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/index.html?print-pdf (printable version)

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SIMULPAST
SIMULATING THE PAST TO UNDERSTAND HUMAN BEHAVIOUR

EAA 2018
BARCELONA, 5-8 SEPTEMBER
REFLECTING FUTURES

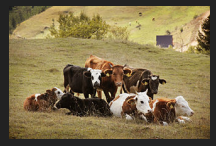
EXPLAINING LAND USE PATTERNS

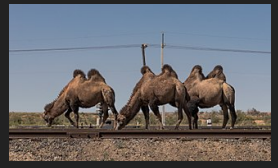
Land use patterns can be understood as **outcomes** of a series of **contingencies** at different scales and different dimensions of **human behavior** and its **environment**.

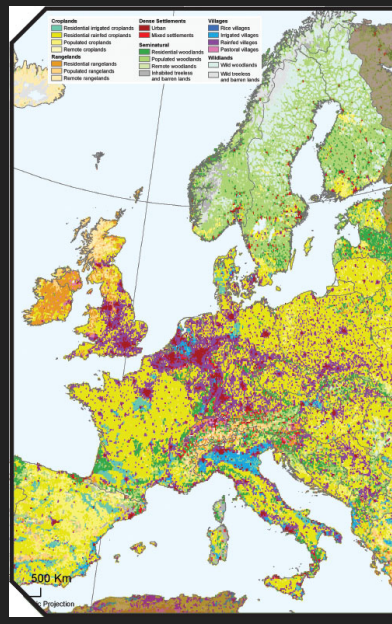












SET OF POSSIBLE STATES IN TERMS OF...

- **Proportions**
  between land use classes
- **Stability**
- **Distributions**
  of land use classes
- **Centralization**
  (decision-making)
- **Specialization**
  (lifestyles)
- **Intensification**
  (labor, resources)
- **Development**
  (productivity, institutions, craftsmanship)
- **Wealth**
  accumulation and distribution
- **Resilience**

IN PREINDUSTRIAL EURASIA...

Subsistence strategies produced mainly two distinguishable land use classes, **farming** and **herding.**

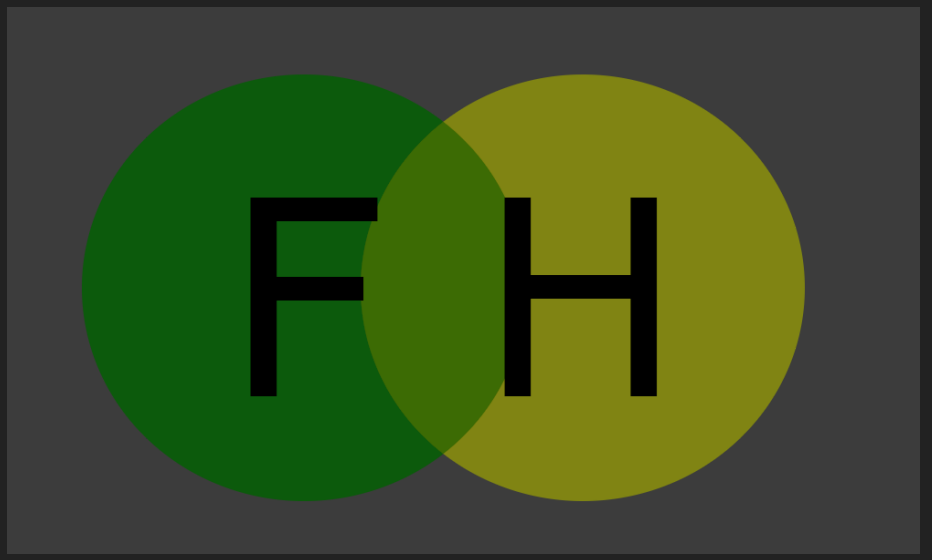
Shades between these may fit in one or another class, depending on the strategies effective **impact on the landscape** (do they generate/use farms or pastures?).

IMPLICIT MODELS

SEPARATE NICHES

Interaction is independent of land use

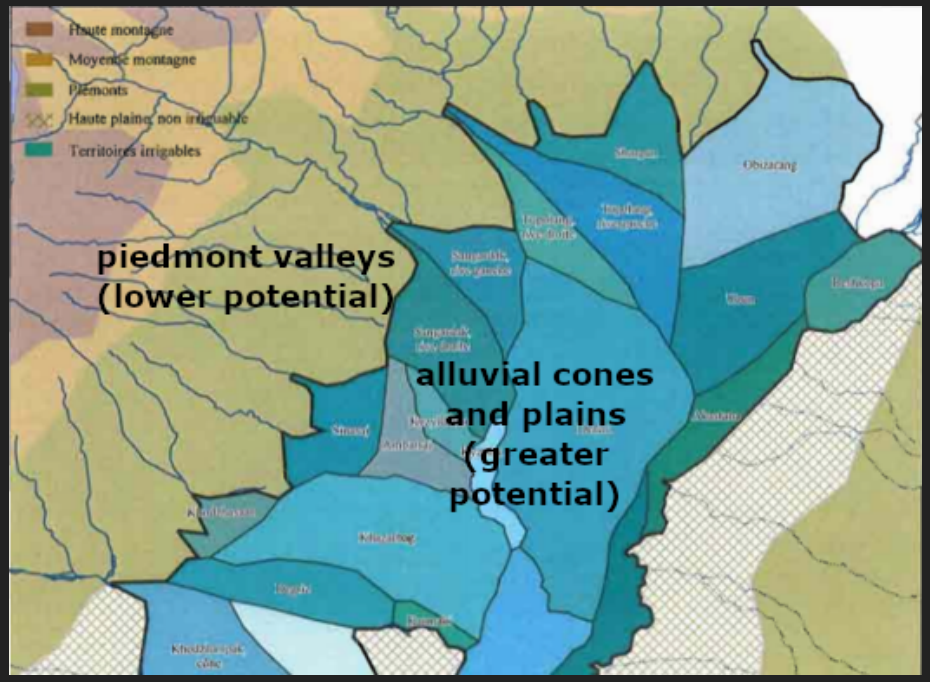
OVERLAPPING NICHES

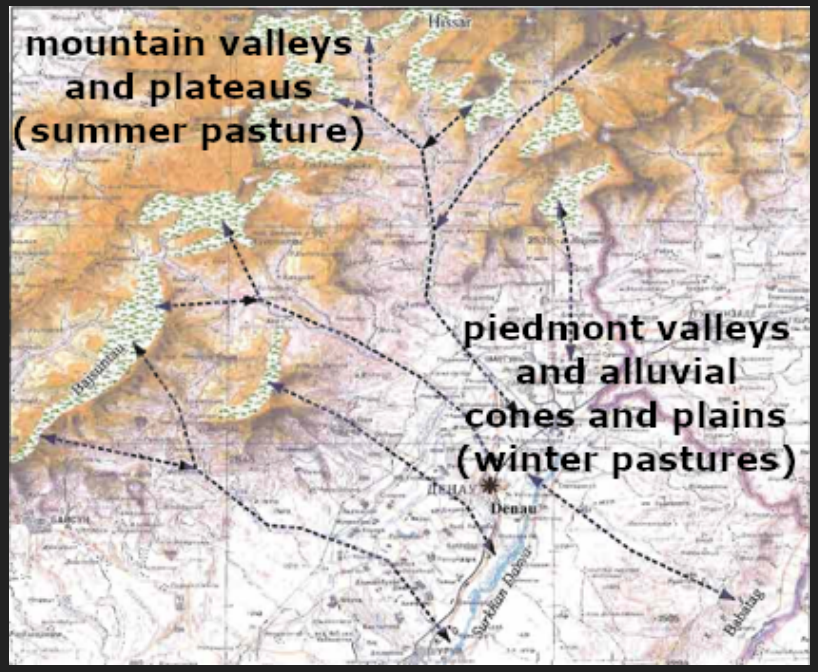


Stakeholders must cooperate or compete for land use

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.

The separate niche models is not useful!

"BAD" QUESTION

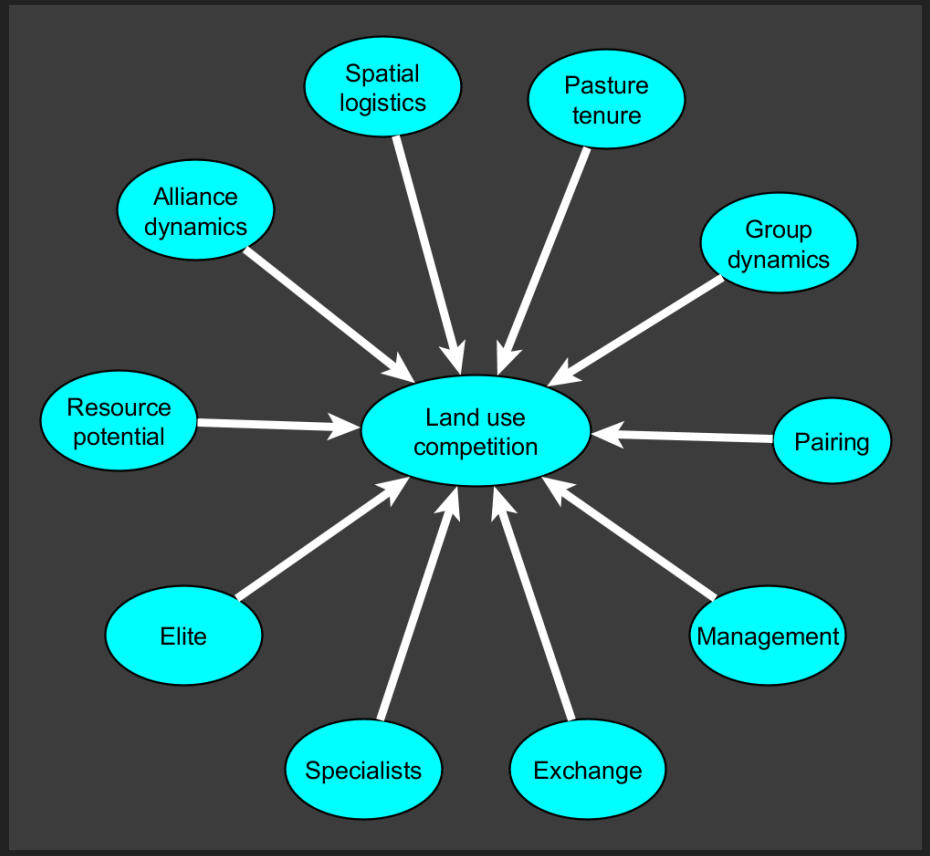
Are farming-herding interactions competitive or cooperative?

"GOOD" QUESTIONS

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

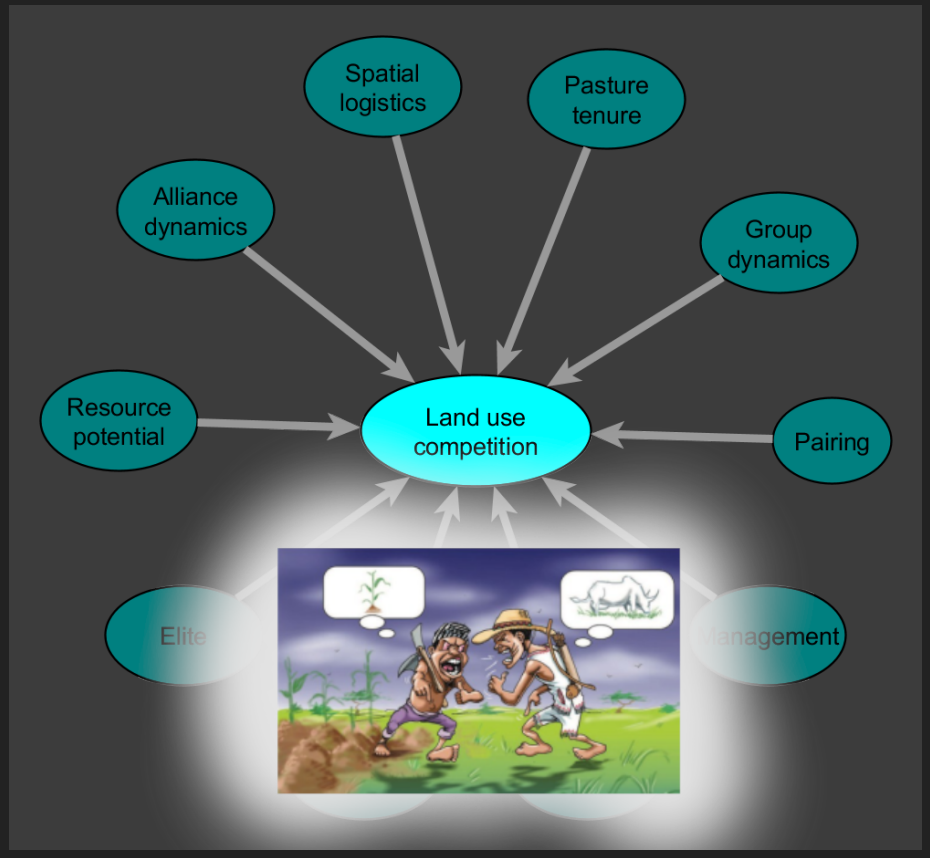
What impact does these aspects have on the existence of certain land use patterns?

MODELING FRAMEWORK



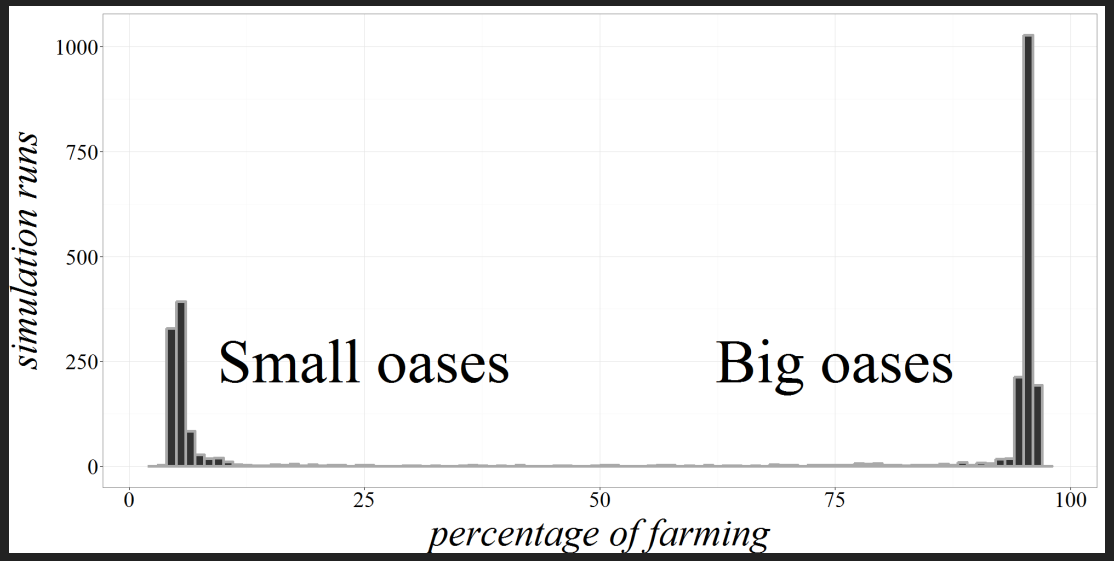
- For **exploring** several mechanisms
- **Land use competition** as the core mechanism
- Progressive and modular **theory-building** approach

MUSICAL CHAIRS MODEL



- **Limited** area
- **Constant pressure** to expand land use classes
- Alternancy between **competitive** and **non-competitive** periods
- Competitive situations resolved **asymmetrically**: herding stakeholders cannot retain the land while herds are away

IMPLICATIONS OF COMPETITION



- Strong bimodality
- Bias towards specialized farming economies

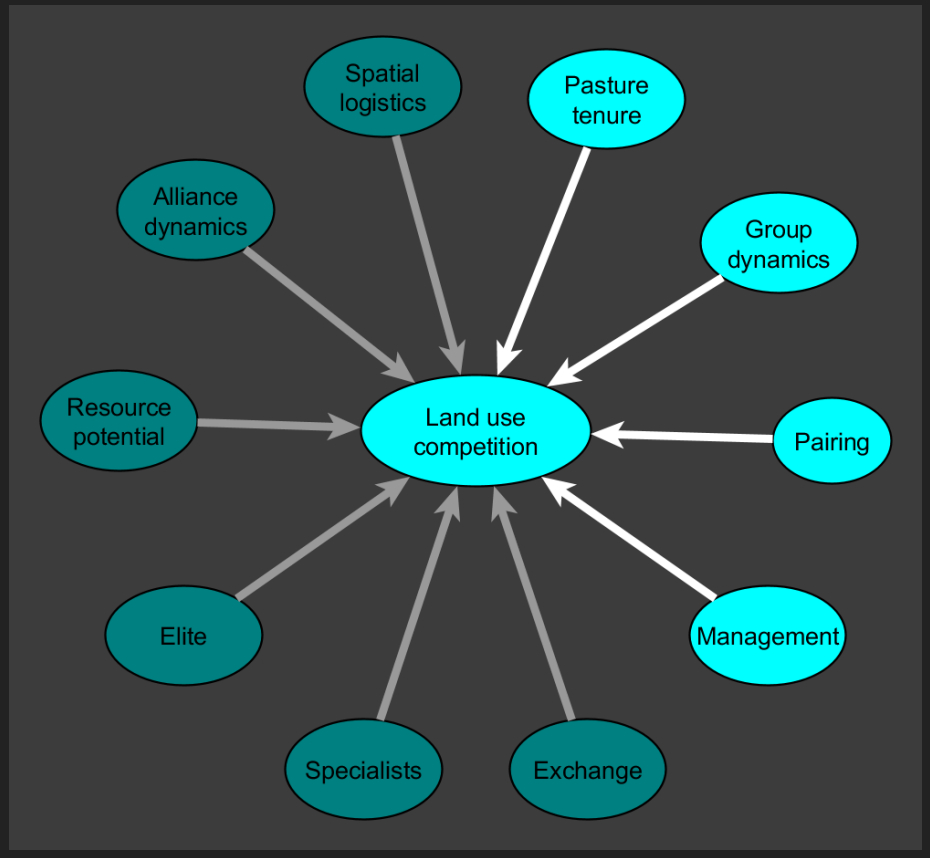
MUSICAL CHAIRS MODEL PUBLICATIONS

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.

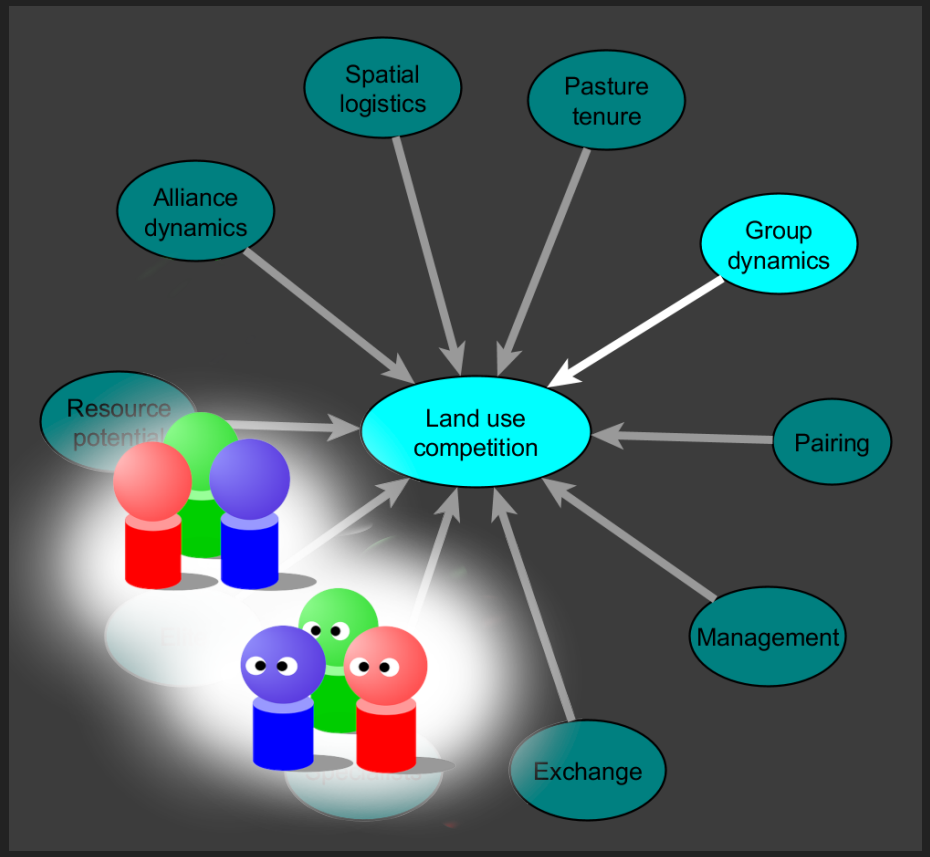
ANGOURAKIS, A., 2016a (February 3). "Musical Chairs" (Version 1). *CoMSES Computational Model Library*. https://www.openabm.org/model/4880/version/1

NICE MUSICAL CHAIRS MODEL



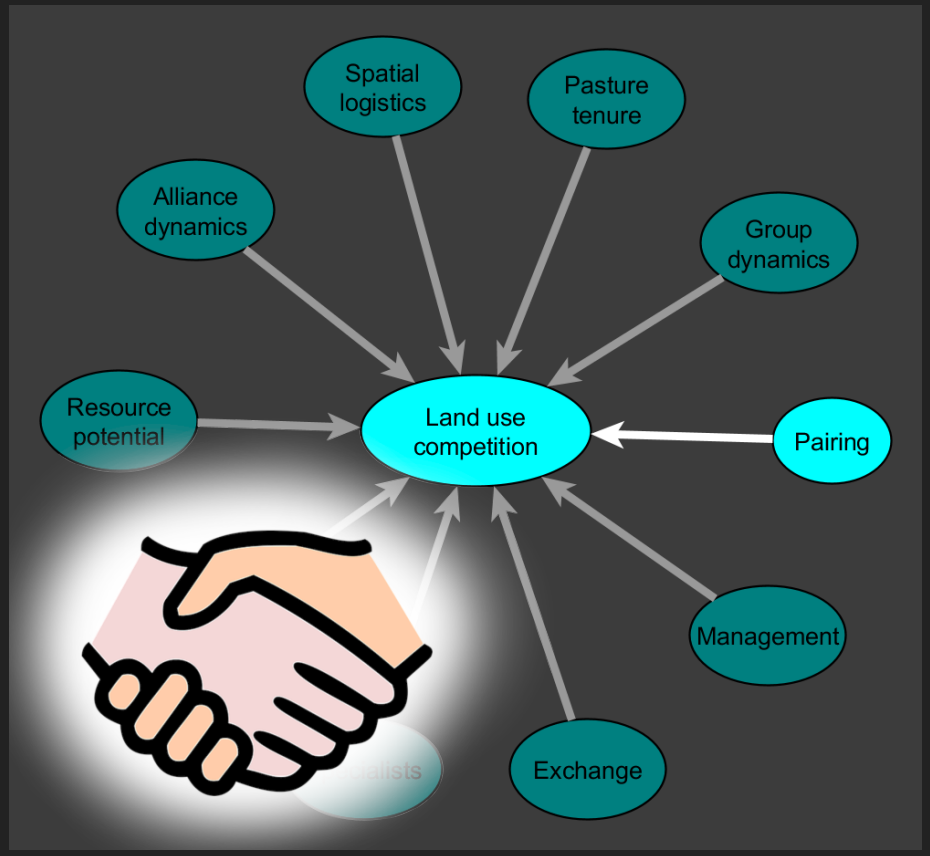
- Group dynamics
- Pairing
- Group management
- Pasture tenure

NICE MUSICAL CHAIRS MODEL



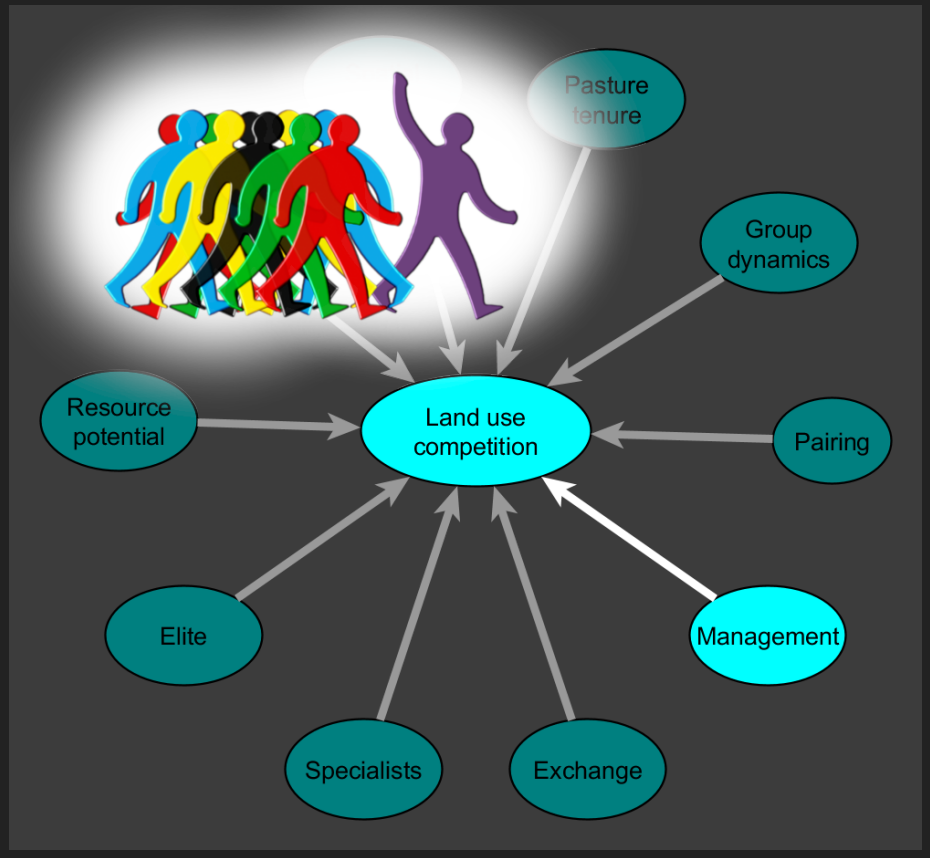
- **Group dynamics**:
  - Herding and farming can **coexist** in the same group
  - **cooperation** within, **competition** between
  - size x effectiveness = competitive **strength**
  - **changing** group allegiance

NICE MUSICAL CHAIRS MODEL



- **Pairing**:
  farming and herding may **perform better** by being affiliated to the same group

NICE MUSICAL CHAIRS MODEL

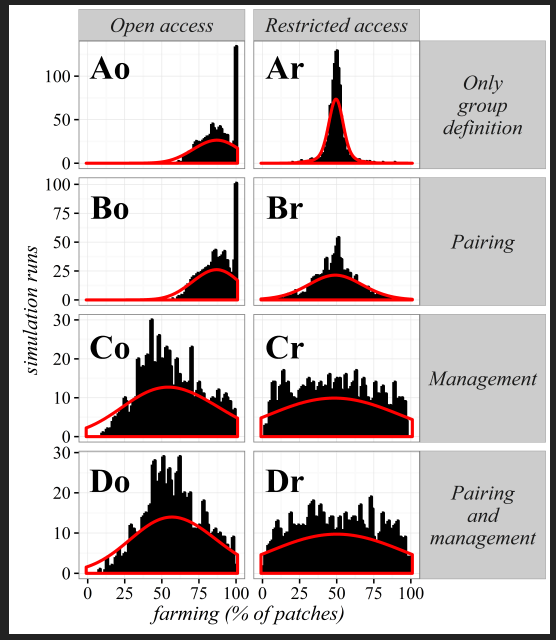


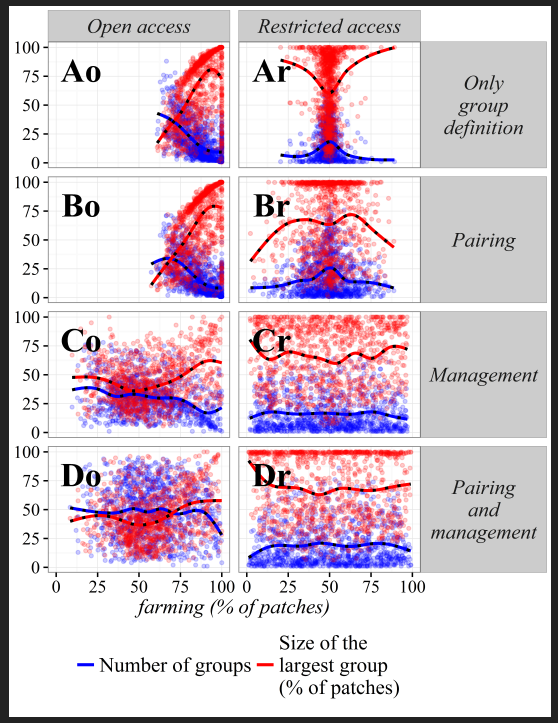
- **Group management**: group leadership presses individual stakeholders to collectively pursue a **farming/herding ratio**

NICE MUSICAL CHAIRS MODEL

- **Pasture tenure**: **open** *versus* **restrictive**. Restrictive access means that pastoral land is *owned* at the group level.

MAIN RESULTS





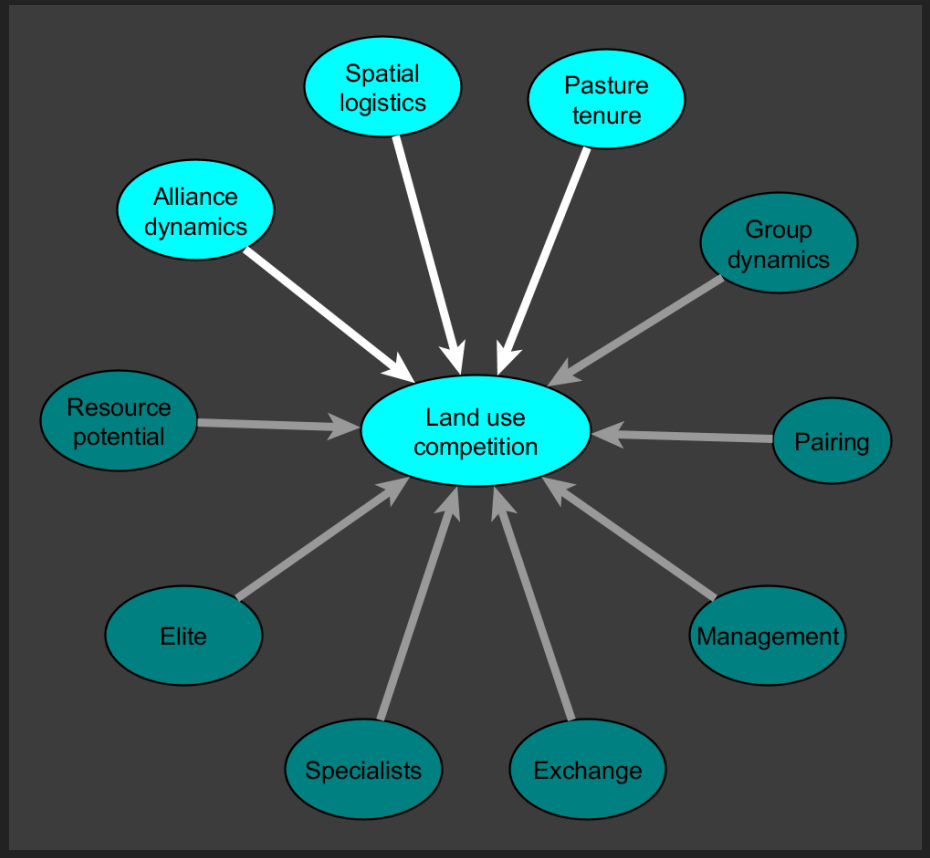
- Land use competition + open access = **bias towards farming**
- Group competition = **larger groups**
- **Pairing** has the **smaller effect**
- **Management** add to **diversity**, assuming group target is arbitrary
- **Restrictive access** greatly **cancels the asymmetry** caused by herding mobility

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

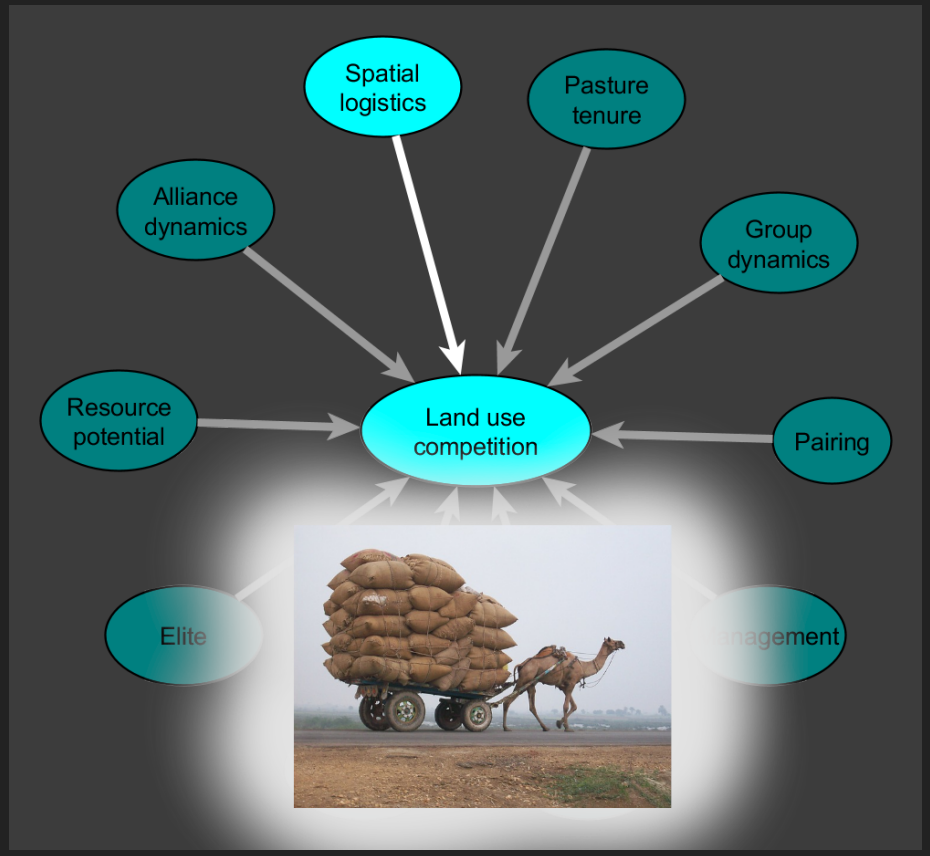


- **Spatial logistics**
- **Alliance dynamics**
- ~~**Pasture tenure**~~ → *Territorial marks*

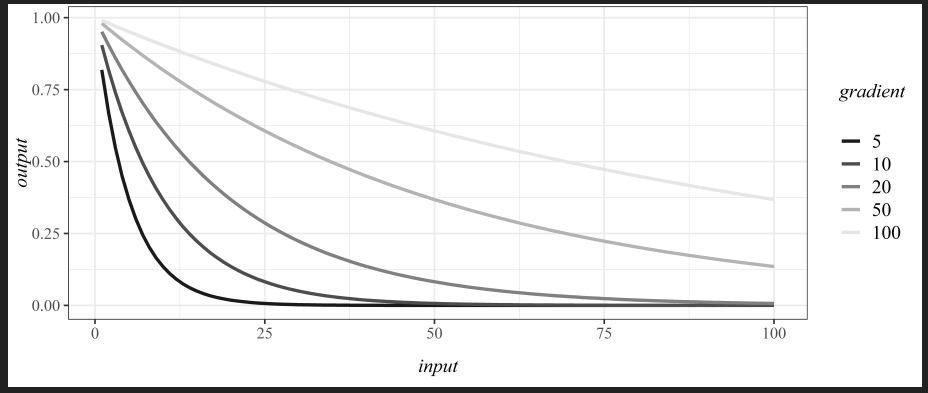
Single-class groups

farming groups or **herding** groups

NOMAD FRONTIER MODEL



- **Spatial logistics**:
  Spatial relationships are relevant for most processes in the model.
  Effects following a **general gradient function:**



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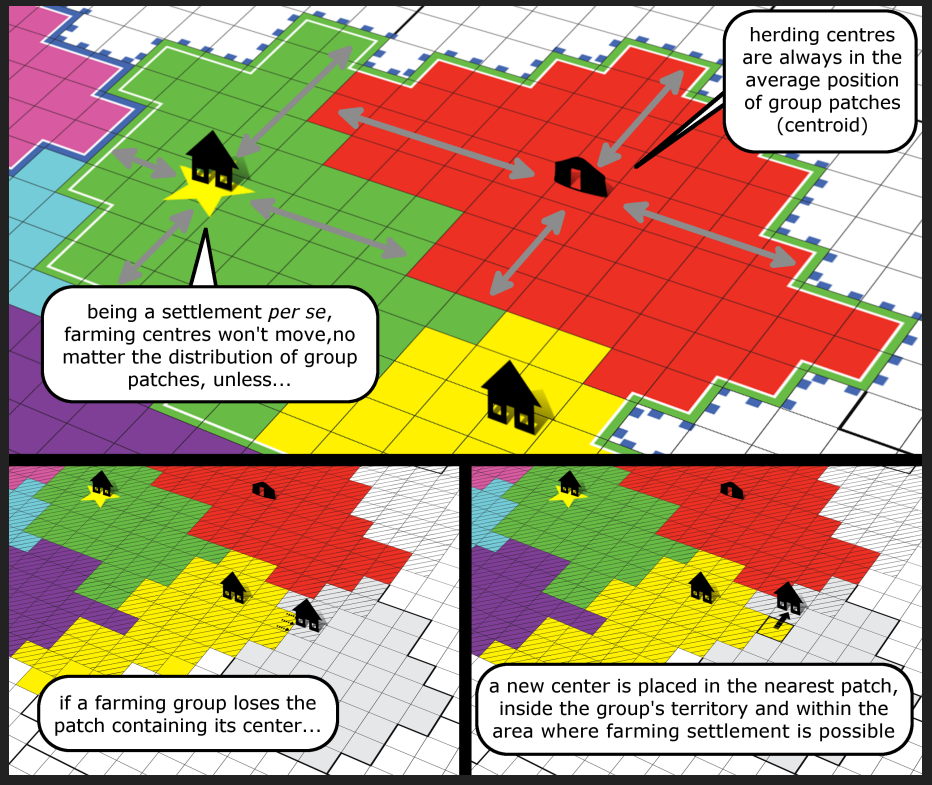
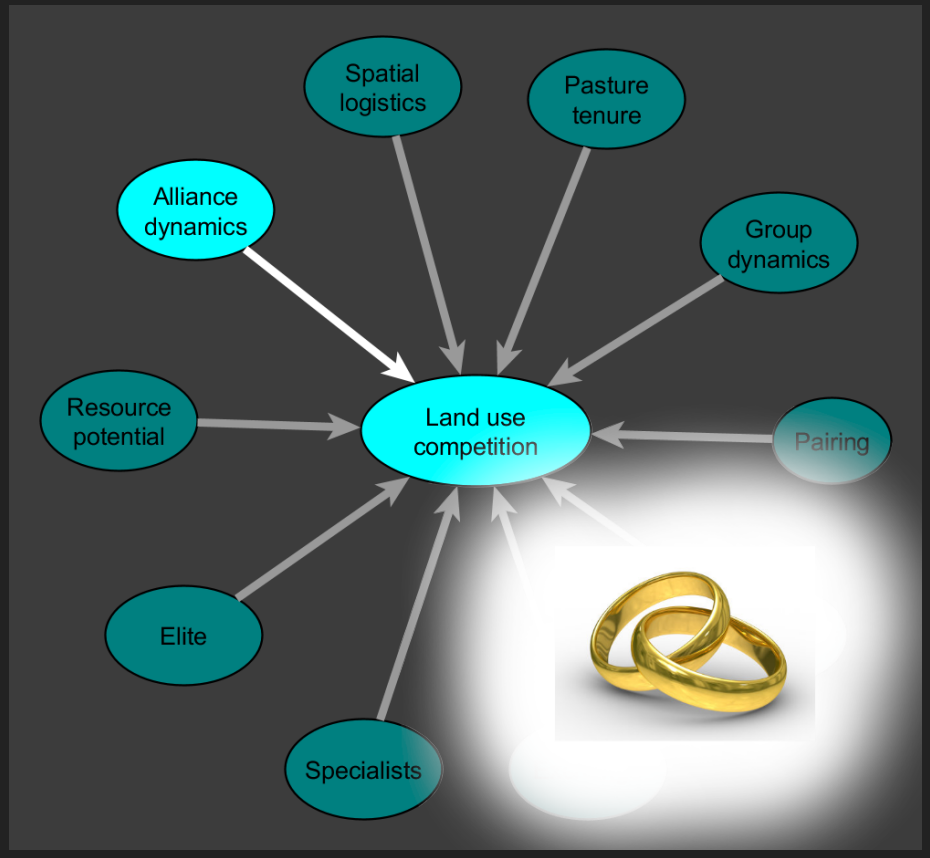


- **Spatial logistics**:
  - Group centres: **reference points** for all stakeholders in a group
  - Farming centres are **fixed**; herding centres **adapt** to group's land use
  - Farming centres move only when **losing** their central patch

NOMAD FRONTIER MODEL



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

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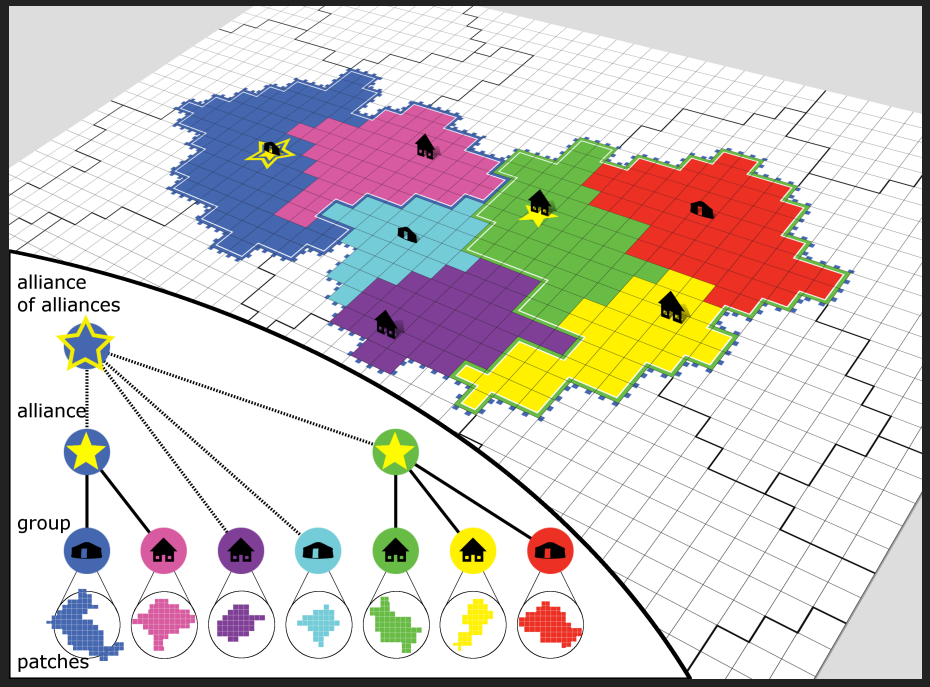
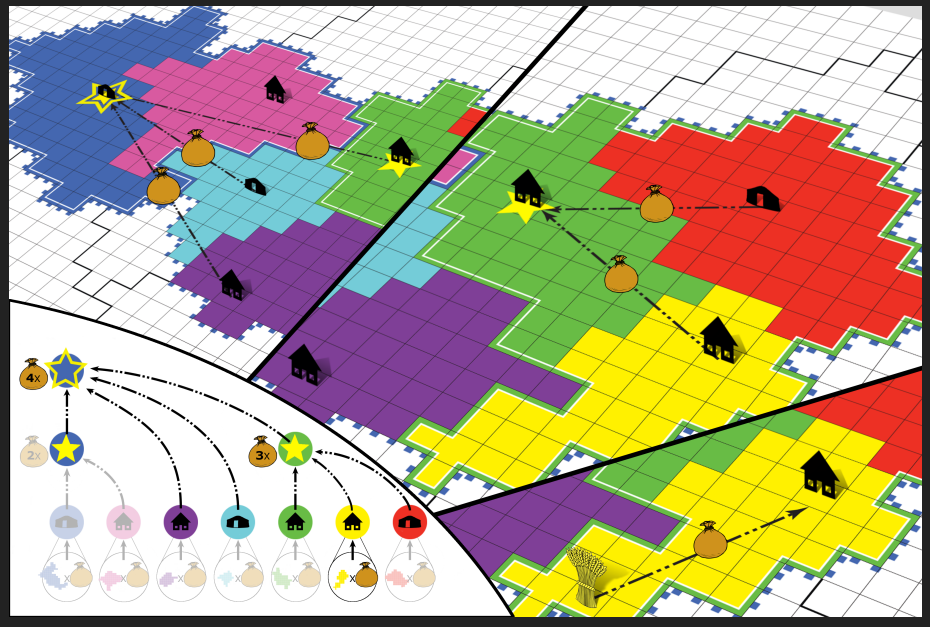


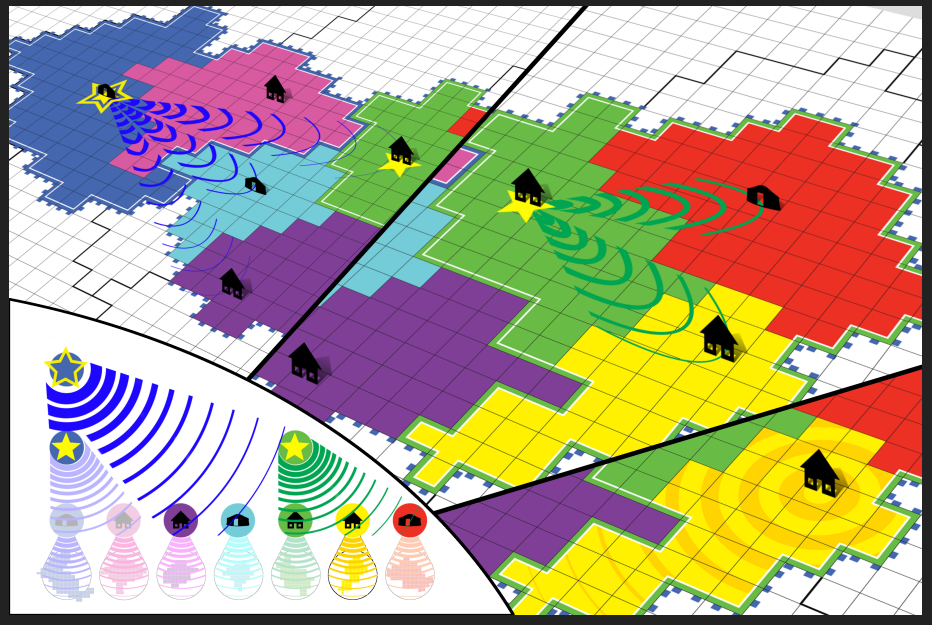
- **Alliance dynamics**:
  - **Emerging hierarchical structures**
    Groups form alliances, which in turn can also form alliances (complex structures).
    Alliances centre is placed in the centre of the most influent group.
    Aliances traits depend on the traits of members and their respective wealth.

NOMAD FRONTIER MODEL



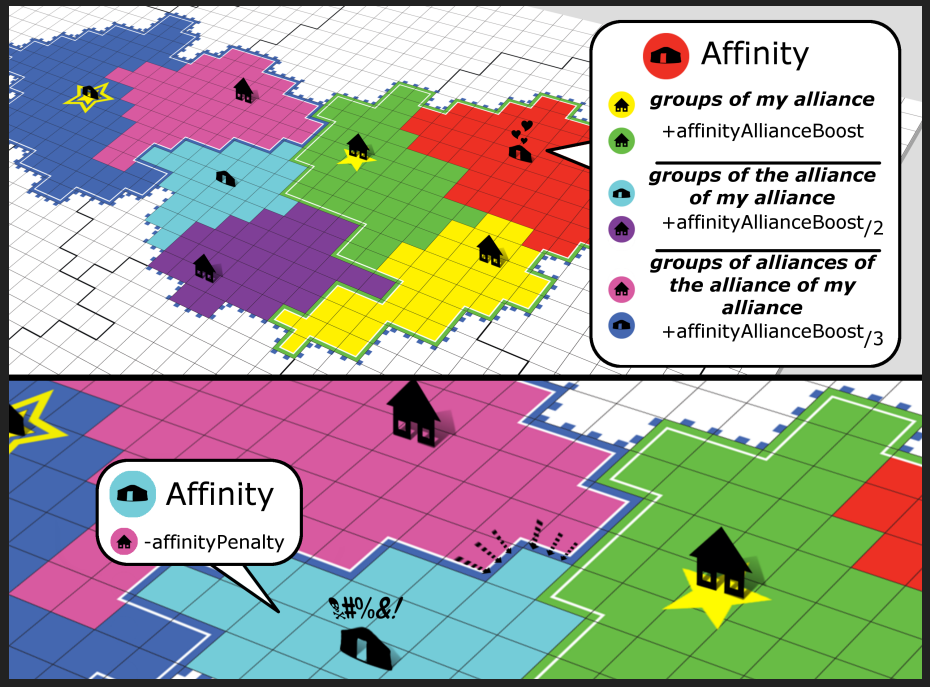
- **Alliance dynamics**:
  - **Production and tribute**
    Patches produce goods that sent to its group centre.
    Groups and alliances can accumulate wealth and send tribute to their alliance.
    Groups and alliances vary in "egoism", *i.e.* a value defining their tendency to keep their wealth.

NOMAD FRONTIER MODEL



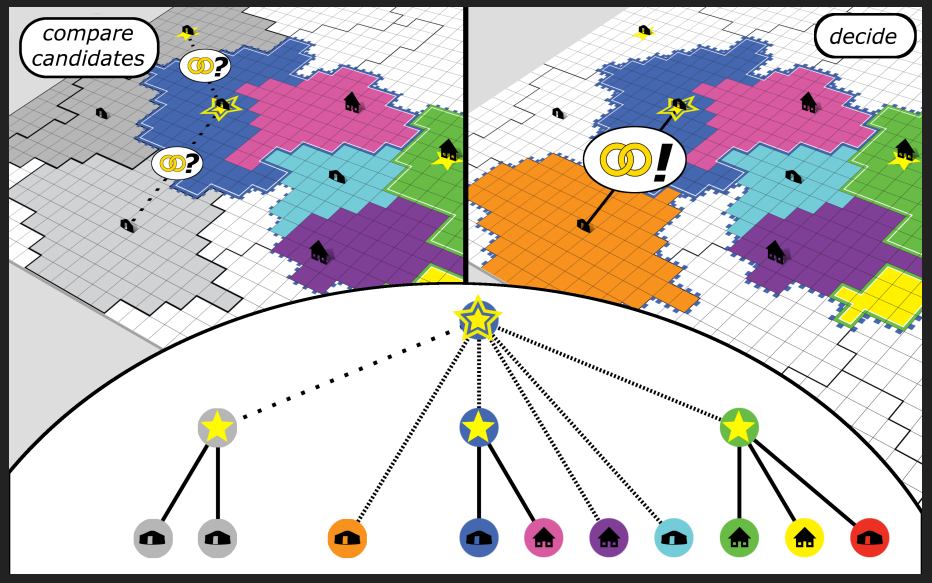
- **Alliance dynamics**:
  - **Governance influence**
    The influence of groups or alliances over members depends on weath and distance to centre.
    Alliance influence also depends on the number of members.

NOMAD FRONTIER MODEL



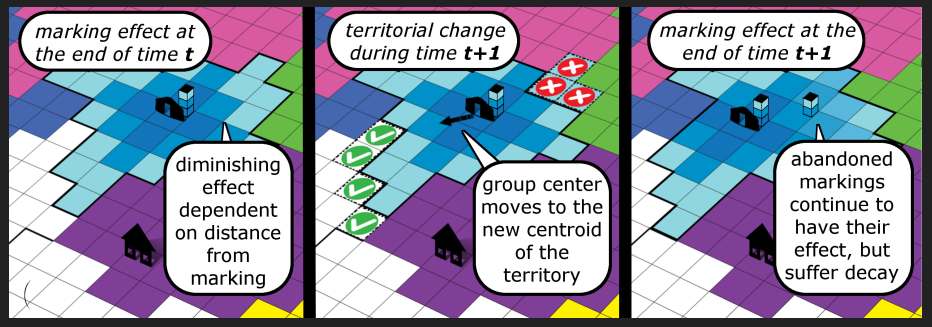
- **Alliance dynamics**:
  - **Affinity**
    Groups have memory of their affinity to other groups.
    Affinity is improved when inside an alliance, decreases with competitive situations, and recovers neutrality with time.

NOMAD FRONTIER MODEL



- **Alliance dynamics**:
  - **Alliance formation**
    Autonomous groups and alliances with enough wealth choose among all possible alliances considering mutual influence and affinity.

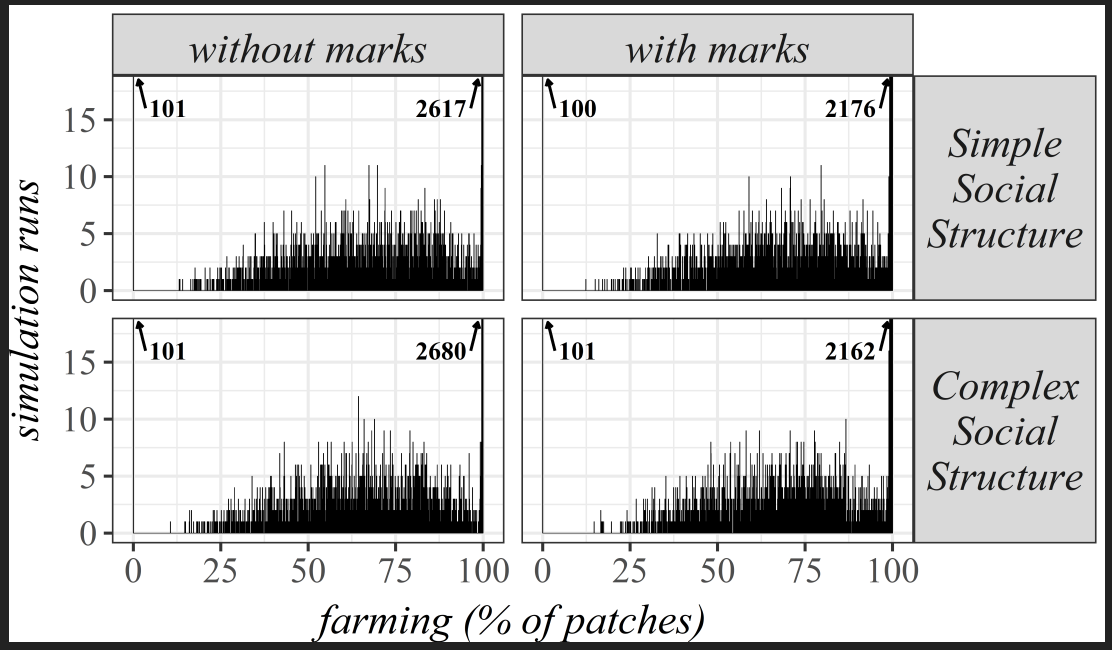
NOMAD FRONTIER MODEL



- **Territorial marks**:

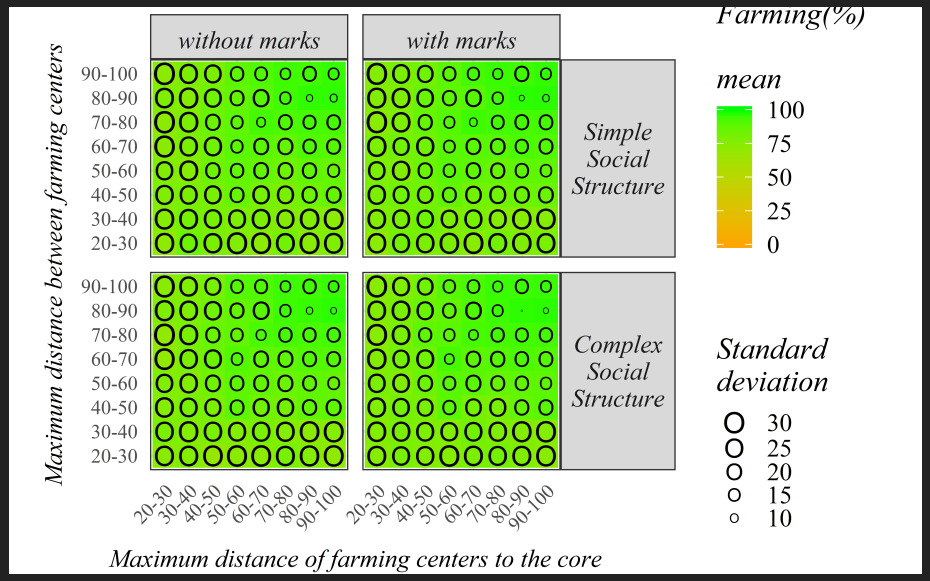
  Pasture tenure is revisited, given its importance in NMC.
  Gradient variation between Open and restrictive access.
  Herding groups signal their territory by **modifying the landscape** in and around their centre (*territorial mark*).
  Every time the centre moves, a new mark is placed.
  The mark effect decreases with **distance** and **decay**.

MAIN RESULTS



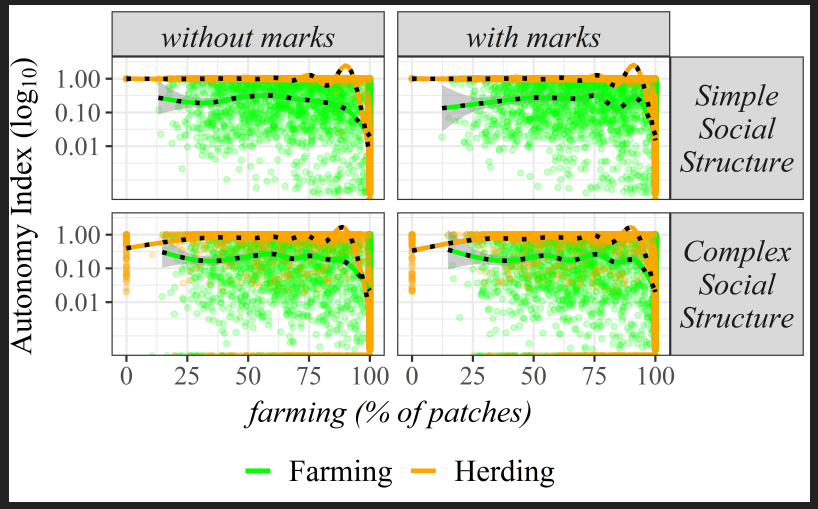
- **Bias towards farming** is even clearer, presumably because of spatial relations
- **Territorial marking** (signal) has a milder effect compared to 'restrictive access' (social norm)
- **Social complexity**, as defined in the model (*alliance dynamics*), has virtually no effect on the diversity of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

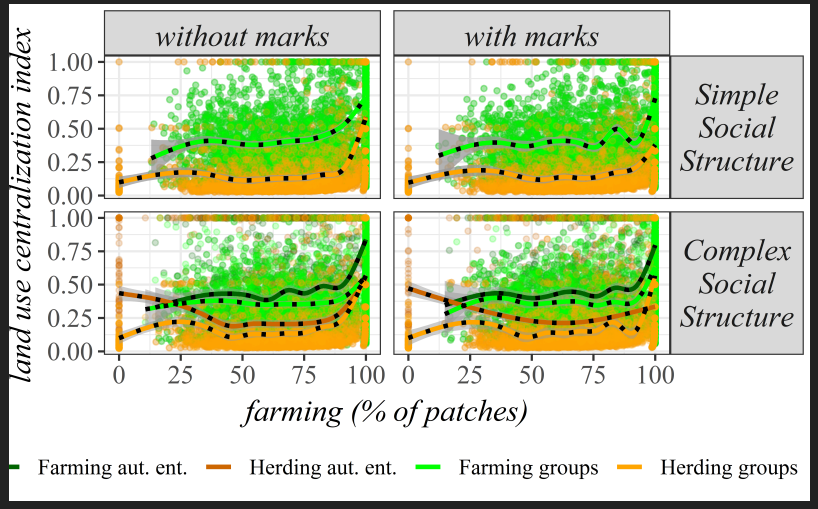
MAIN RESULTS



- **Distibution of farming centres** is important:
  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

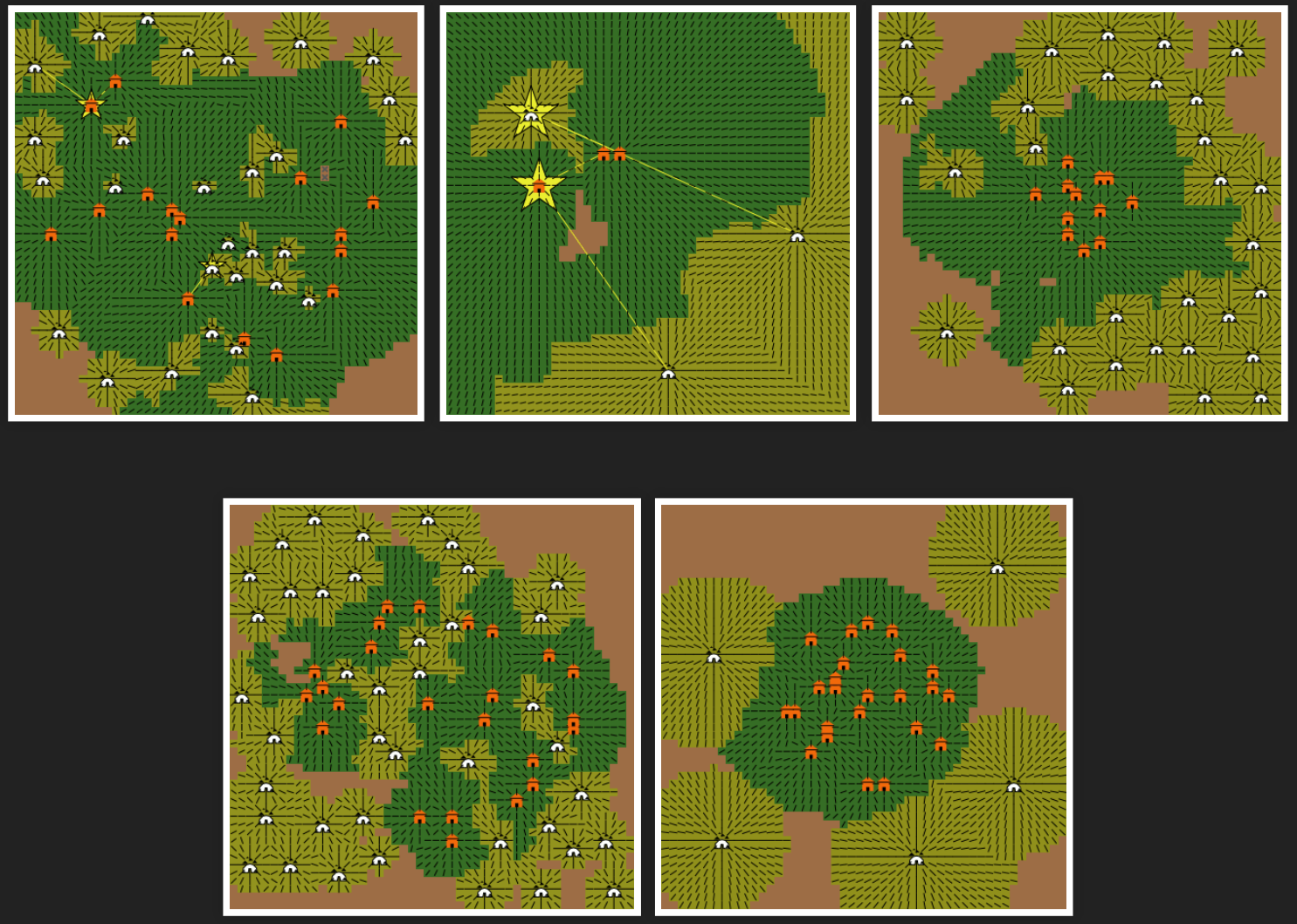




- **Farming** predominance linked to **centralisation**
- ... while **herding** predominance is associated with **more and *more autonomous* groups/alliances**

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

$$Landusecentralizationindex = \frac{bigAutonomousEntityTerritory}{(countAutonomousEntities * meanAutonomousEntityTerritory)}$$



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*

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