession

Stock higher in intermediate stage

Carbon stock

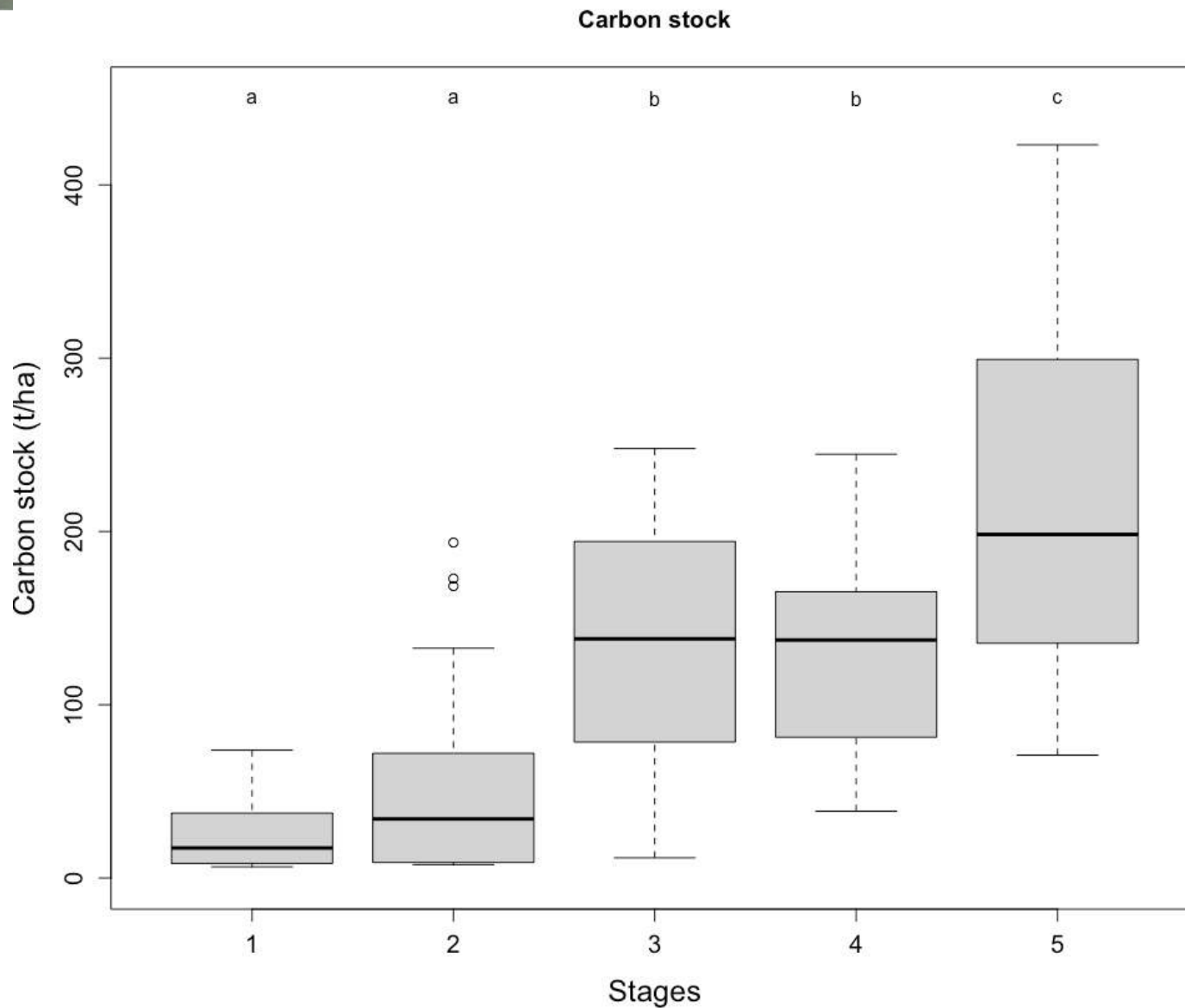


C stock increase with succession

Stock higher in intermediate stage

No statistical difference

Carbon stock



- Carbon stock increase with succession

Soil sensitivity to erosion: methods

Parameters :

- Soil bulk density : cylinder method
 - Soil texture : sampling
- topsoil, 4 replicates per plot

Jepsen *et al.* 1997

Hieke and Schmidt 2013

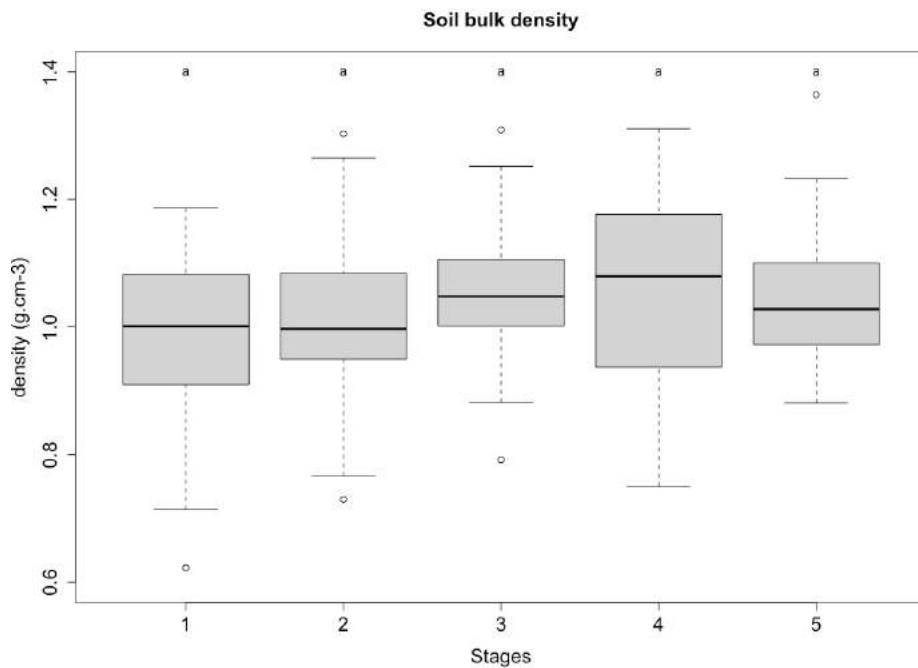
Soil sensitivity to erosion

Parameters :

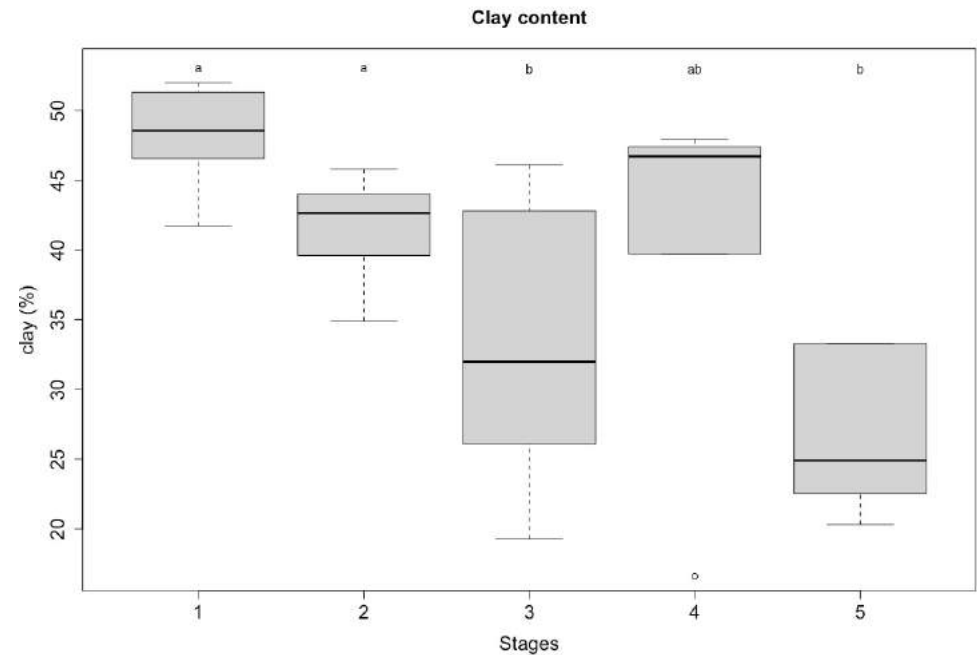
- Soil bulk density : cylinder method
 - Soil texture : sampling
- topsoil, 4 replicates per plot

Jepsen *et al.* 1997

Hieke and Schmidt 2013



Bulk density : no variation



Clayey soils less affected by erosion
(Hieke and Schmidt 2013)



Soil fertility: methods

Parameters :

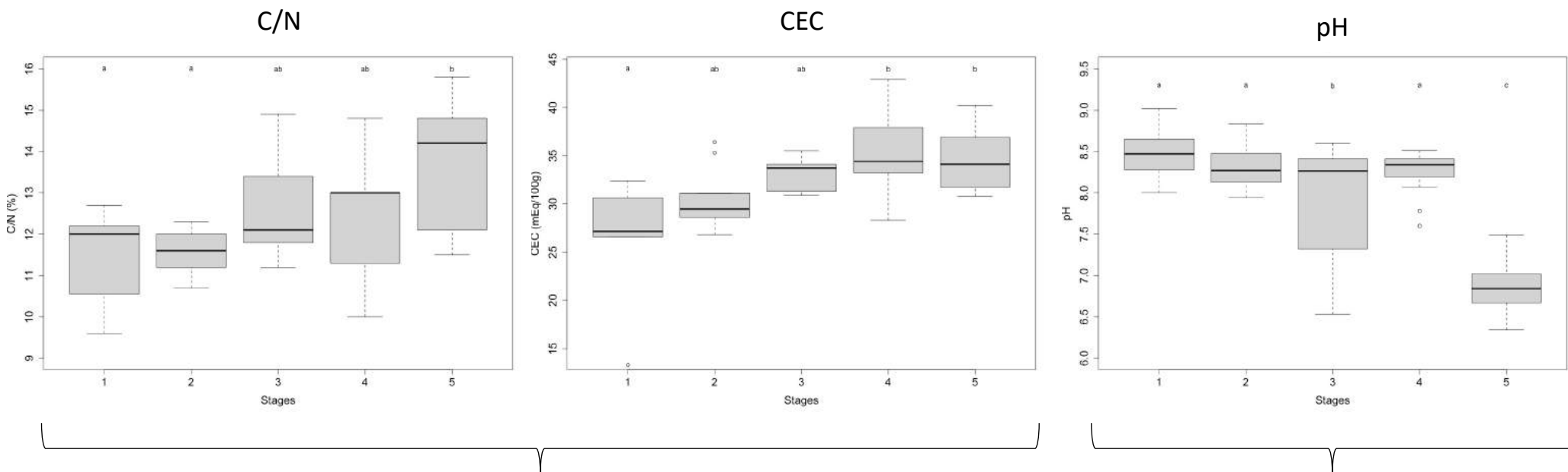
- C/N
 - Cation exchange capacity
 - pH
- sampling, topsoil, 4 replicates per plot

Soil fertility

Parameters :

- C/N
- Cation exchange capacity
- pH

→ sampling, topsoil, 4 replicates per plot



C/N and CEC increase
with succession

pH decreases (8.5 → 6.8)

Conclusion



- Post-cultural succession
 - Carbon stock: increase, 1-2 and 3-4 similar
 - Soil erosion: no uni-directional response
 - Fertility: C/N increase, CEC increase, pH decrease
- ES levels drivers
 - Succession stage is a driver of ES levels
 - Heterogeneity in some stages
 - Other drivers to consider: soil (mainly lithosols and brunisols), bedrock, topography, plant species
- Shrublands and woodlands development: an issue for stakeholders

**Thank you for your
attention**



References

- Hieke, F., & Schmidt, J. (2013). The effect of soil bulk density on rill erosion-results of experimental studies. *Zeitschrift für Geomorphologie*, 57(2), 245-266.
- Burkhard, B., Kroll, F., Müller, F., & Windhorst, W. (2009). Landscapes' capacities to provide ecosystem services-a concept for land-cover based assessments. *Landscape online*, 15, 1-22.
- Mayer, L. A. R. Y. (2000). Satellite remote sensing of flood related landscape change resulting from hurricanes in Baja California and the southwestern United States. *IAHS PUBLICATION*, 201-214.
- Čuka, A., Mirošević, L., Faričić, J., & Graovac Matassi, V. (2017). Phylloxera revisited: The spread of grapevine disease in Dalmatia and its influence on socio-economic development and agricultural landscape. *Annales-Anali za Istrske in Mediteranske Studije-Series Historia et Sociologia*, 27(1), 101-118.
- Eggleston, H. S., Buendia, L., Miwa, K., Ngara, T., & Tanabe, K. (2006). 2006 IPCC guidelines for national greenhouse gas inventories.
- Bartholomé, O., Grigulis, K., Colace, M. P., Arnoldi, C., & Lavorel, S. (2018). Methodological uncertainties in estimating carbon storage in temperate forests and grasslands. *Ecological Indicators*, 95, 331-342.
- Montero, G., Pasalodos-Tato, M., López-Senespleda, E., Onrubia, R., & Madrigal, G. (2013). Ecuaciones para la estimación de la biomasa en matorrales y arbustados mediterráneos. 6CFE01-139.
- Zianis, D., & Mencuccini, M. (2004). On simplifying allometric analyses of forest biomass. *Forest Ecology and Management*, 187(2-3), 311-332.
- Balloy, B., Bispo, A., Bouthier, A., Chenu, C., Cluzeau, D., Degan, F., & Metzger, L. (2017). Tour d'horizon des indicateurs relatifs à l'état organique et biologique des sols.
- Jepsen, R., Roberts, J., & Lick, W. (1997). Effects of bulk density on sediment erosion rates. *Water, Air, and Soil Pollution*, 99(1), 21-31.
- Lavorel, S., Grigulis, K., Leitinger, G., Kohler, M., Schirpke, U., & Tappeiner, U. (2017). Historical trajectories in land use pattern and grassland ecosystem services in two European alpine landscapes. *Regional environmental change*, 17(8), 2251-2264.
- Jepsen, M. R., Kuemmerle, T., Müller, D., Erb, K., Verburg, P. H., Haberl, H., ... & Reenberg, A. (2015). Transitions in European land-management regimes between 1800 and 2010. *Land use policy*, 49, 53-64.