

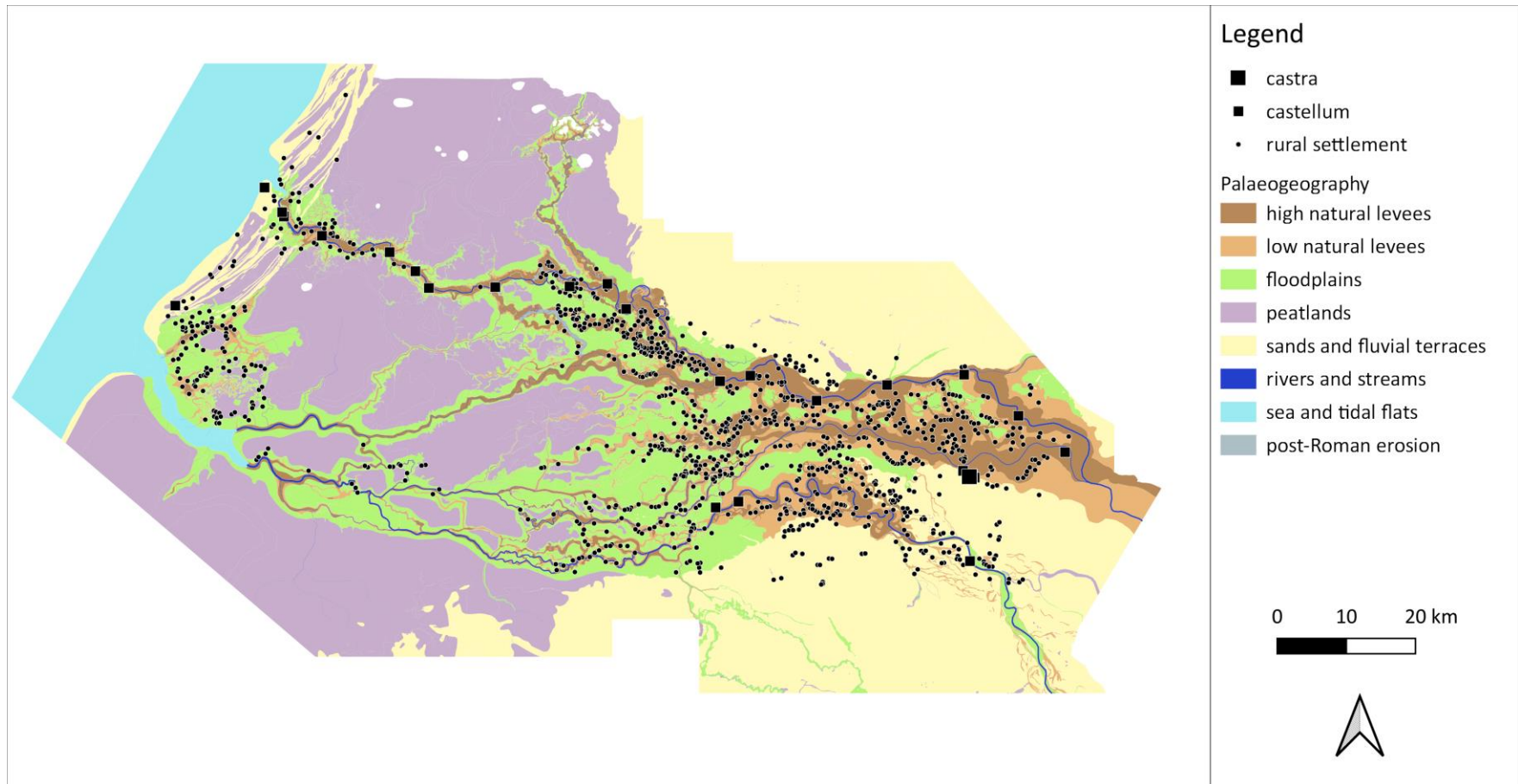
## A COMPARISON OF APPROACHES



# INTRODUCTION

- in this paper
  - > we compare two approaches to model the impact of settlement on land use in the Roman period in the Dutch river area: the **Past Land Use Scanner (PLUS)** and **ROMFARMS**
  - > we discuss issues of scale, temporal resolution and model inputs, together with questions of technical implementation and validation
  - > how should we evaluate the model outcomes? what are the advantages and limitations of each?

# THE DUTCH *LIMES* (15 BCE – 275 CE)



# THE SURPLUS QUESTION

“Batavian lands were never able to provide the necessary food for all the soldiers stationed there [the limes region]”

Willems, W.J.H. 1986. *Romans and Batavians. A Regional Study in the Dutch Eastern River Area*, p.424

“No local community could suddenly have started to produce the surplus required to feed the troops”

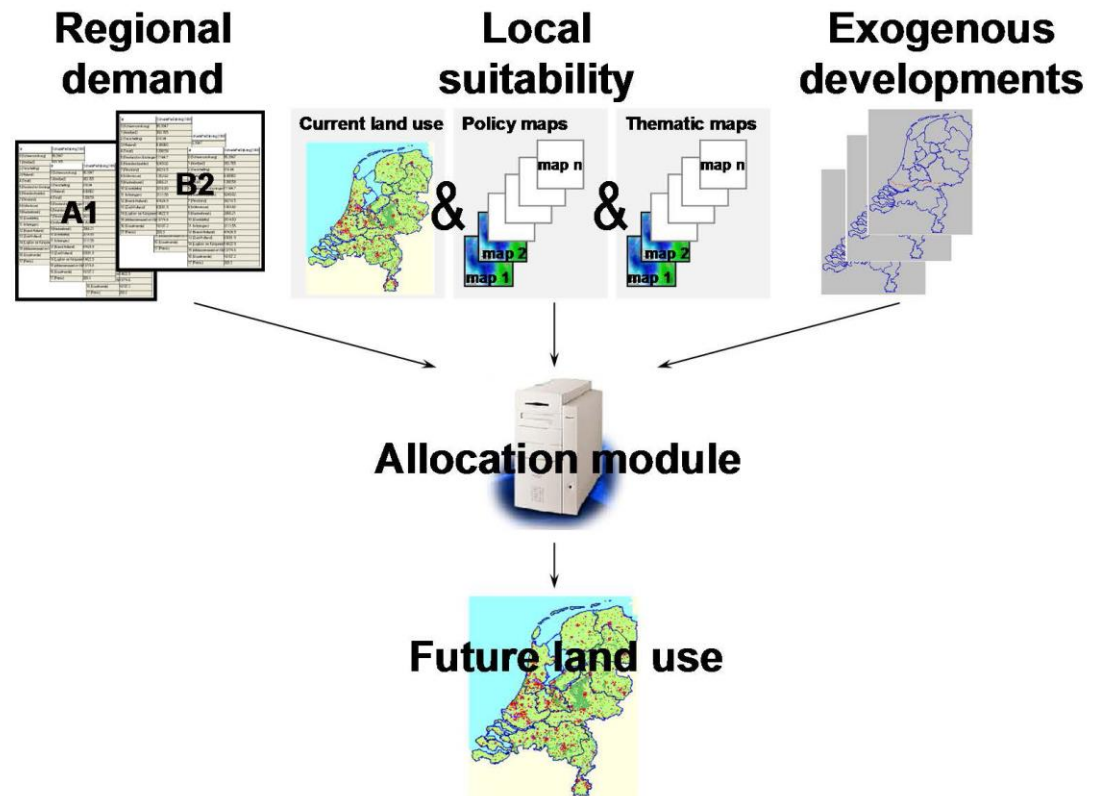
Whittaker, C.R. 2004. *Rome and Its Frontiers*, p. 104

“The total rural population, even estimated at a minimum, was also able to produce enough surplus cereals, e.g. emmer and barley, to fulfil the demand of the Roman army and its associates for these cereals”

van Dinter, M. et al. 2014. *Could the local population of the Lower Rhine delta supply the Roman army? Part 2*, p. 32

# PLUS (PAST LAND USE SCANNER; DE KLEIJN ET AL. 2018)

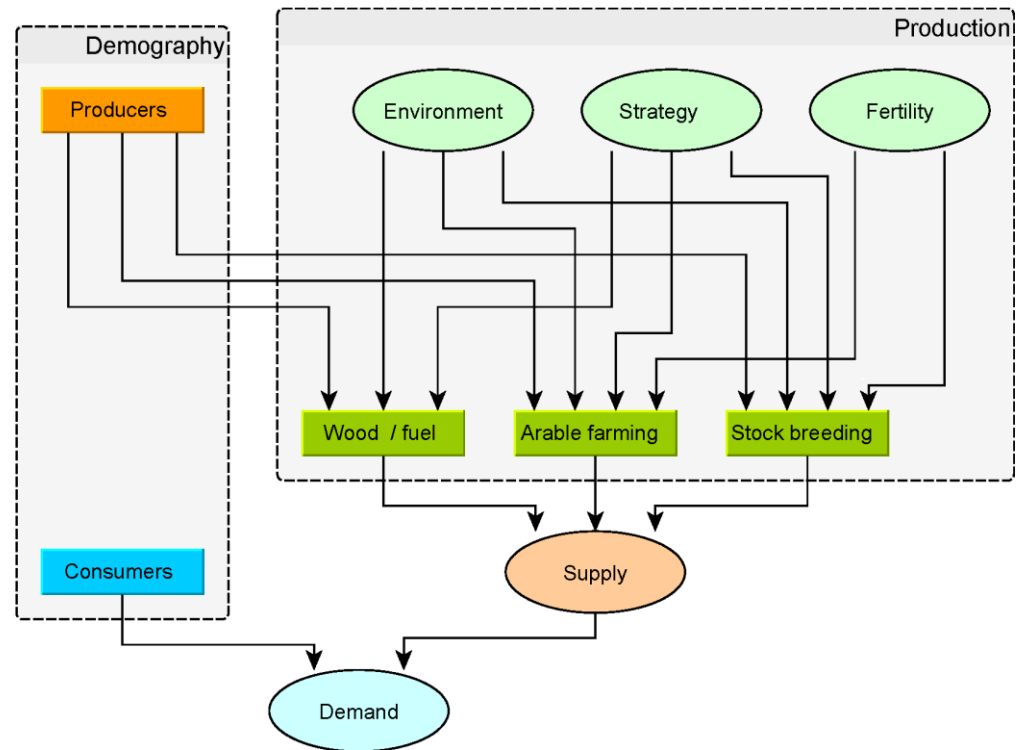
- simulates Roman land use by comparing supply and demand of land
- equation-based
  - > efficient raster calculations
- predictive purpose
  - > originally designed for modern planning



Koomen 2016

# ROMFARMS (JOYCE 2019)

- simulates interplay and dependencies of factors in Roman agricultural production
- agent-based model
  - > combined with system dynamics modelling
- heuristic purpose
  - > predict agricultural yields under a wide range of scenarios



# CRITERIA FOR MODEL COMPARISON

- **technical**
  - > software and computational resources required
  - > reproducibility and ease of use
- **methodological / conceptual**
  - > underlying mechanisms and theoretical frameworks
  - > spatial and temporal scope
- **application**
  - > assumptions for models and experimental runs in relation to outcomes
- **outcomes and validation**
  - > internal consistency and comparison to archaeological insights

# TECHNICAL

- **PLUS**



- > **GeoDMS**

- > process and visualize large geographic datasets
    - > often used in conjunction with GIS
    - > limited programming options

- **ROMFARMS**



- > **NetLogo**

- > limited spatial analysis
    - > extensive programming options
    - > runs into computational limitations

- both are Free and Open Source Software





# METHODOLOGICAL / CONCEPTUAL

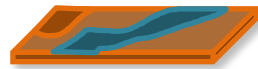
Aspect	PLUS	ROMFARMS
Modeling approach	<ul style="list-style-type: none"> <li>discrete choice theory</li> </ul>	<ul style="list-style-type: none"> <li>complex systems dynamics</li> </ul>
Spatial Resolution	<ul style="list-style-type: none"> <li>100 x 100 m grid</li> </ul>	<ul style="list-style-type: none"> <li>100 x 100 m grid</li> <li>10 x 10 km blocks</li> </ul>
Temporal resolution	<ul style="list-style-type: none"> <li><b>snapshots in time</b></li> </ul>	<ul style="list-style-type: none"> <li><b>annual time steps</b></li> <li>scenarios run over 100 years</li> </ul>
Spatial vs. non spatial	<ul style="list-style-type: none"> <li>non-spatial demand</li> <li>spatial land suitability</li> <li>competition for land</li> <li><b>spatial allocation of land use</b></li> </ul>	<ul style="list-style-type: none"> <li>spatial (local) demand</li> <li>spatial land suitability</li> <li>limited competition for land</li> <li><b>no spatial allocation of land use</b></li> </ul>

# INPUTS

- **model parameters**
  - > size of civilian and military population (consumers)?
  - > size of rural population (workforce)?
  - > proportion of calories obtained from cereals?
  - > proportion of calories produced locally?
  - > how much land was needed and available?
- **data**
  - > typical size, number and dating of settlements
  - > archaeobotanical and zooarchaeological evidence for diet and imports
  - > land suitability



## Physical suitability



palaeogeography  
(Groenhuijzen 2018)

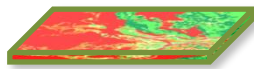


simulation of woodland

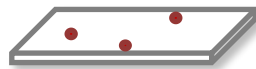


expert suitability scores (0-5)  
(Gouw-Bouwman et al. 2016)

## Distance relationships



time to travel through one cell



settlements  
(Verhagen et al. 2016)



travel time to  
settlements



buffer around military structures

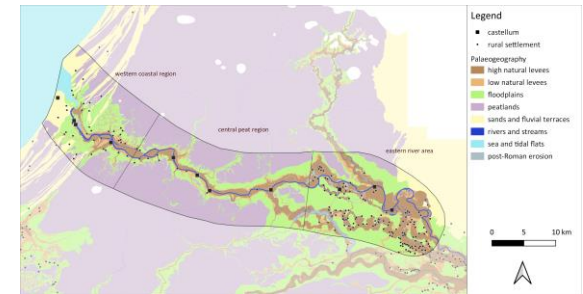


cleared areas for wood around  
military structures

## Political factors

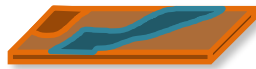
140 CE: no imports from area north of the limes

**PLUS**



**landuse**  
**70 CE / 140 CE**

## **Physical suitability + demography**



palaeogeography  
(Groenhuizen 2018)



settlements  
(Verhagen et al. 2016)

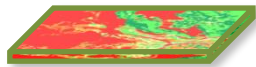


simulation of woodland



simulation of agrarian production

## **Distance relationships**



nearest suitable cell



settlements  
(Verhagen et al. 2016)



site catchments

## **Technology factors**

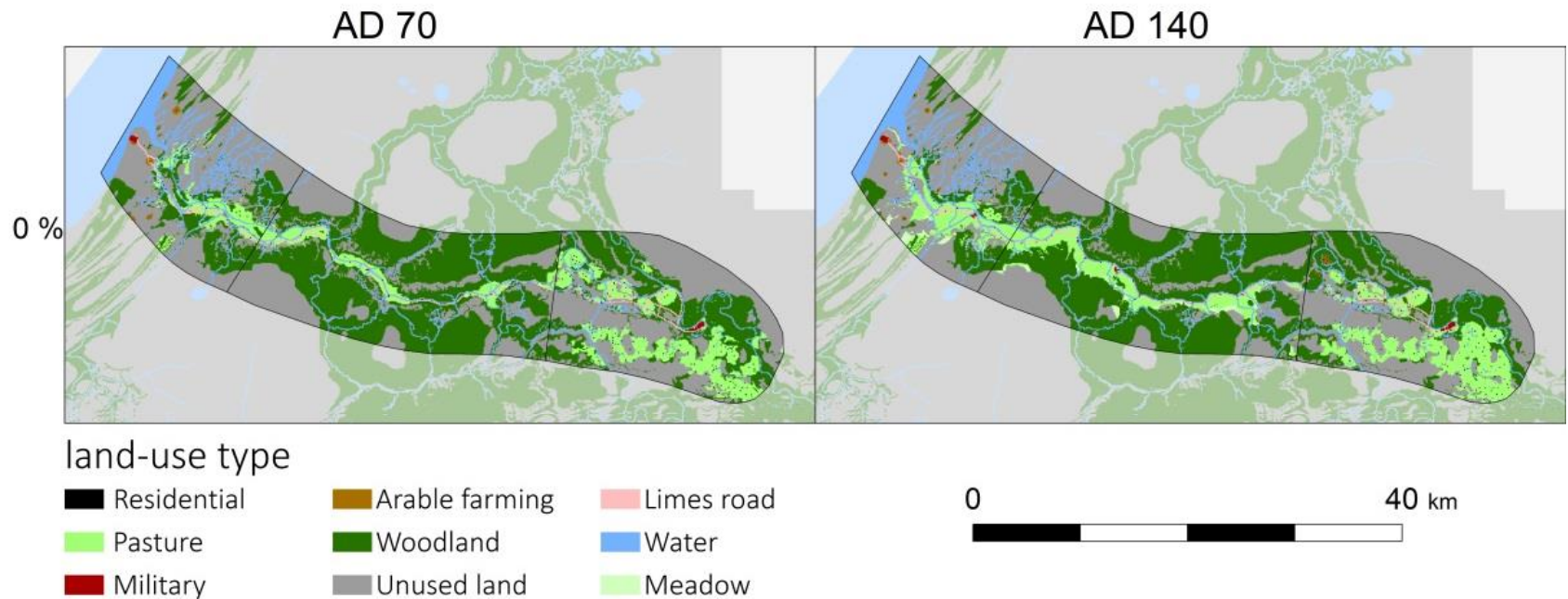
*extensification or intensification*



**agrarian production  
15 BCE – 275 CE**

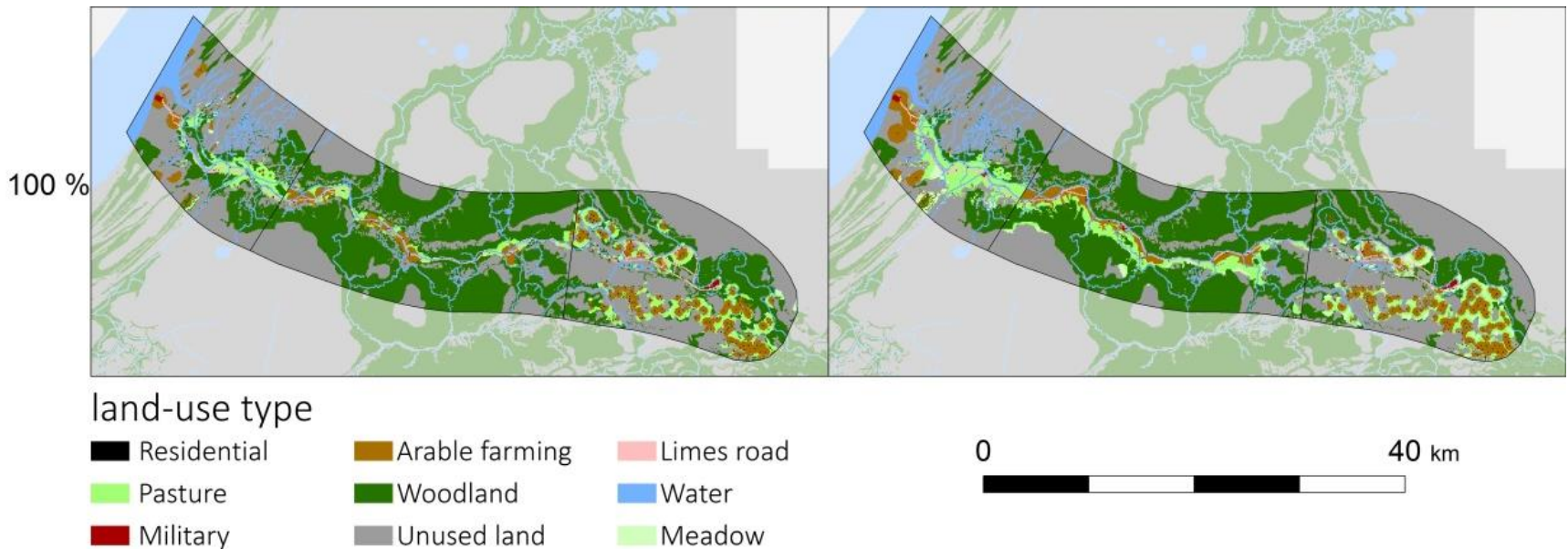
# OUTCOMES (PLUS)

**spatial prediction of land use,  
depending on surplus production scenarios**



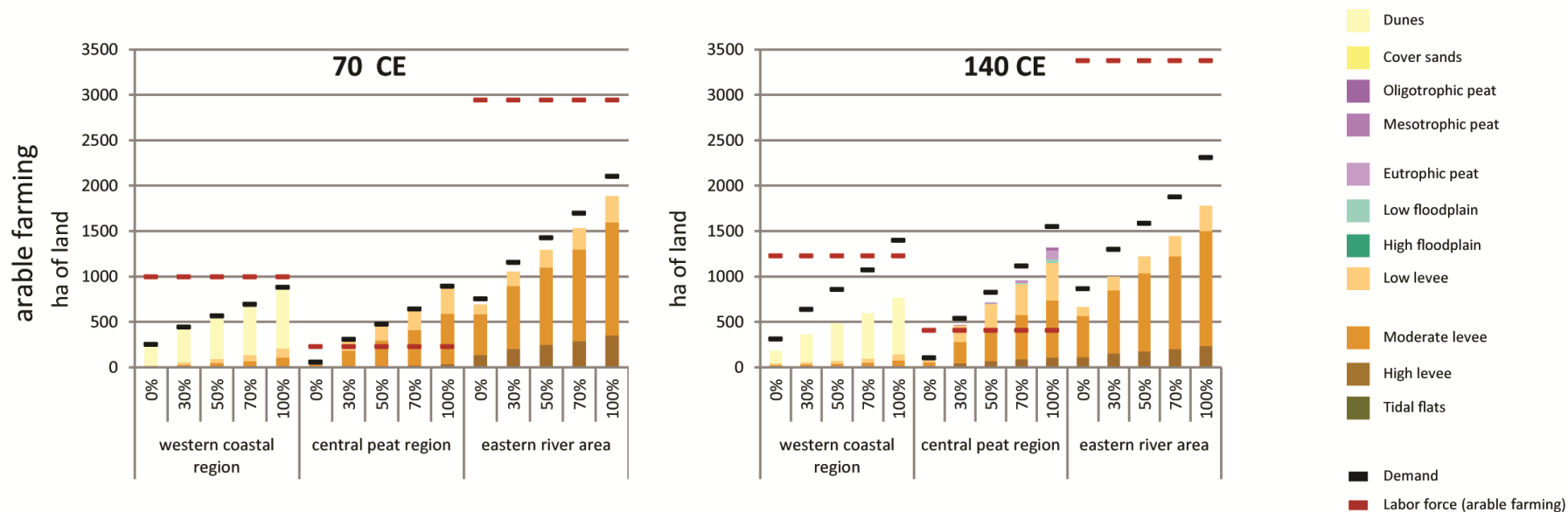
# OUTCOMES (PLUS)

**spatial prediction of land use,  
depending on surplus production scenarios**





# OUTCOMES (PLUS)



**allocation over land units:  
demand not met in all scenarios**

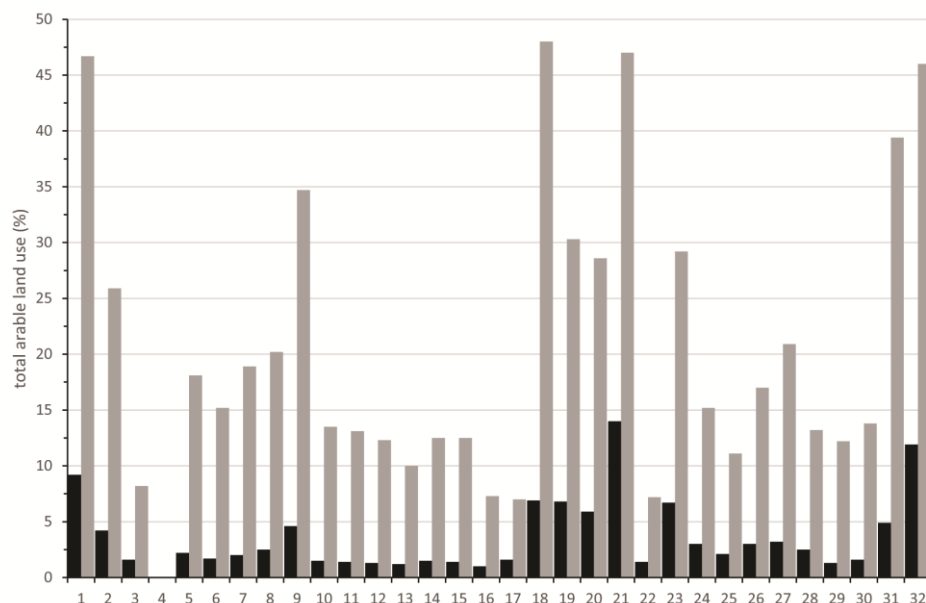
**unproductive areas used  
in some scenarios (competition for land)**





# OUTCOMES (ROMFARMS)

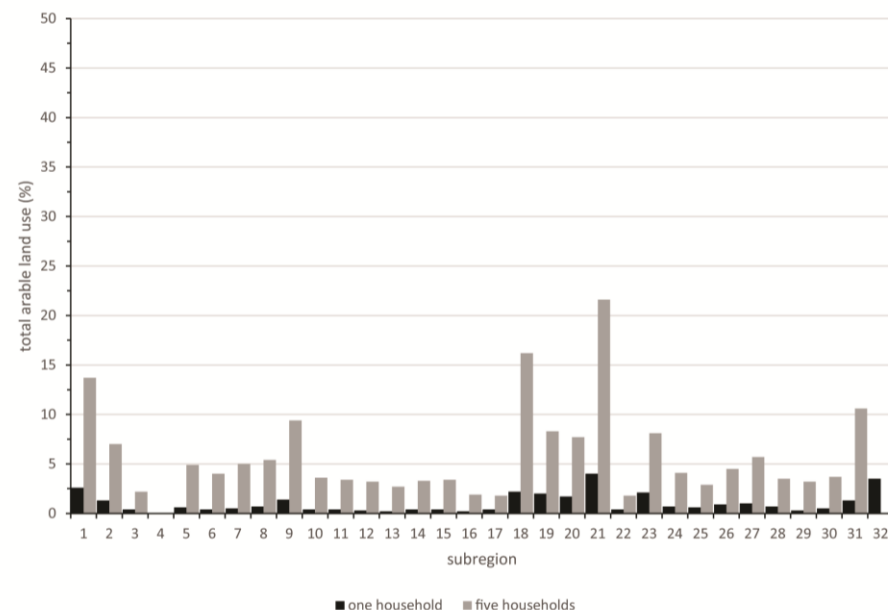
extensification



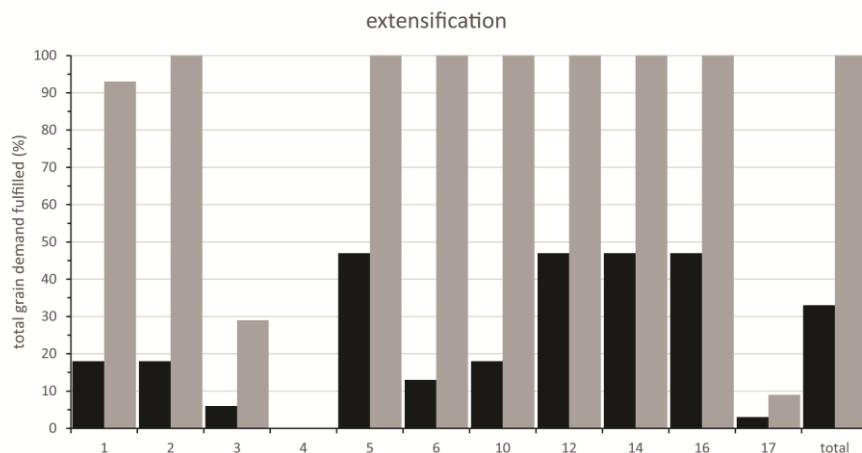
**two scenarios:  
extensification and  
intensification**

**workforce not sufficient to  
take all available land into  
production**

intensification

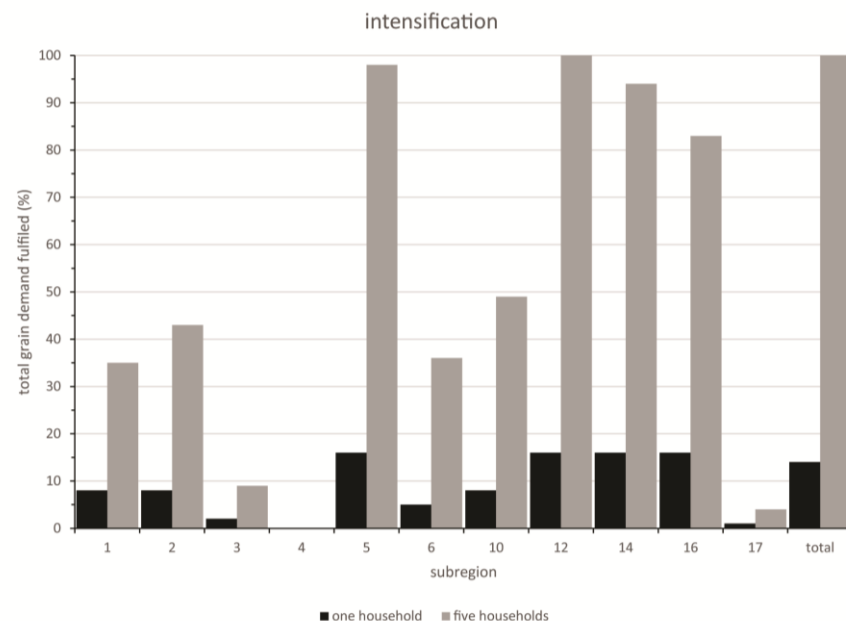


# OUTCOMES (ROMFARMS)



**local demand only fulfilled  
when sufficient workforce is  
available**

**regional redistribution likely**



# VALIDATION

- outcomes restricted to yields (calories) and area used (hectares)
  - > PLUS also predicts the spatial allocation of land use categories
- internal validation
  - > what model parameters are most influential?
  - > equifinality?
- external validation
  - > plausibility of outcomes
    - > where is land use predicted?
    - > do demographic estimates match the evidence?



# COMPATIBILITY

- ABM simulation dominant in archaeology
  - > geographical scale of most interest to archaeologists, local and (micro-)regional
  - > lack of spatial simulation models at the intermediate level (macro-regional / national)
    - > added value of the PLUS
- upscaling ROMFARMS to the PLUS is easier than the other way around
  - > detailed, exploratory approach of ROMFARMS useful to run more scenarios in the PLUS
  - > but, ROMFARMS could benefit from advanced spatial allocation procedures
- full integration would lead to computational ‘overkill’
  - > however, tools for transferring approaches and principles between the models are currently lacking
    - > NAS<sup>2</sup>A project

# WANT TO READ MORE?

<https://doi.org/10.3390/heritage4030118>

The screenshot displays the MDPI Heritage journal website. At the top, the MDPI logo is on the left, and navigation links for '25th Anniversary', 'Journals', 'Information', 'Author Services', 'Initiatives', and 'About' are in the center. On the right, there are 'Sign In / Sign Up' and 'Submit' buttons. Below this is a search bar with the text 'Search for Articles:' and input fields for 'Title / Keyword', 'Author / Affiliation', 'Heritage' (selected), and 'All Article Types'. A 'Search' button and an 'Advanced' link are also present. The breadcrumb trail reads 'Journals / Heritage / Volume 4 / Issue 3 / 10.3390/heritage4030118'. On the left sidebar, there is a 'heritage' logo, buttons for 'Submit to this Journal', 'Review for this Journal', and 'Edit a Special Issue', followed by an 'Article Menu' with links to 'Article Overview', 'Article Versions', 'Related Info Links', and 'More by Authors Links'. The 'Full Article Text' section is expanded, showing a table of contents with links to 'Introduction', 'A Comparison of Approaches', 'Comparison of the PLUS and ROMFARMS', and 'Discussion'. The main article content area shows the title 'Different Models, Different Outcomes? A Comparison of Approaches to Land Use Modeling in the Dutch Limes' by Philip Verhagen, Maurice de Kleijn, and Jamie Joyce. It includes author affiliations, a list of authors with their roles, and a list of authors who contributed equally to the work. The article is labeled as 'Open Access' and 'Article'. The academic editor is Francesco Soldovieri. The article was received on 30 July 2021, revised on 26 August 2021, accepted on 30 August 2021, and published on 1 September 2021. It belongs to the Special Issue 'Geocomputation and Remote Sensing for Modelling in Landscape Archaeology'. At the bottom of the article, there are buttons for 'Download PDF', 'Browse Figures', and 'Citation Export'. On the right sidebar, there are social media sharing icons and a 'Like' button with a count of 0.