

# A GAME OF... CHAIRS, MUSICAL CHAIRS

A theory-building Agent-Based approach to agro-pastoral landscapes in Eurasia

Andreas Angourakis, Agnese Fusaro, Verónica Martínez Ferreras, Josep M. Gurt

Session #672 - CAA @ EAA: *Computational Models in Archaeology*

available at [https://andros-spica.github.io/EAA2018\\_simulation/](https://andros-spica.github.io/EAA2018_simulation/)

[https://andros-spica.github.io/EAA2018\\_simulation/index.html?print-pdf](https://andros-spica.github.io/EAA2018_simulation/index.html?print-pdf) (printable version)



UNIVERSITAT DE  
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Facultat de Geografia  
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DE LA UNIVERSITAT DE BARCELONA



GOBIERNO  
DE ESPAÑA



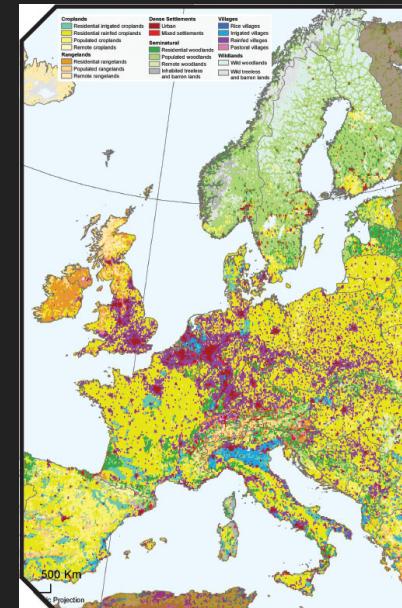
SIMULPAST  
SIMULATING THE PAST TO UNDERSTAND HUMAN BEHAVIOUR

**EAA 2018**

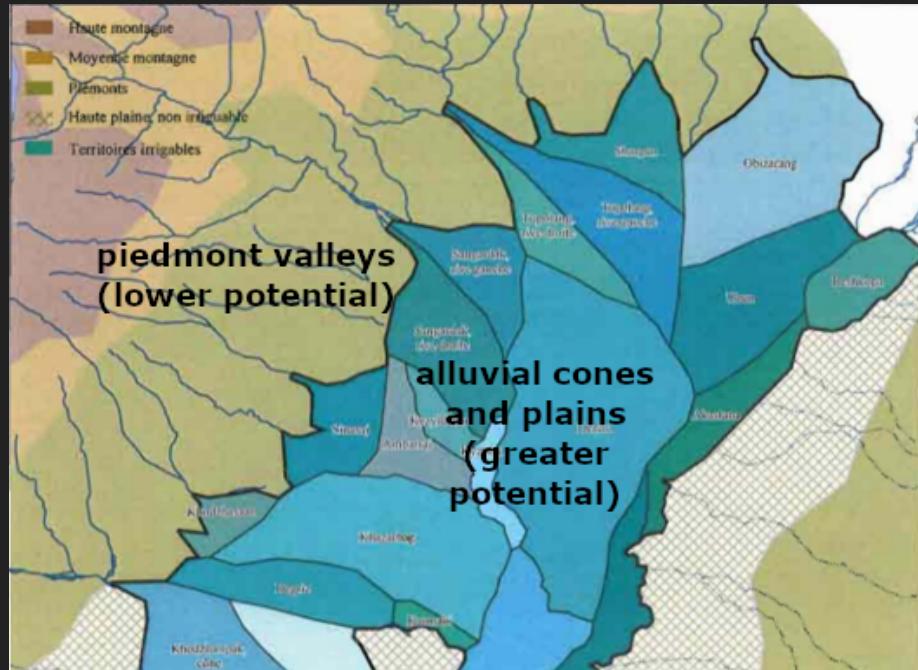
BARCELONA,  
5-8 SEPTEMBER  
REFLECTING FUTURES



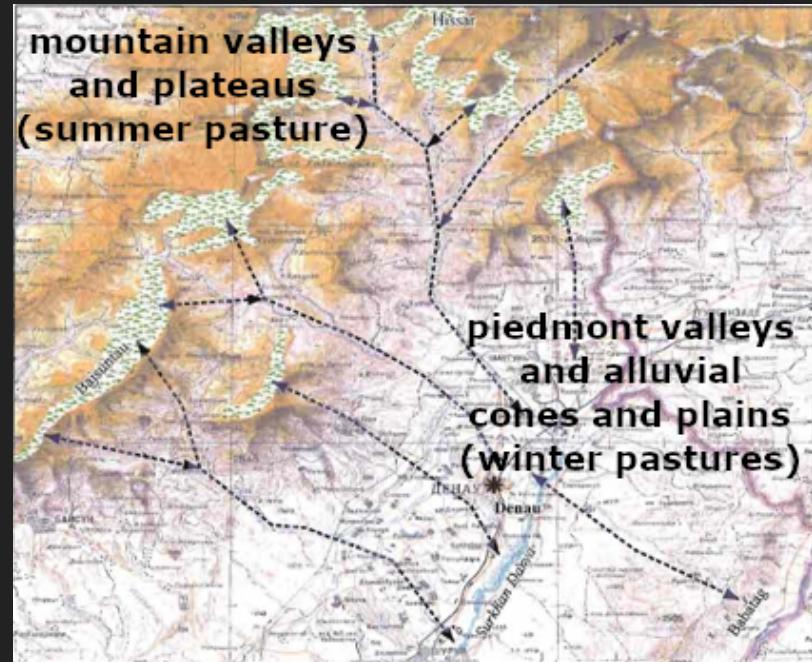
# EXPLAINING LAND USE PATTERNS



# FARMING



# HERDING



Stride, S. (2005). Géographie archéologique de la province du Surkhan Darya (Ouzbékistan du sud / Bactriane du nord). Ph.D thesis, Université Paris I Panthéon-Sorbonne.

**Overlapping niches:** Stakeholders must cooperate or compete for land use

## "BAD" QUESTION

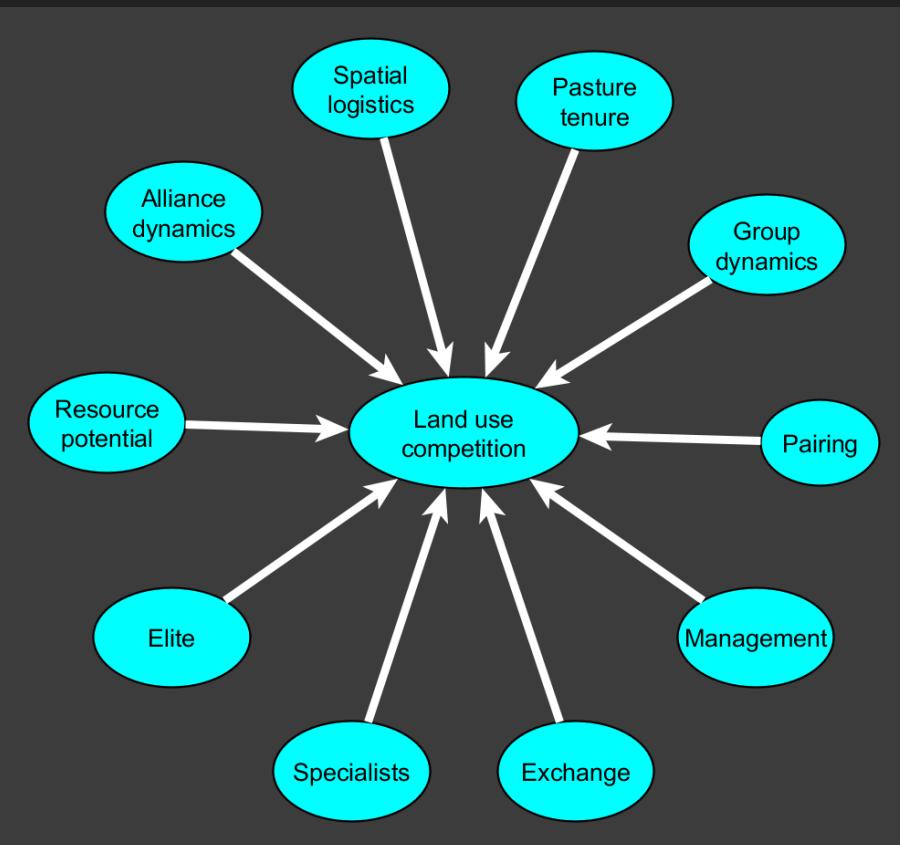
Are farming-herding interactions competitive or  
cooperative?

# "GOOD" QUESTIONS

Through which **mechanisms** and under which **conditions** may stakeholders cooperate or compete?

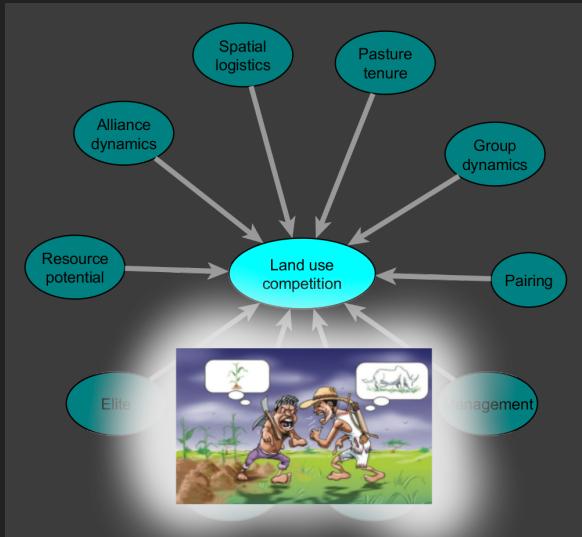
What impact does these aspects have on the existence of certain land use patterns?

# MODELING FRAMEWORK



- For **exploring** several mechanisms
- **Land use competition** as the core mechanism
- Progressive and modular **theory-building** approach

# MUSICAL CHAIRS MODEL

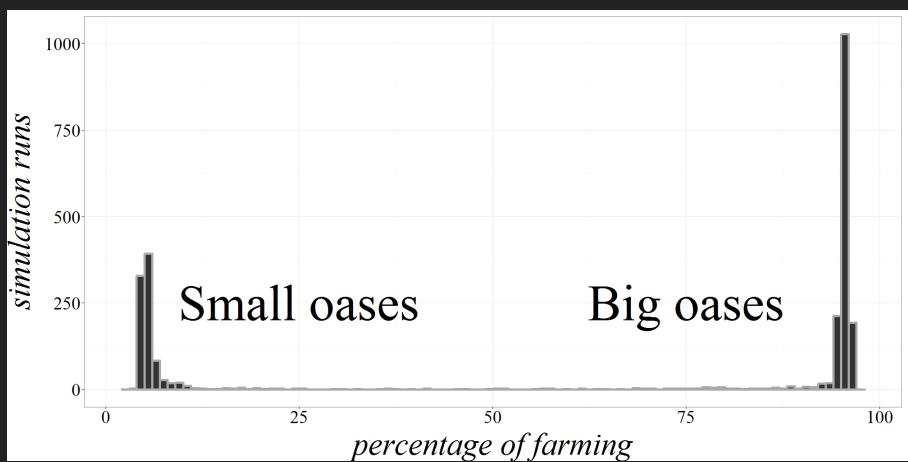


- Limited area
- Constant pressure
- competitive and non-competitive periods
- Competitive situations resolved asymmetrically

→ Strong bimodality

→ Bias favouring farming

Publications ↓



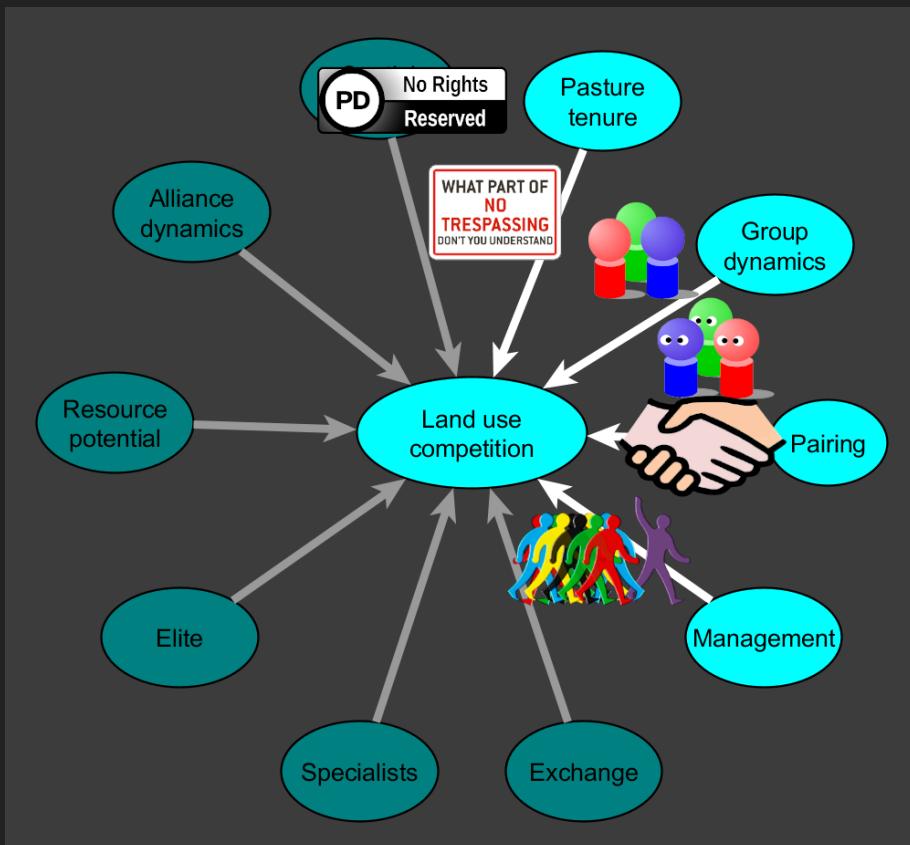
# MUSICAL CHAIRS MODEL PUBLICATIONS

ANGOURAKIS, A., RONDELLI, B., STRIDE, S., RUBIO-CAMPILLO, X., BALBO, A. L., TORRANO, A., MARTÍNEZ, V., MADELLA, M.; GURT, J. M. 2014, "Land Use Patterns in Central Asia. Step 1: The Musical Chairs Model", *Journal of Archaeological Method and Theory*, 21: 405-425.  
<http://dx.doi.org/10.1007/s10816-013-9197-0>.

ANGOURAKIS, A. 2014, "Exploring the oases of Central Asia: A model of interaction between mobile livestock breeding and sedentary agriculture", in Antela-Bernárdez, B. and Vidal, J. (eds.) *Central Asia in Antiquity: Interdisciplinary Approaches*, BAR International Series 2665, pp. 3-16.

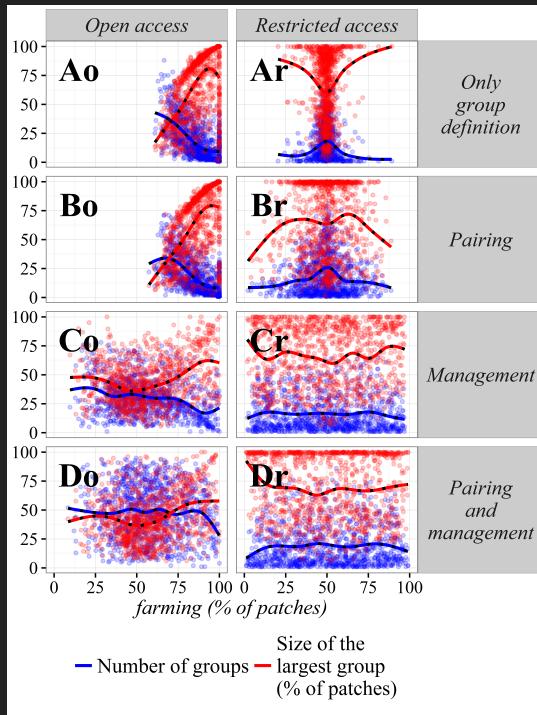
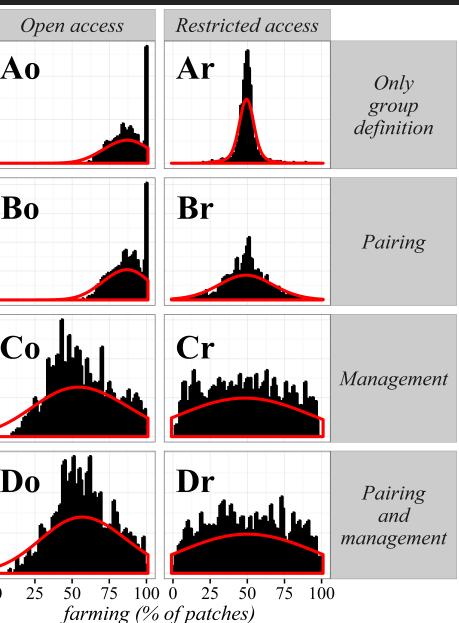
ANGOURAKIS, A., 2016a (February 3). "Musical Chairs" (Version 1). *CoMSES Computational Model Library*. <https://www.openabm.org/model/4880/version/1>

# NICE MUSICAL CHAIRS MODEL



- **Group dynamics**
- **Pairing**
- **Group management**
- **Pasture tenure**

# MAIN RESULTS



- Land use competition + open access = **bias towards farming**
- Group competition = **larger groups**
- **Pairing** has the **smaller effect**
- **Management** add to **diversity**, assuming group target is arbitrary
- **Restrictive access** greatly **cancels the asymmetry** caused by herding mobility

Publications ↓

# NICE MUSICAL CHAIRS MODEL PUBLICATIONS

Angourakis, A., Salpeteur, M., Martínez, V., and Gurt, J.M. (2017). The Nice Musical Chairs model. Exploring the role of competition and cooperation between farming and herding in the formation of land use patterns in arid Afro-Eurasia. *Journal of Archaeological Method and Theory*, 21: 405-425. <http://dx.doi.org/10.1007/s10816-016-9309-8>.

Angourakis, A. (2017, January 9). "Nice Musical Chairs" (Version 5). *CoMSES Computational Model Library*. <https://www.openabm.org/model/4885/version/5>

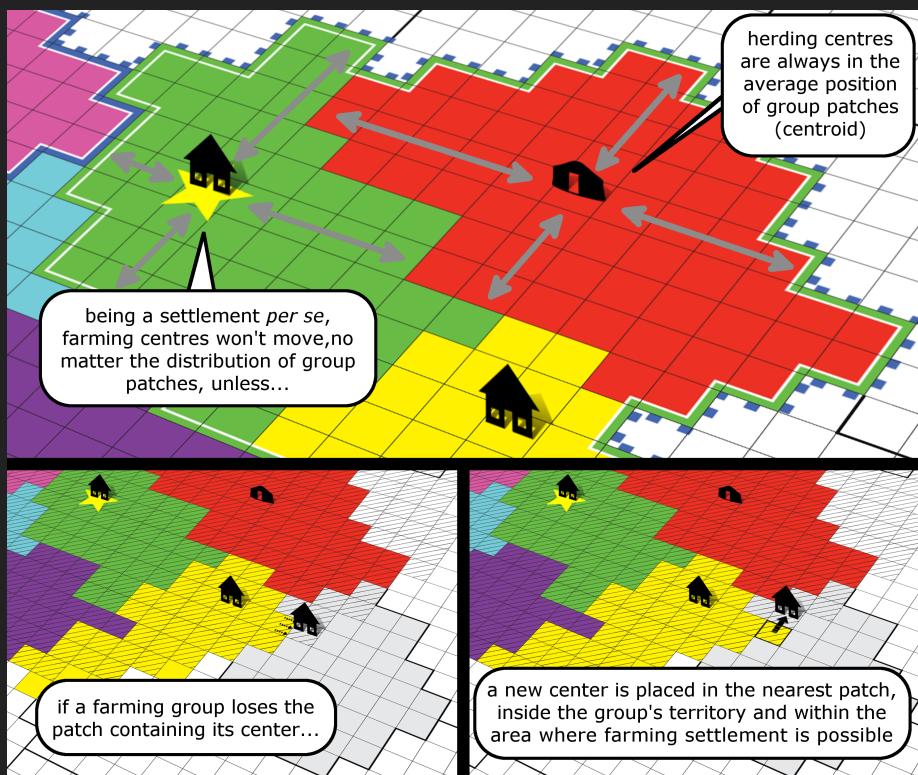
# NOMAD FRONTIER MODEL



**Single-class groups**  
farming groups or **herding** groups

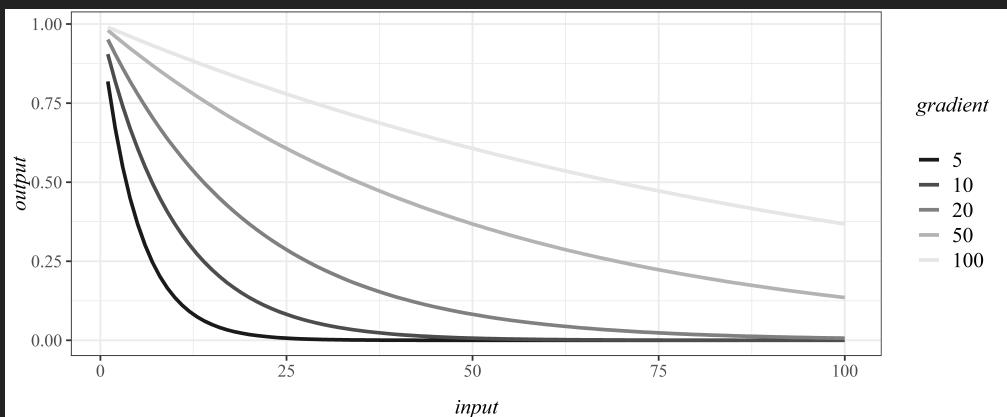
- **Spatial logistics**
- **Alliance dynamics**
- **Pasture tenure**

# NOMAD FRONTIER MODEL

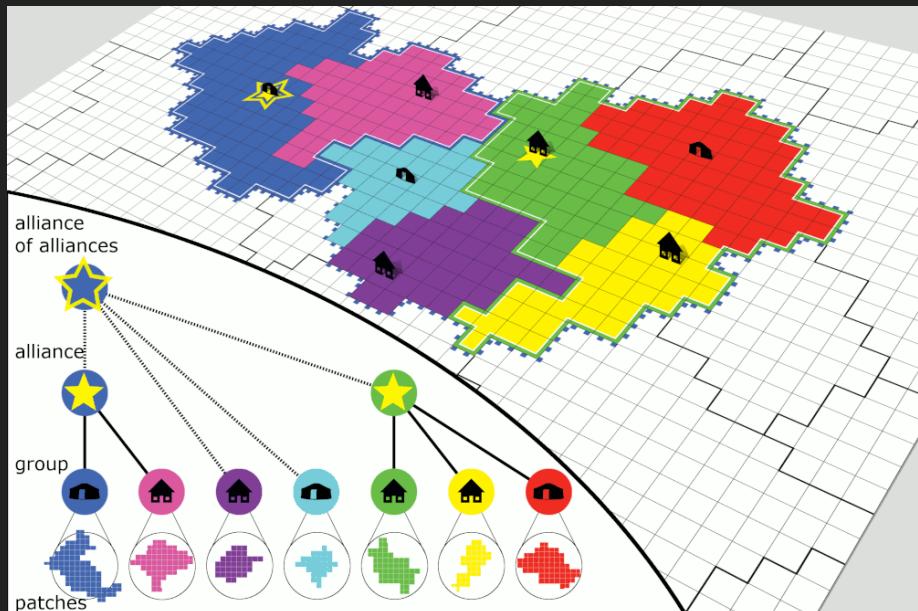


- **Spatial logistics:**

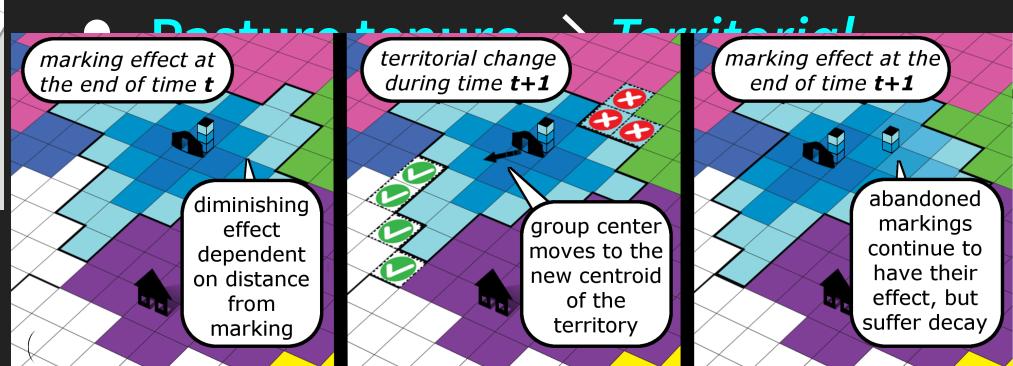
- **Distance** as a factor
- Farming and herding **group centres**



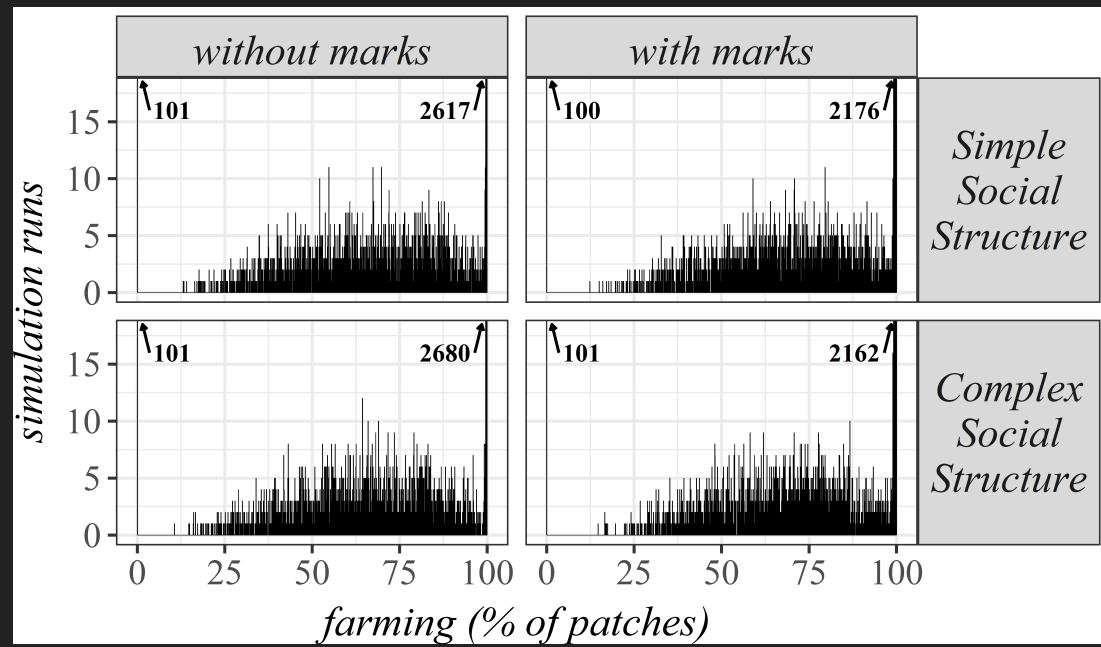
# NOMAD FRONTIER MODEL



- **Alliance dynamics:**
  - Emerging hierarchical structures
  - Production and tribute
  - Governance influence
  - Affinity and Alliance formation

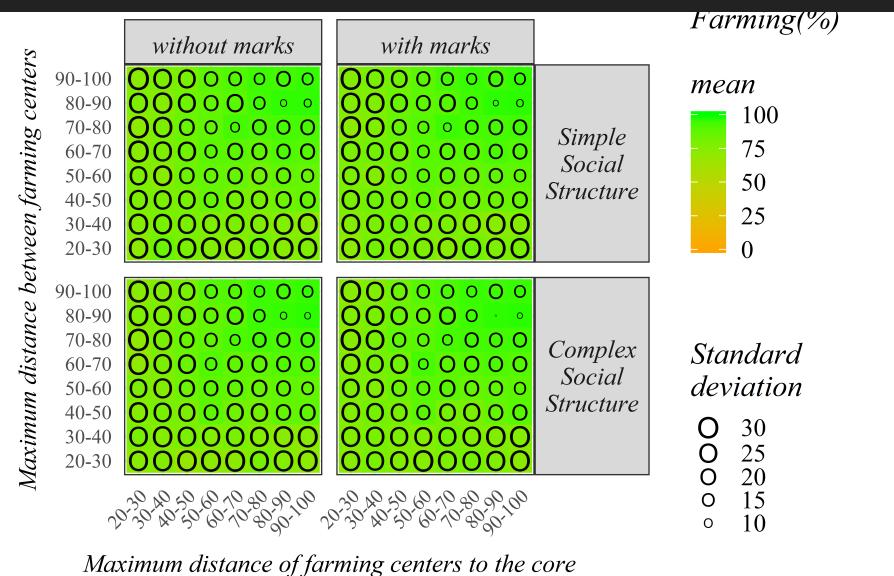


# MAIN RESULTS



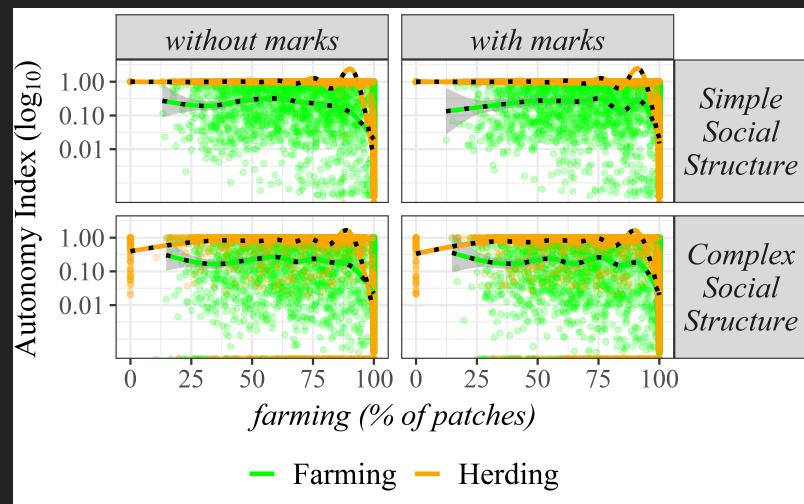
- Bias towards farming is even clearer, presumably because of spatial relations
- Territorial marking (signal) has a milder effect compared to 'restrictive access' (social norm)
- Social complexity, as defined in the model (*alliance dynamics*), has virtually no effect on the diversity of land use patterns.

# MAIN RESULTS



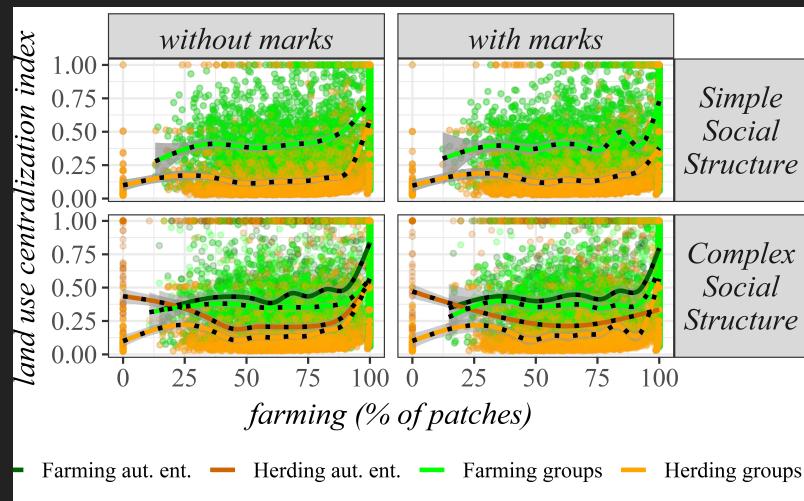
- **Distibution of farming centres**  
increased probability of *big oasis* if farming centres position is not constrained
- **Marginalisation of herding groups:**  
Herding Centre mobility cause them to be 'pushed' more easily

# MAIN RESULTS

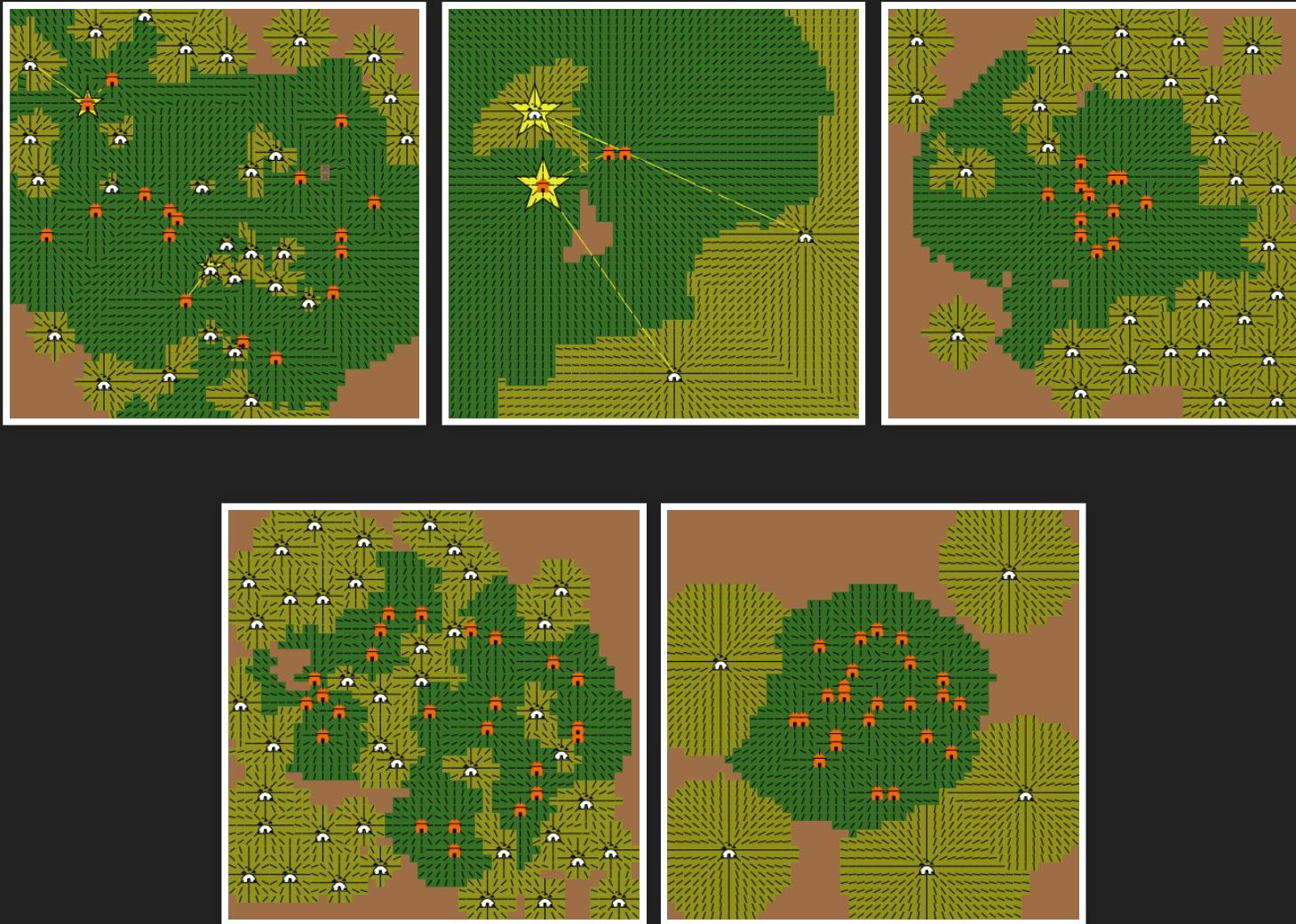


- **Farming** predominance linked to **centralisation**
- ... while **herding** predominance is associated with **more and more autonomous groups/alliances**

$$Autonomyindex = \frac{\text{numAutonomousEntities} * \text{numGroups}}{\text{maxNumGroups}^2}$$



$$\begin{aligned} Landusecentralizationindex = \\ \frac{\text{bigAutonomousEntityTerritory}}{(\text{countAutonomousEntities} * \text{meanAutonomousEntityTerritory})} \end{aligned}$$



Simulations: 1000 steps (years). Steps shown: 5, 10, and 100 steps intervals up to 1000.

# CONCLUSIONS

- Land use competition favours farming
- "Big oases" tend to be centralised territories (few groups)
- Any association between farming and herding stakeholders (*explored so far*) tend to benefit farming in the long run
- The most effective strategy (*explored so far*) for herding stakeholder is to invest in territorial marks

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## THANK YOU!

address any questions to A. Angourakis: [andros.spica@gmail.com](mailto:andros.spica@gmail.com)



