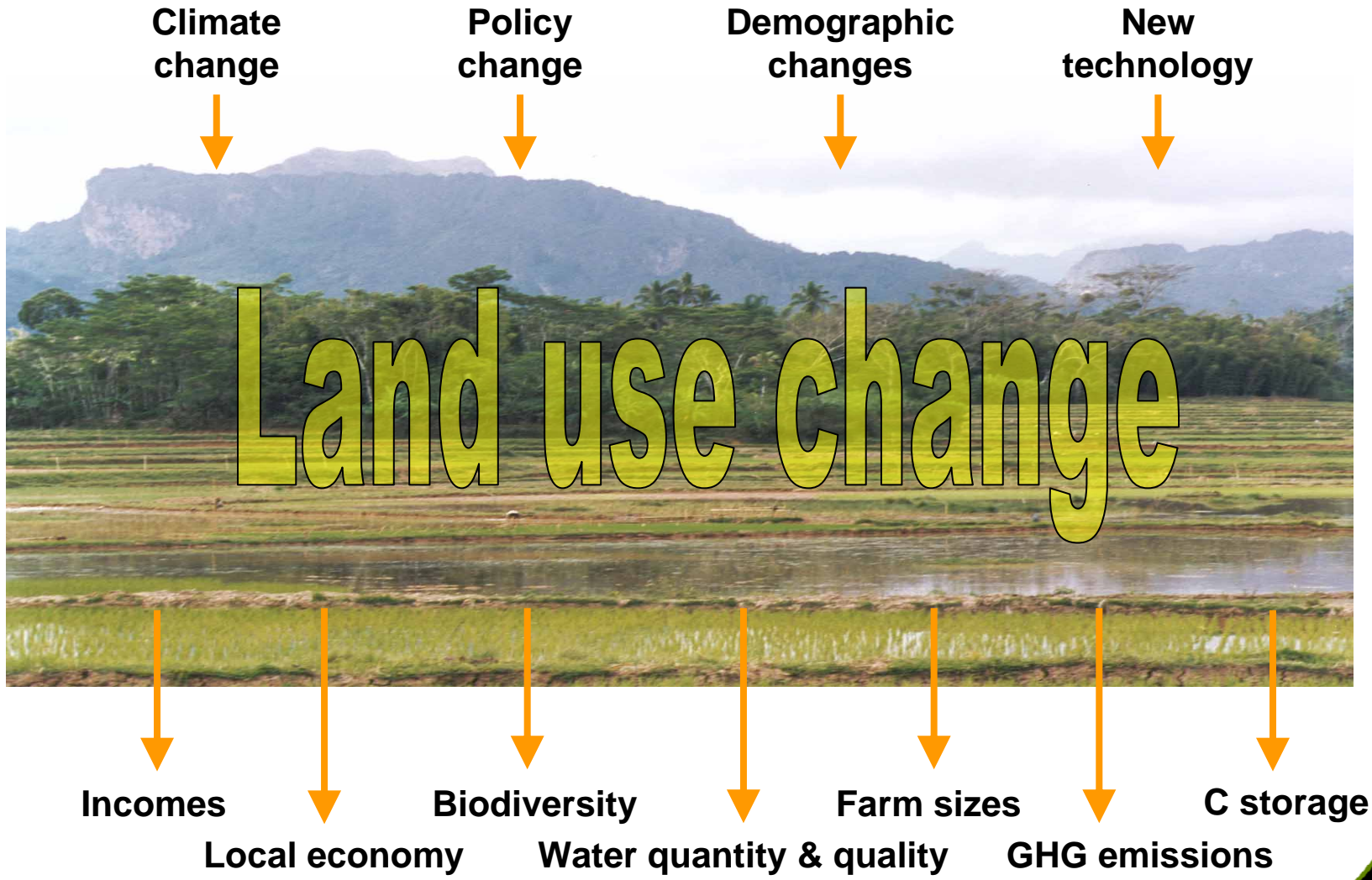


Integrating simulation models of human decision-making and biophysical processes

Robin Matthews
Climate Change Theme Leader
Macaulay Institute, Aberdeen AB15 8QH

*Paper presented at Food Security and Environment Change Conference
Oxford, UK, 2–4 April 2008*

Rural land use systems



Incorporating human behaviour



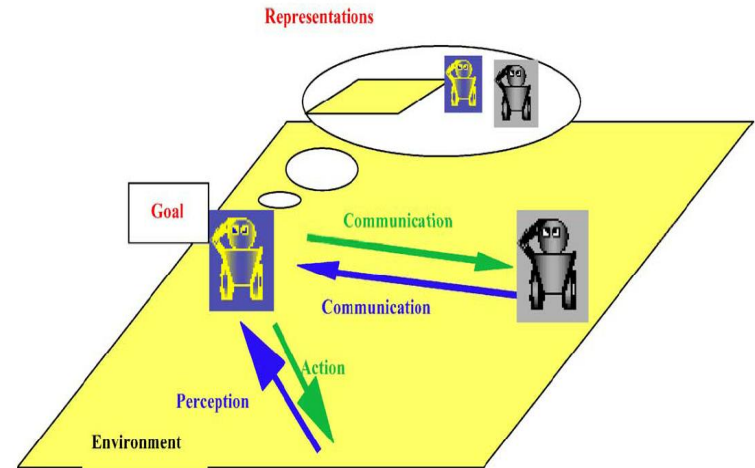
Dominant factor influencing socio-ecological systems dynamics is the presence of humans:

- ability to remember and learn from the past
- ability to perceive both current and future states of their biophysical and social environment
- ability to communicate with each other and establish social networks
- ability to establish institutions that govern their behaviour
- ability to make decisions and carry out actions

Agent-based modelling

ABM: a number of 'intelligent' virtual agents which:

- have the ability to communicate and exchange information with each other
- can interact with their environment
- have the ability to change their actions as a result of these interaction
- have only partial knowledge of the system as a whole (bounded rationality)



ABM offers a way to couple social, economic, and ecological models:

- social interaction
- micro-level decision-making
- multiple-scale level decision-making
- population level adaptation
- co-evolution between agents and their environment

Linking to biophysical models

Antle, J.M. *et al.* (2001):

- ‘loosely-coupled’
 - exchange driving variables
- ‘closely-coupled’
 - sharing common sub-processes - temporal and spatial scales may be determined by the original (sub-)models being coupled together
- ‘fully integrated’
 - most rigorous
 - ensures common understanding of underlying assumptions and theories
 - software designed to meet the needs of the integrated work, rather than the work having to be fitted around constraints and assumptions of existing software

People and Landscapes Model (PALM)

- **Household agents**
 - decision-making
 - inter-household interactions
 - imitation of successful strategies
 - buying/selling commodities
- **Patches on a landscape**
 - CENTURY soil organic matter model
 - Ritchie water balance model
 - DSSAT crop models
 - Trees model
- **Livestock model**

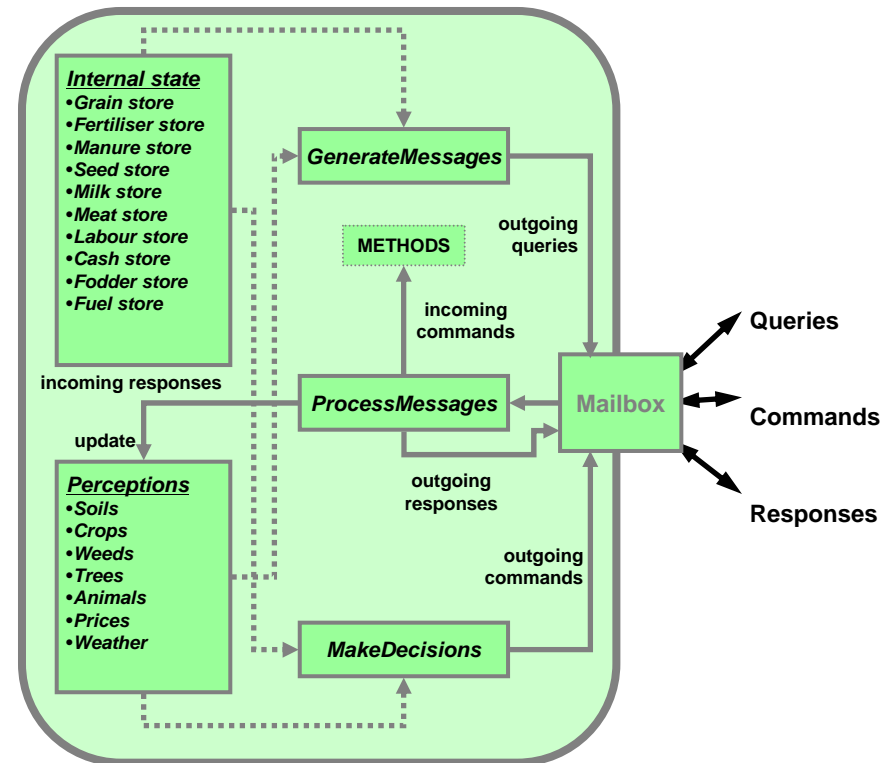


Papers

- Matthews, R.B., 2002. Chapter 15 in *Crop-Soil Simulation Models: Applications in Developing Countries* (R.B. Matthews & W. Stephens, Editors), CAB International, Wallingford, UK, pp. 209-230.
- Matthews, R.B. & Pilbeam, C.J., 2005. Paper presented at MODSIM05 conference, Dec 9-12, 2005, Melbourne, Australia.
- Matthews, R.B. & Pilbeam, C.J., 2005. *Agriculture, Ecosystems & Environment* 111(1-4):119-139.
- Matthews, R.B. et al., 2005. Paper presented at MODSIM05 conference, Dec 9-12, 2005, Melbourne, Australia.
- Matthews, R.B., 2006. *Ecol. Modelling* 194(4):329-343.

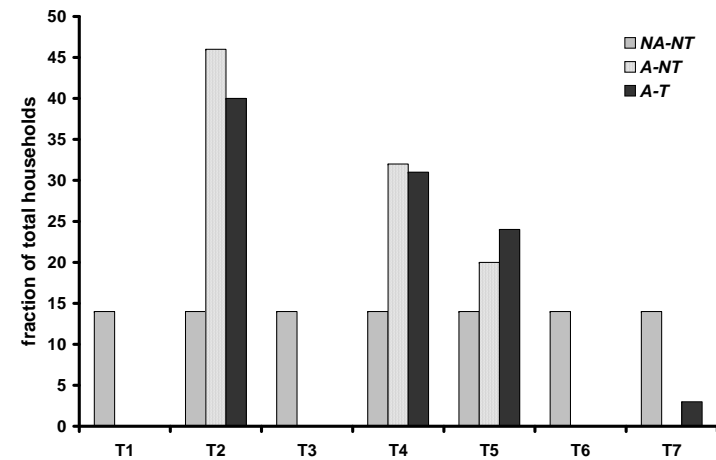
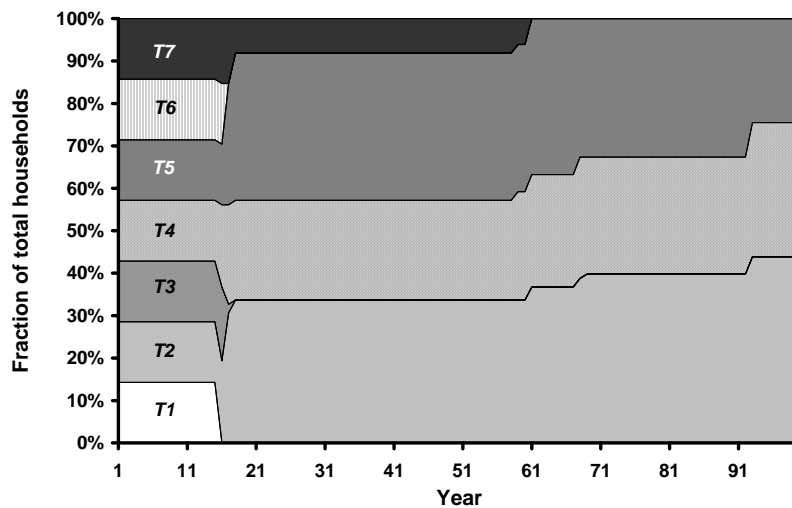
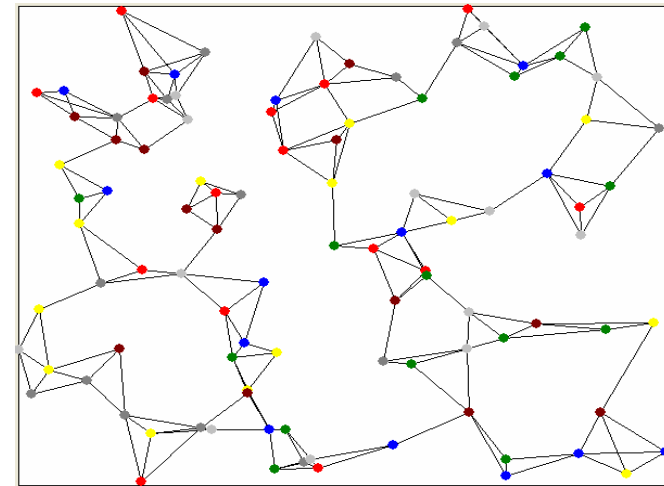
PALM: Agent components

- **Communication module**
 - reception, interpretation
- **Knowledge base - ‘memory’**
- **Perception of its environment**
 - may be global or local
 - ‘bounded rationality’
- **Decision-making module**
 - its own internal state
 - communication with other agents
 - conditions within the environment



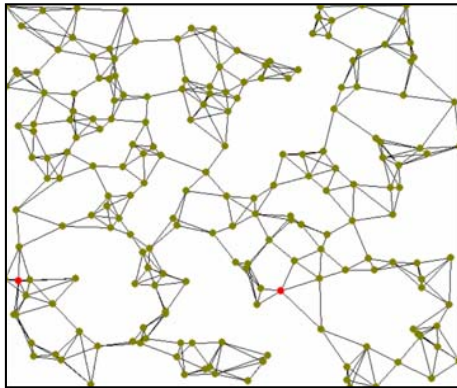
(Matthews, 2006)

Farmer networks

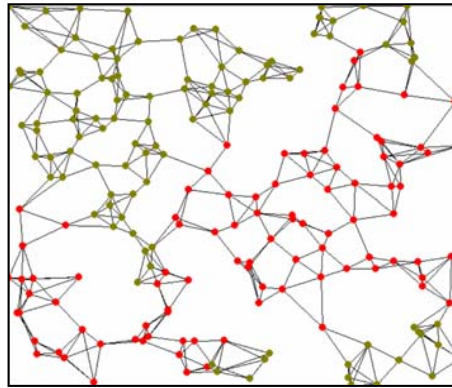


Uptake of biofuel crops

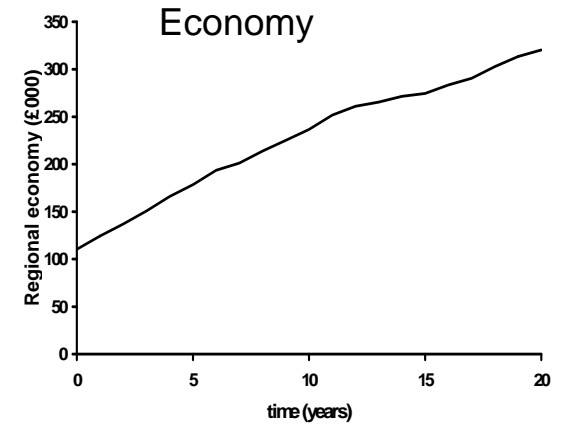
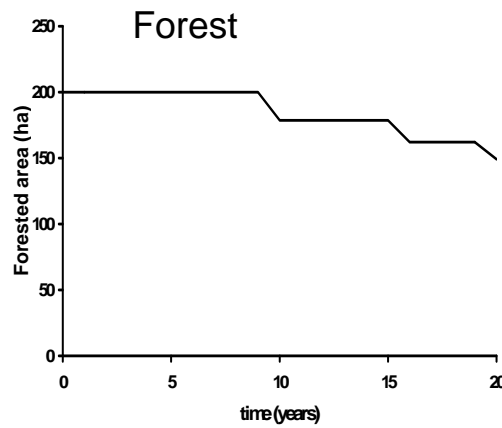
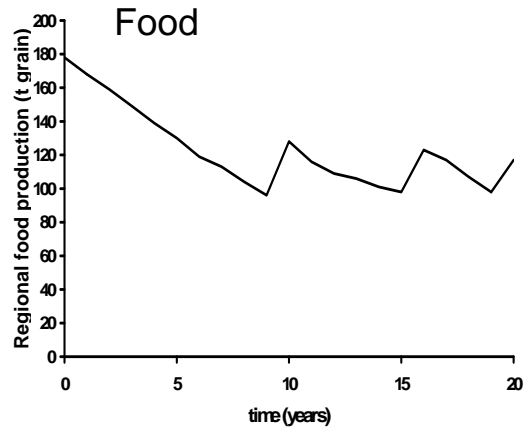
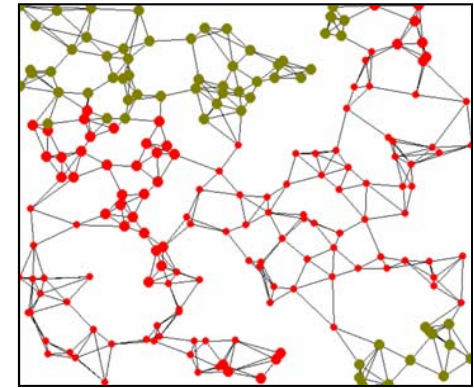
0 years



10 years



20 years



Model complexity

- **The dilemma:**
 - users want simple explanations
 - but ... socio-ecological systems are complicated, perhaps even complex!
- **KISS – Keep it Simple, Stupid**
- **KIDS – ‘Keep It Descriptive, Stupid’ – *Edmonds***
- **‘Make things as simple as possible, but no simpler’ – *Albert Einstein***
- **Holling’s ‘Rule of Hand’ - holarchies**
- **Balance required:**
 - incorporate enough sophistication to capture all the relevant processes
 - simple enough so that understanding of these processes and their interactions is not obscured