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Modelling land use change futures

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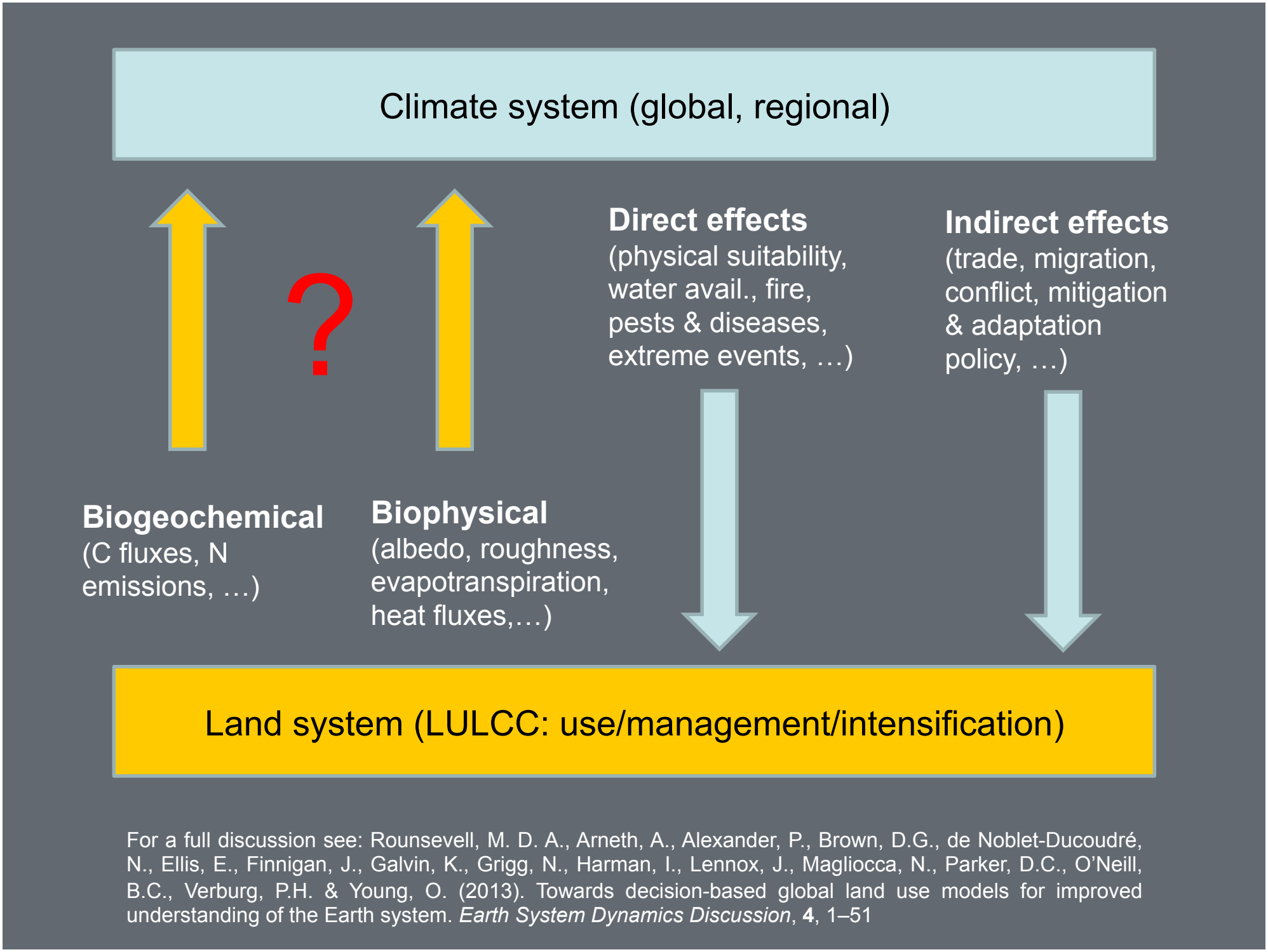
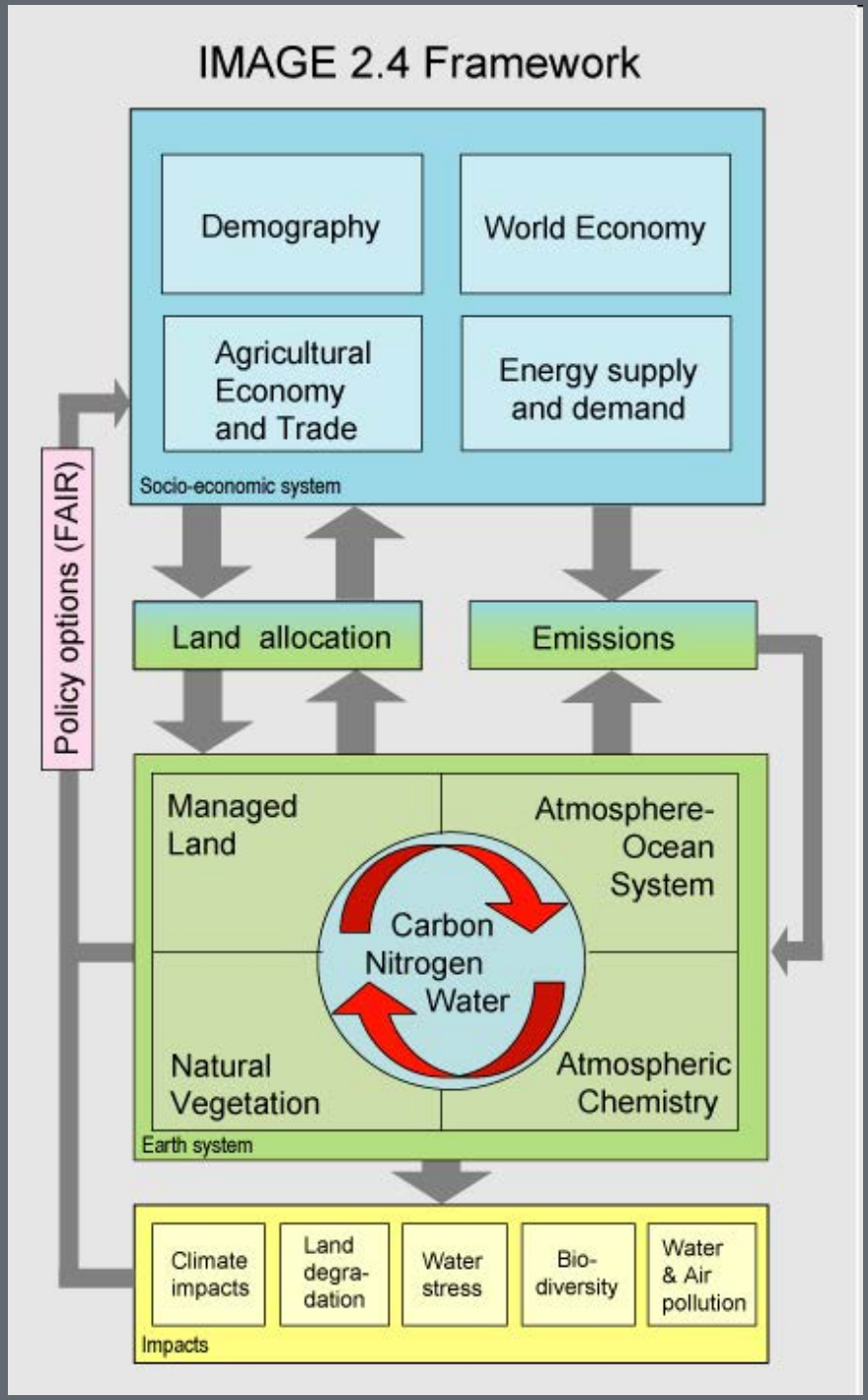


For a full discussion see: Rounsevell, M. D. A., Arneth, A., Alexander, P., Brown, D.G., de Noblet-Ducoudré, N., Ellis, E., Finnigan, J., Galvin, K., Grigg, N., Harman, I., Lennox, J., Magliocca, N., Parker, D.C., O'Neill, B.C., Verburg, P.H. & Young, O. (2013). Towards decision-based global land use models for improved understanding of the Earth system. *Earth System Dynamics Discussion*, **4**, 1–51

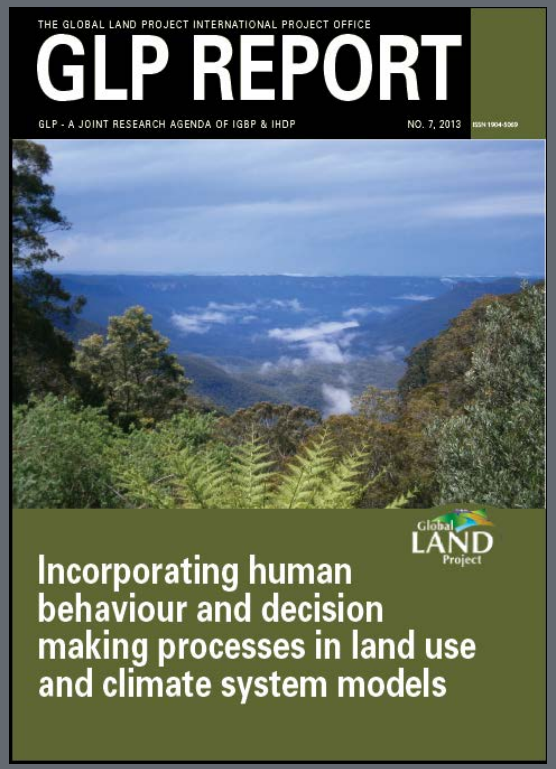
Global Integrated Assessment Models (IAMs), e.g. IMAGE

- Currently the main way to model global scale LULCC
- Links to Computable General Equilibrium (CGE) models to represent economic sectors
- Other global scale LULCC models exist, e.g. CLUE-Mondo, PLUM, MagPie, …
- … BUT, the land use modelling community rarely engages in global scale applications. WHY?



What we don't model very well (if at all) for global scale LULCC …

- Human behaviour and decision making processes (non-economic factors)
- Human agency, adaptive learning and agent evolution
- Societal structures (e.g. networks and interactions)
- Endogenous institutions (both formal and informal)
- Global tele-connections (other than trade), e.g. knowledge, migration, land grabbing, iLUC, …
- Technological development and impacts on LULCC
- …



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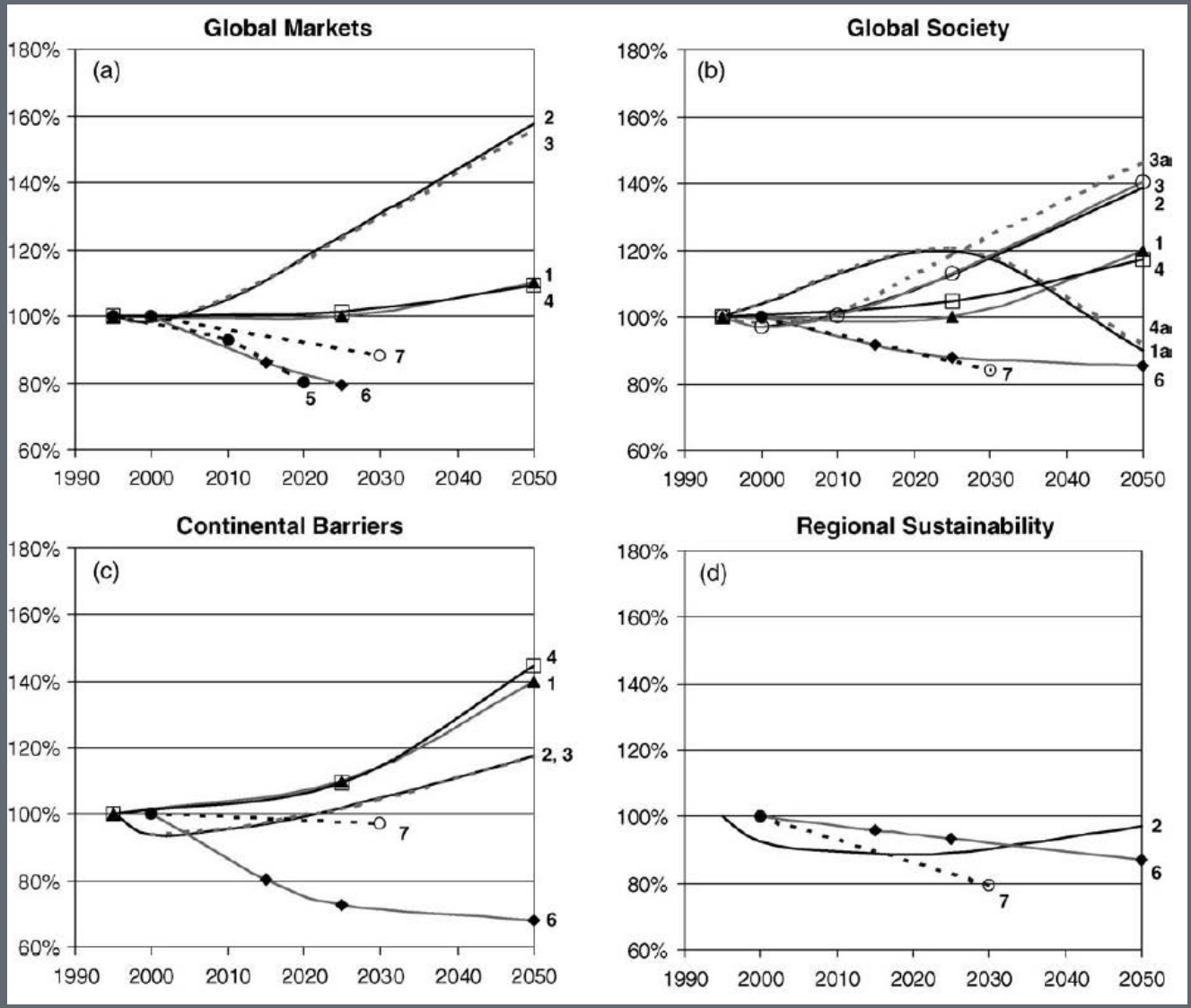
Comparing global scale and regional scale LULCC models

Cropland in Europe for 7 different LULCC scenario studies mapped onto the SRES framework

Global studies:
1, 2 (Image), 3, 4, 5

Regional studies:
6 (Ateam), 7 (EuRuralis)



Source: Busch, G. (2007). Future European agricultural landscapes - What can we learn from existing quantitative land use scenario studies? *Agriculture, Ecosystems & Environment*

LULCC model comparison in LUC4C

- LUC4C project - *land use change: assessing the net climate forcing, and options for climate change mitigation and adaptation*
- Funded by the European Commission FP7 Programme
- Aims to improve LULCC representation in climate modelling
- Will undertake a comparison of IAMs and global scale LULCC models
- Cross-scale comparison – regional vs global models compared for regional windows (Europe, …)
- Limited capacity to compare bottom-up agent-based models
- Contribution of LUC4C to LU-MIP?

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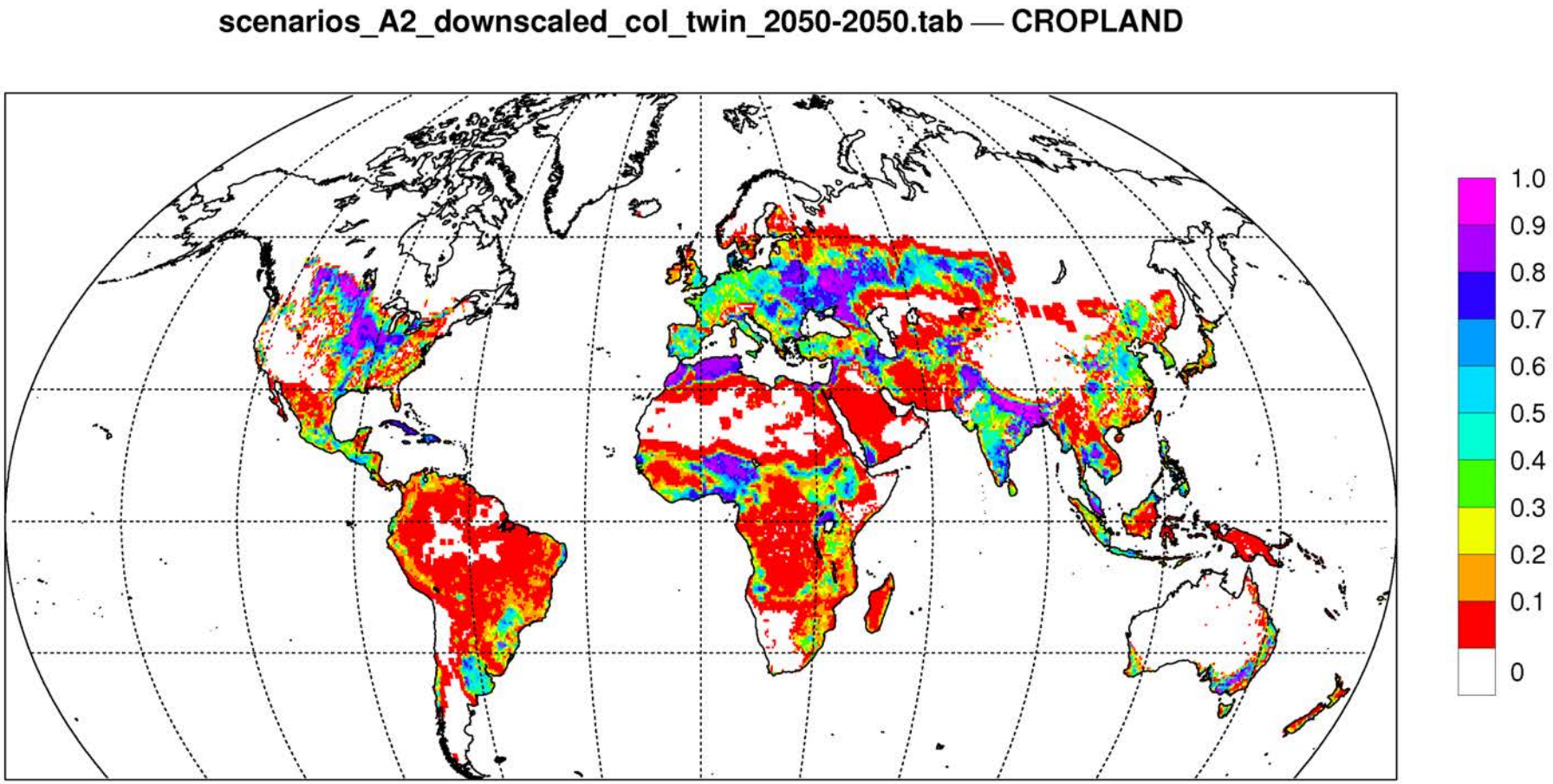
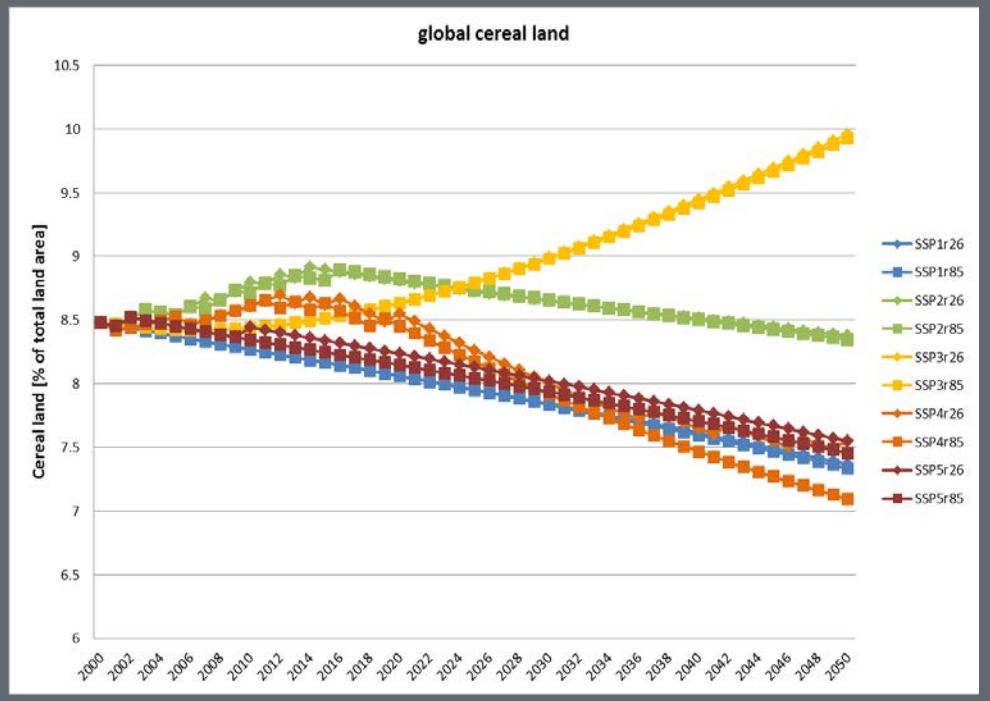
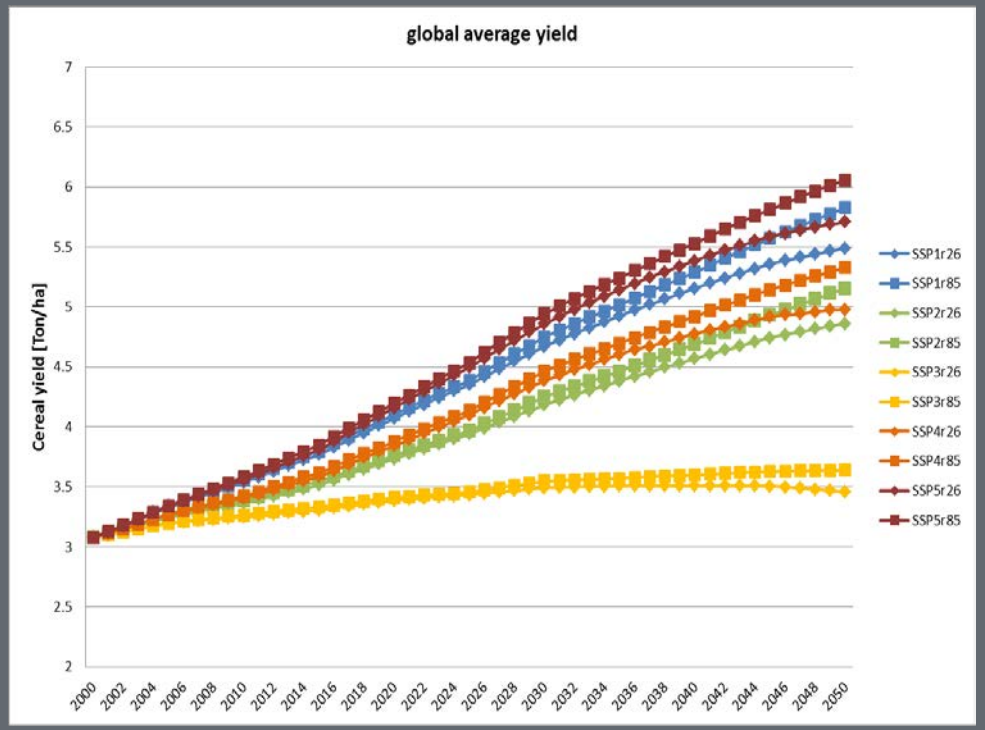
Any questions?

Example PLUM outputs



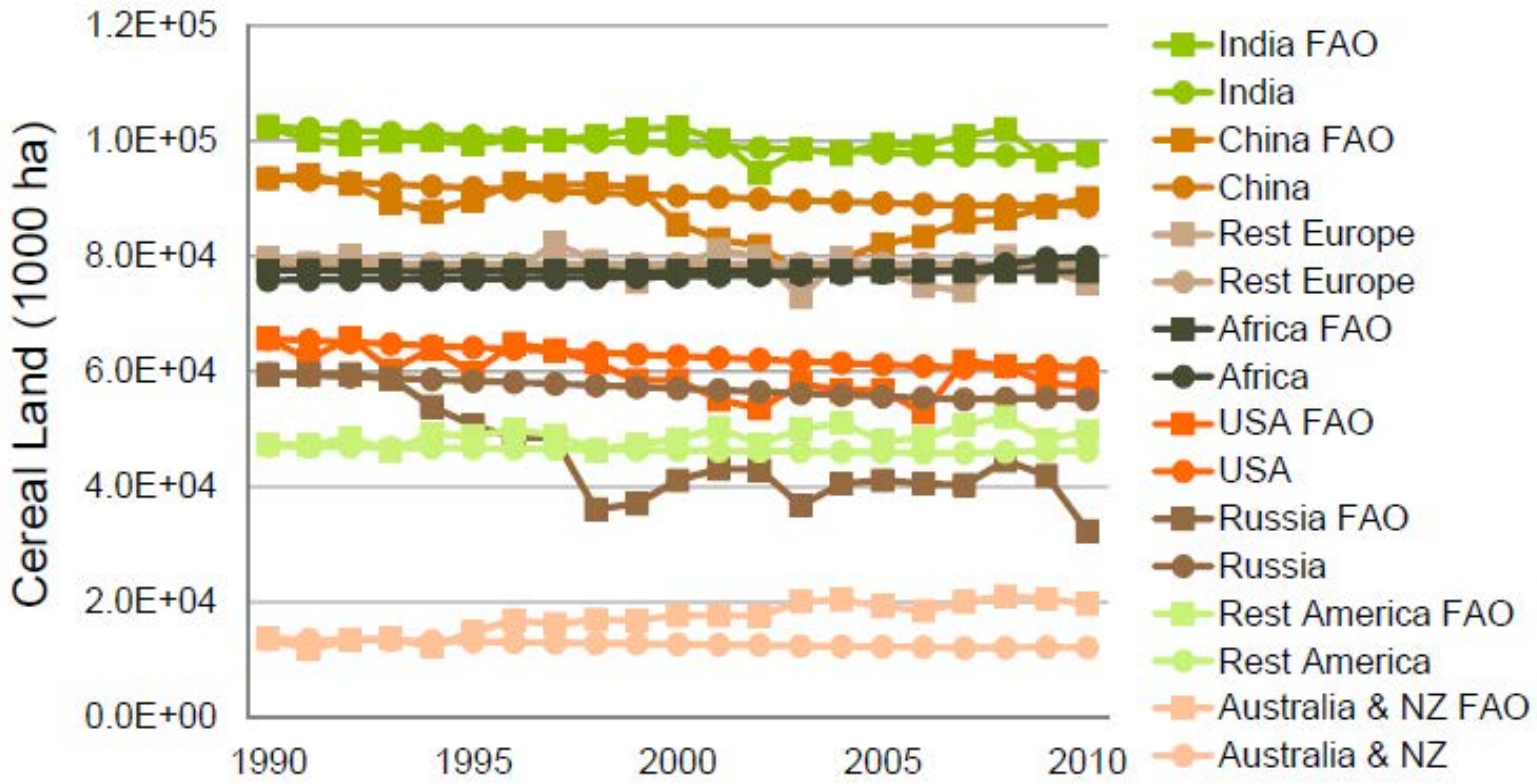
PLUM linked with LPJ-GUESS: Global simulations for the SSPs/ RCPs

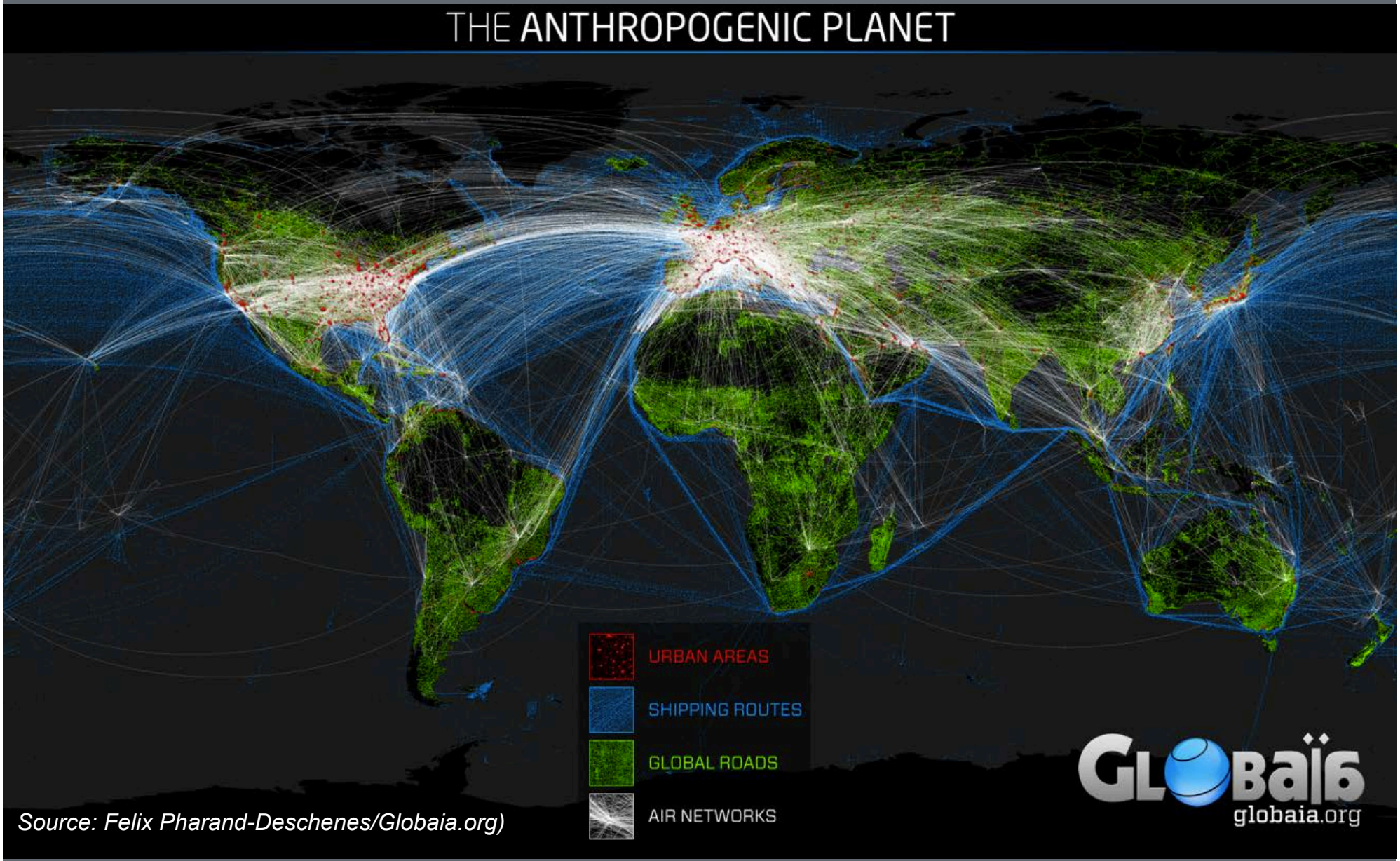




Source: Kerstin Baumanns & Stefan Olin, Lund University

Cereal land for regions



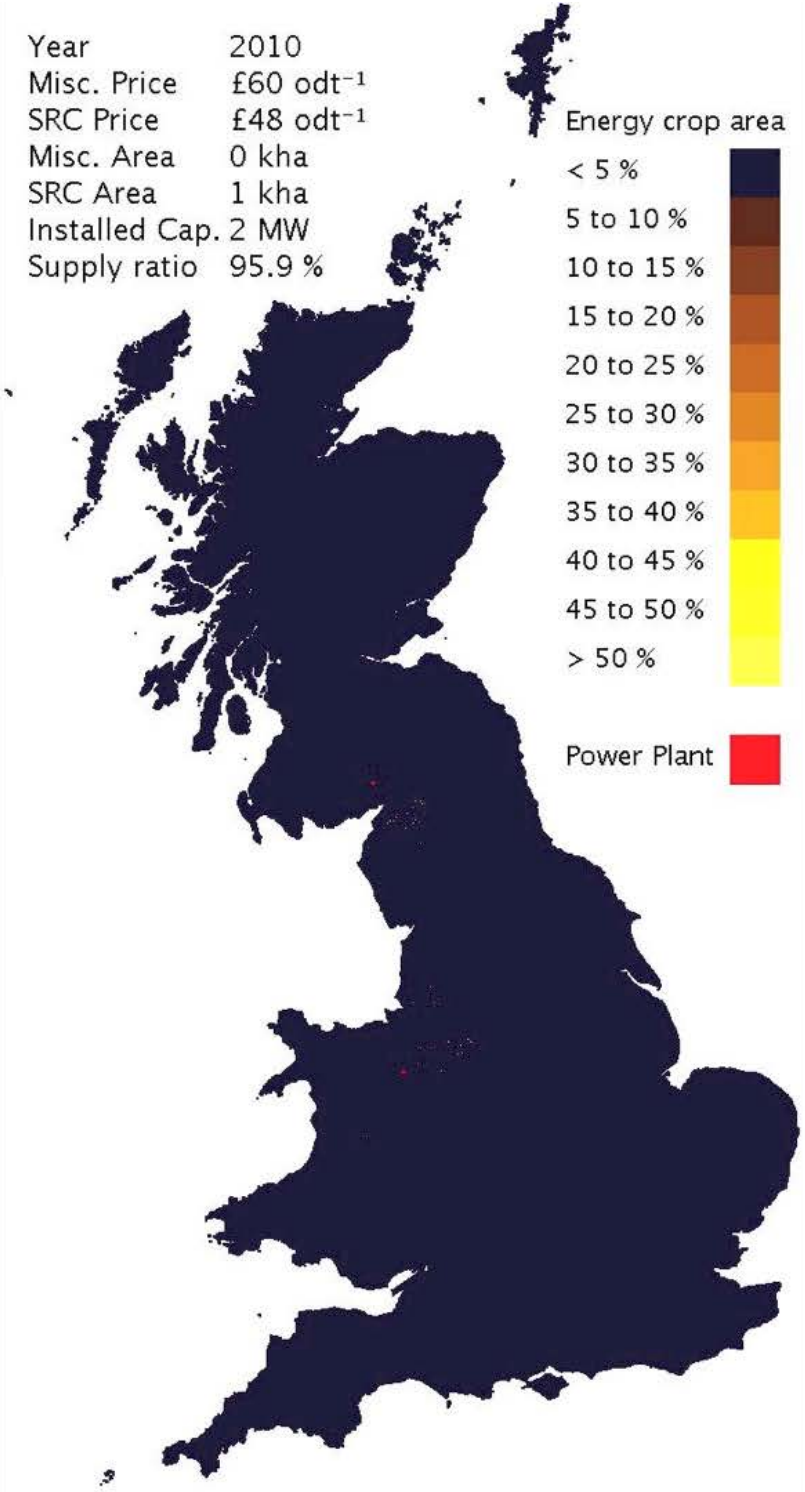


… but also, human migration, knowledge, land grabbing, iLUC, …

Local/regional scale LULCC models

… are different!

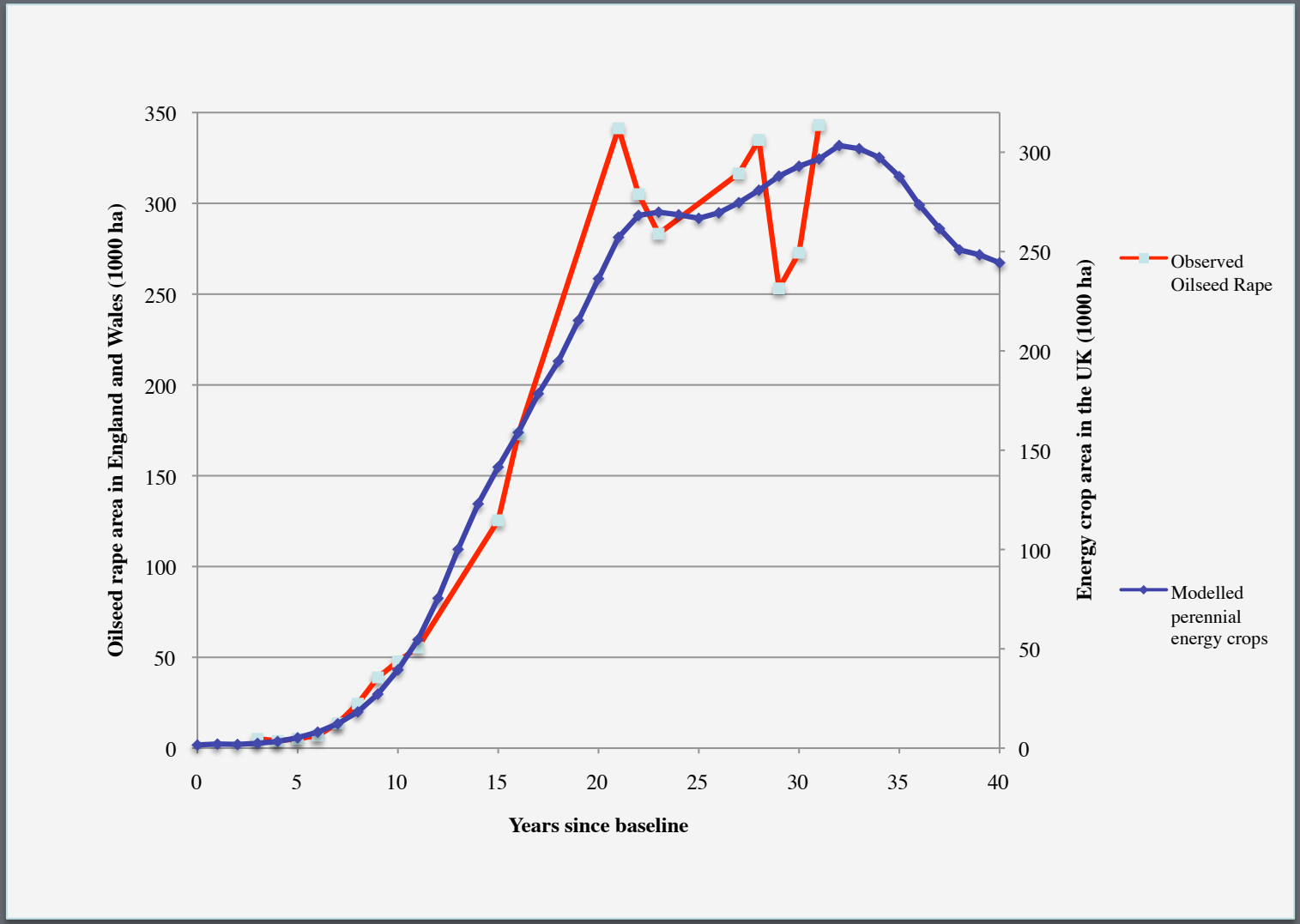
Bottom-up modelling paradigms based on complex systems thinking to represent human agency, behaviour and decision making processes



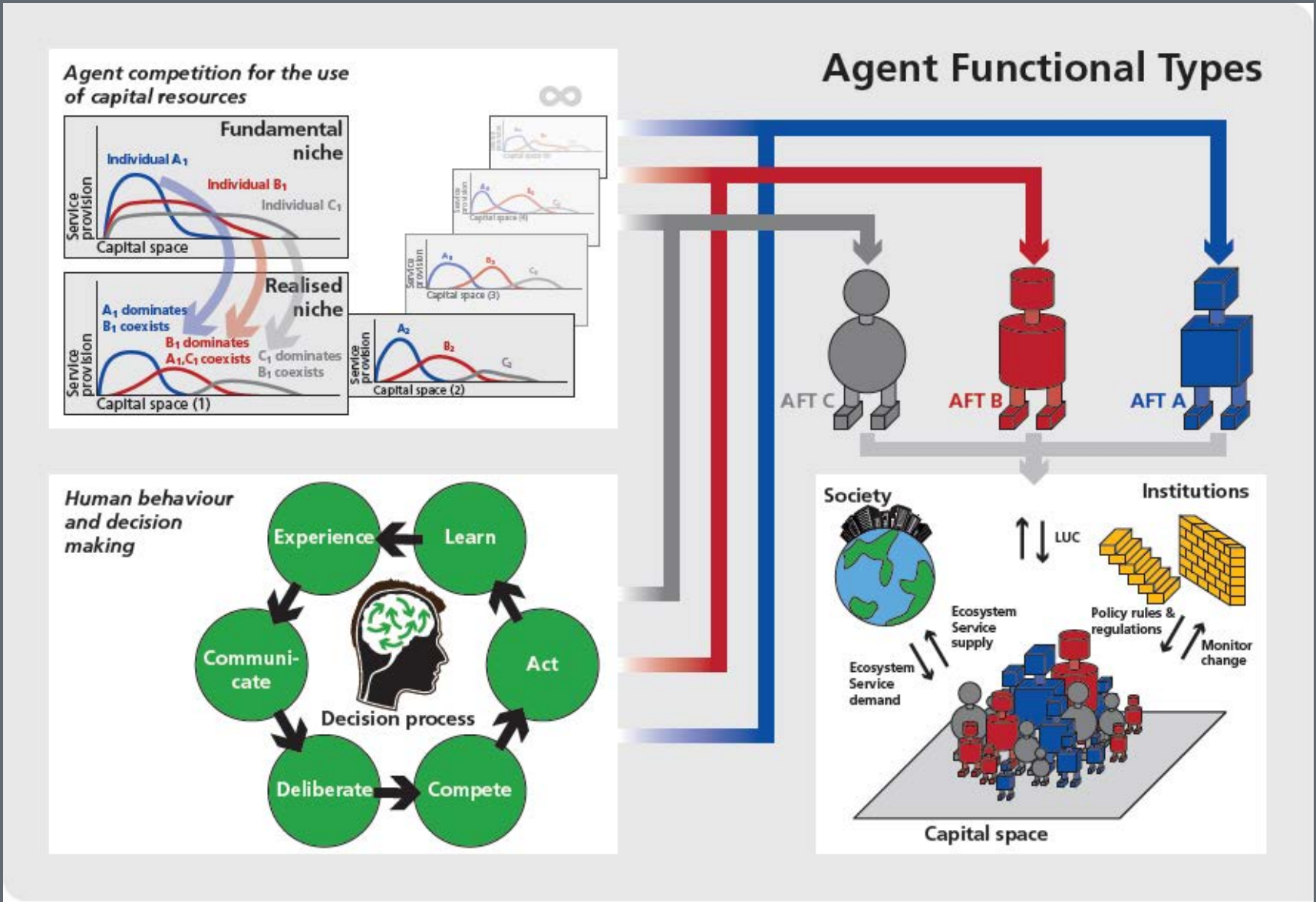
Mitigation policy:

Simulating time-lags in the uptake of energy crops (miscanthus and Short Rotation Coppicing)

After: Alexander et al. (2013). Modelling the perennial energy crop market: the role of spatial diffusion. *J Roy Soc Interface*, **10**

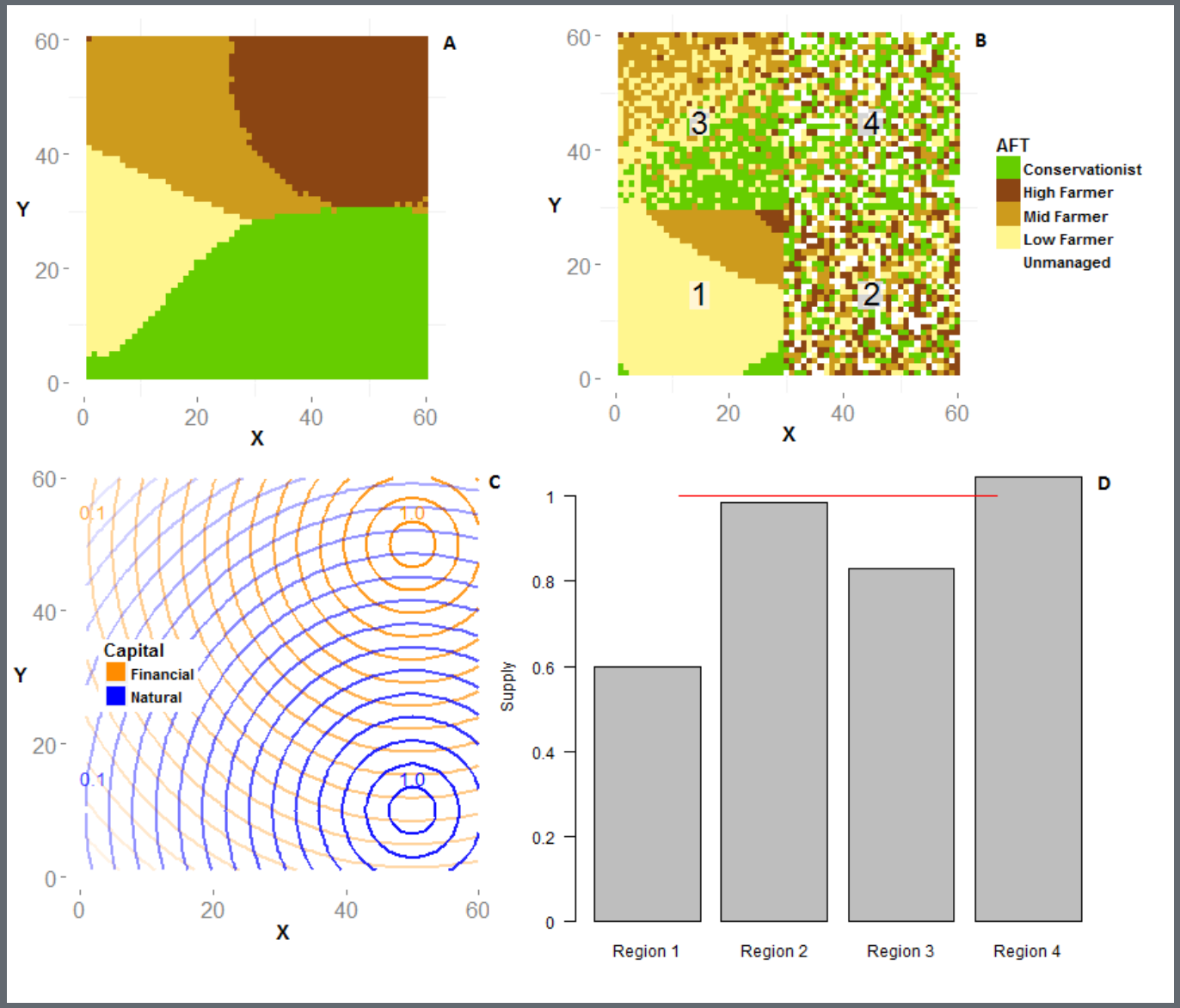


Time lags in adaptation - historic oilseed rape data for England and Wales, against a baseline year of 1966, and mean modelled perennial energy crop areas, using a baseline year of 2010
(Source: Peter Alexander, SRUC, Edinburgh)



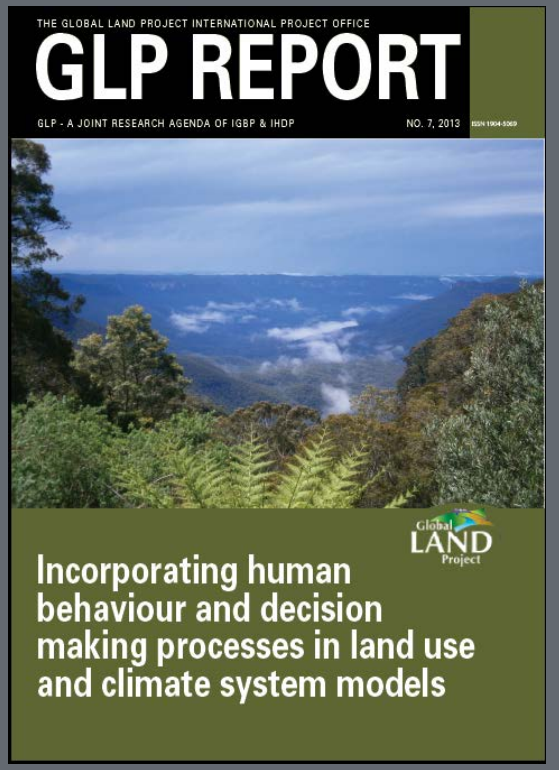
After Arneth et al., in prep. Global models of human decision-making for land-based mitigation and adaptation assessment

Simulating the effect of the regionalisation of demand on agricultural land abandonment

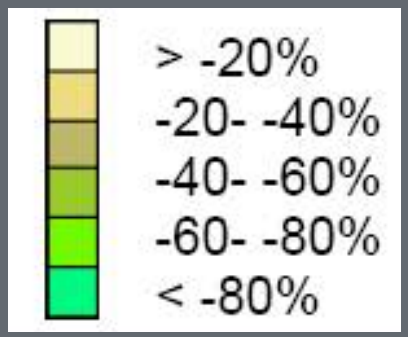


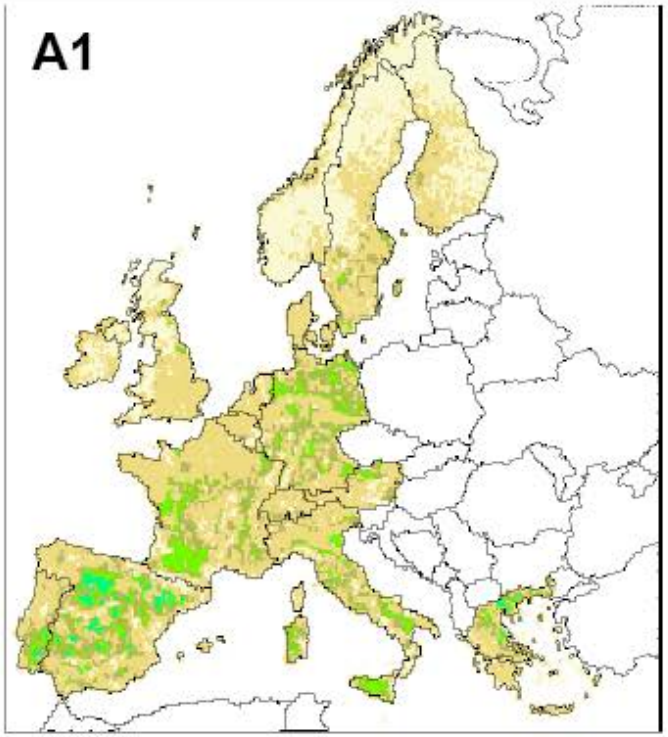
Concluding remarks …

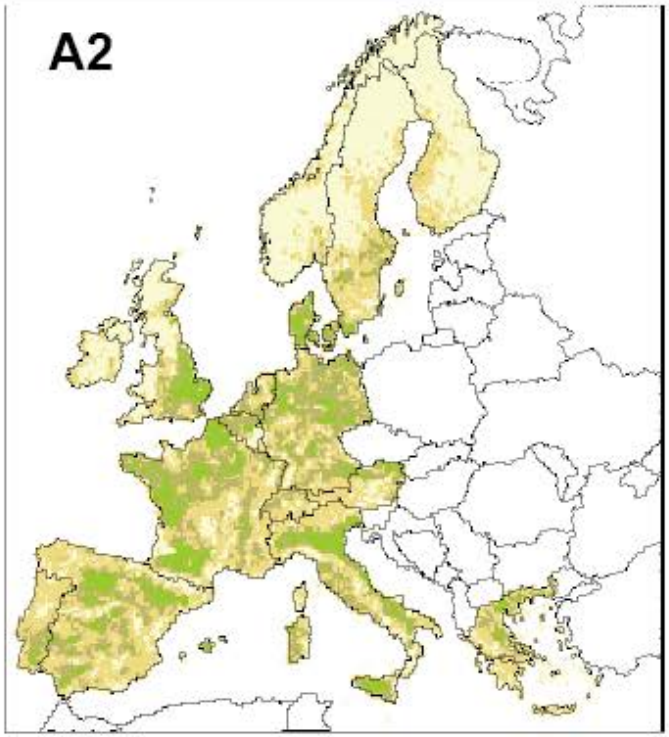
- Exploring alternatives to IAMs at the global scale
- The need for LULCC models to better represent human behaviour and decision making processes, e.g. institutions, , agent learning and evolution, tele-connections, …
- Model comparison of LULCC models across spatial scales (LUC4C project)

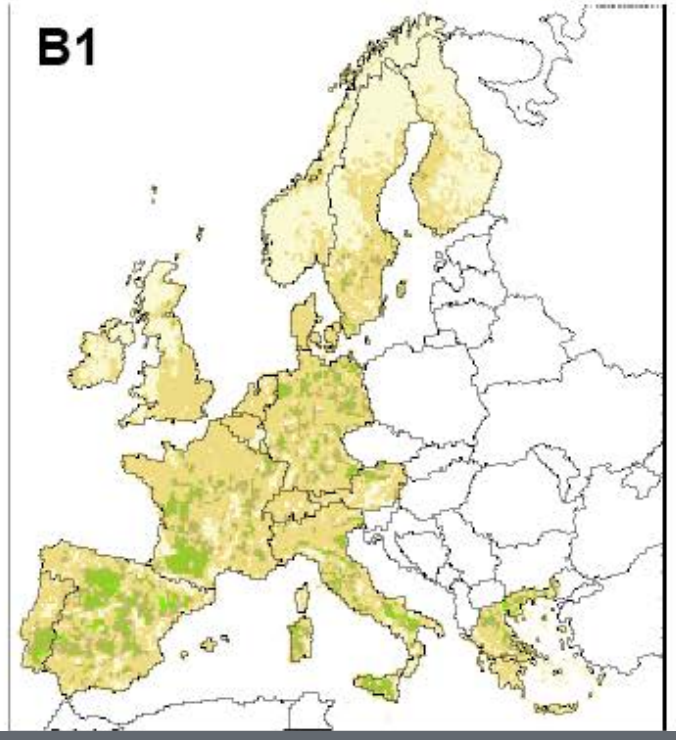


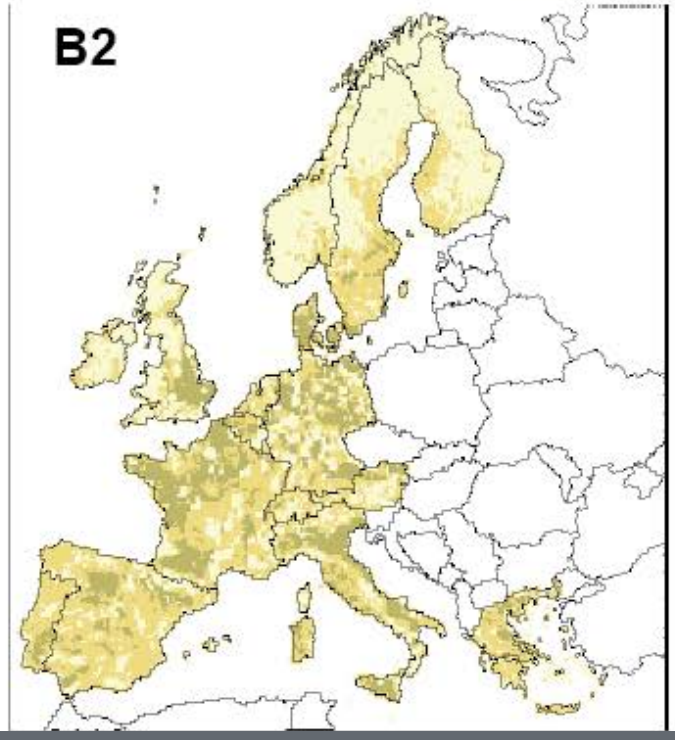
Change in cropland area (for food production) by 2080 compared to baseline (%) for the 4 SRES storylines and HADCM3





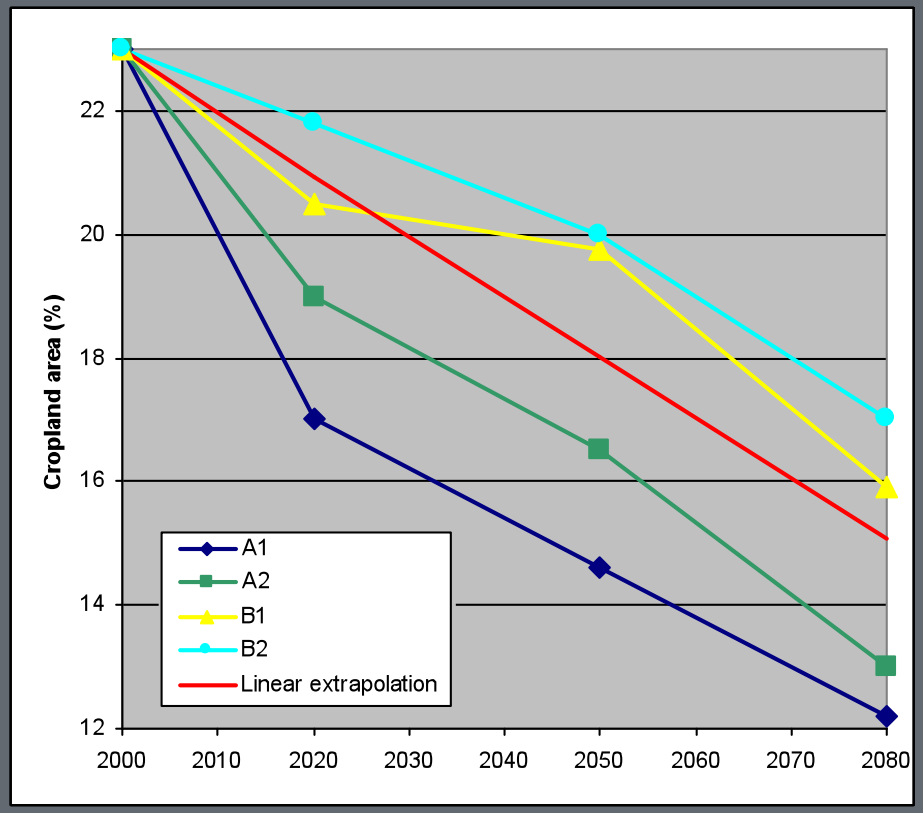




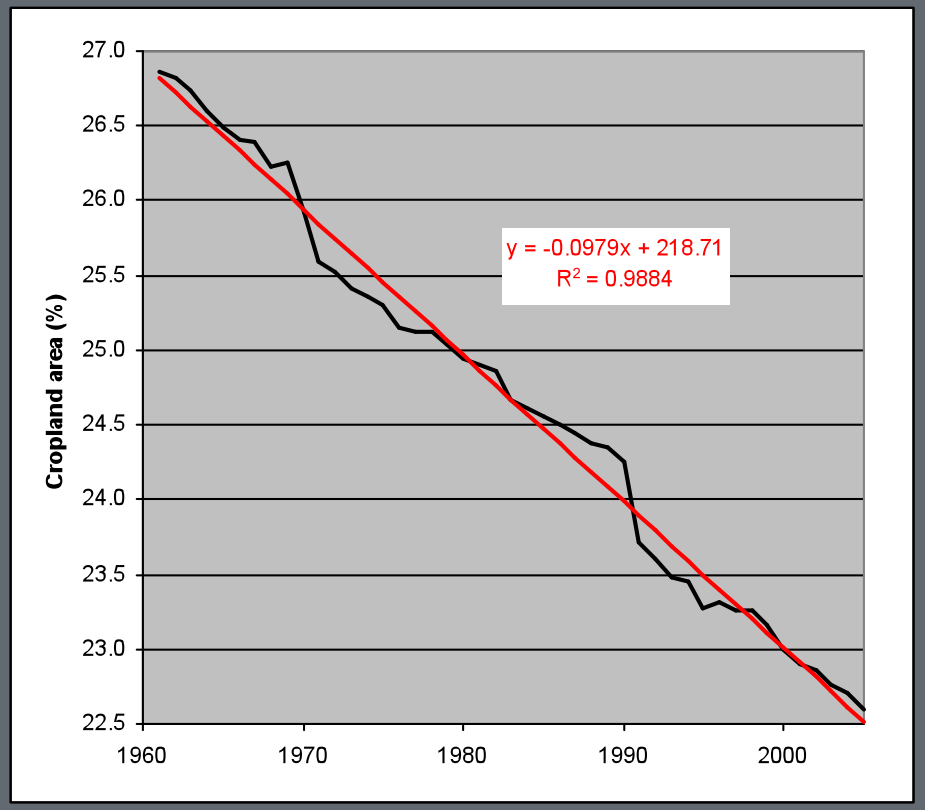


After: Schröter et al. (2005). Ecosystem service supply and vulnerability to global change in Europe. *Science*, **310** (5752), 1333-1337

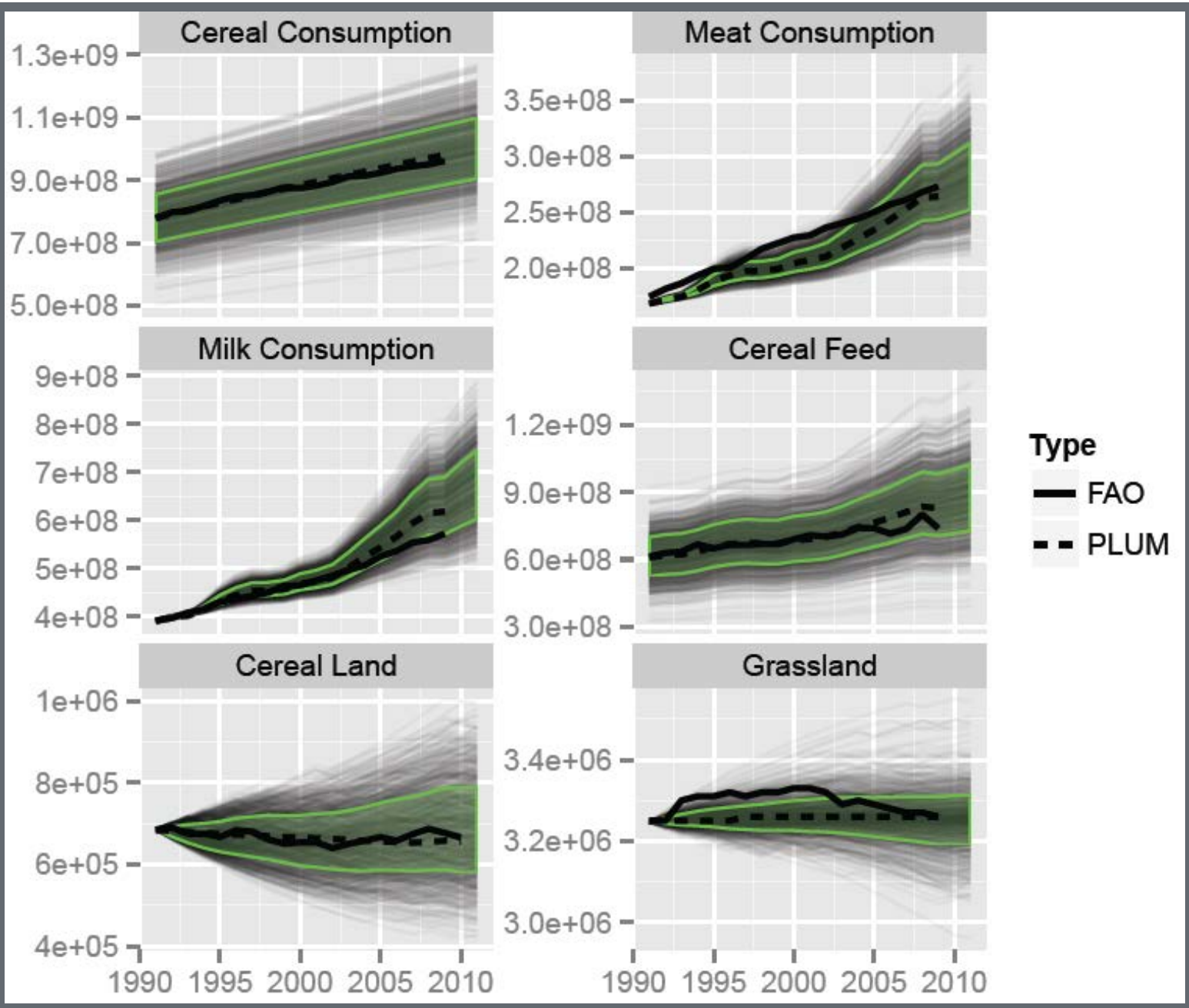
Change in cropland areas within the EU15 (% land surface)



Potential futures (IPCC-SRES)



Past observed (source: FAO)



Global observed (FAO, black line) and modelled (PLUM, dashed black line) cereal consumption (tons), meat consumption (t), milk consumption (t), cereal feed (t), cereal land (1000 ha) and grassland (1000 ha). The faint grey lines are single model runs and the grey shaded area indicates the standard deviation of the output for the model runs.

The core properties of human agency*

- **Intentionality** - action plans and strategies for realizing them, involving other participating agents.
- **Forethought** - the temporal extension of agency: setting goals and anticipating likely outcomes of prospective actions to guide and motivate their efforts.
- **Self-reactiveness** - the ability to construct appropriate courses of action and to motivate and regulate their execution.
- **Self-reflectiveness** - self-examination of functioning through self-awareness and reflection on personal efficacy, the soundness of thoughts and actions, and the meaning of pursuits, leading to corrective adjustments, if necessary.

"*The metacognitive capability to reflect upon oneself and the adequacy of one's thoughts and actions is the most distinctly human core property of agency. People do not operate as autonomous agents. Nor is their behaviour wholly determined by situational influences. Rather, human functioning is a product of a reciprocal interplay of intrapersonal, behavioural, and environmental determinants*"

*After: Bandura, A. (2006). Towards a psychology of human agency. *Perspectives on Psychological Science* DOI: 10.1111/j.1745-6916.2006.00011.x 2006 1: 164

Pro's and con's of IAMs for LULCC modelling

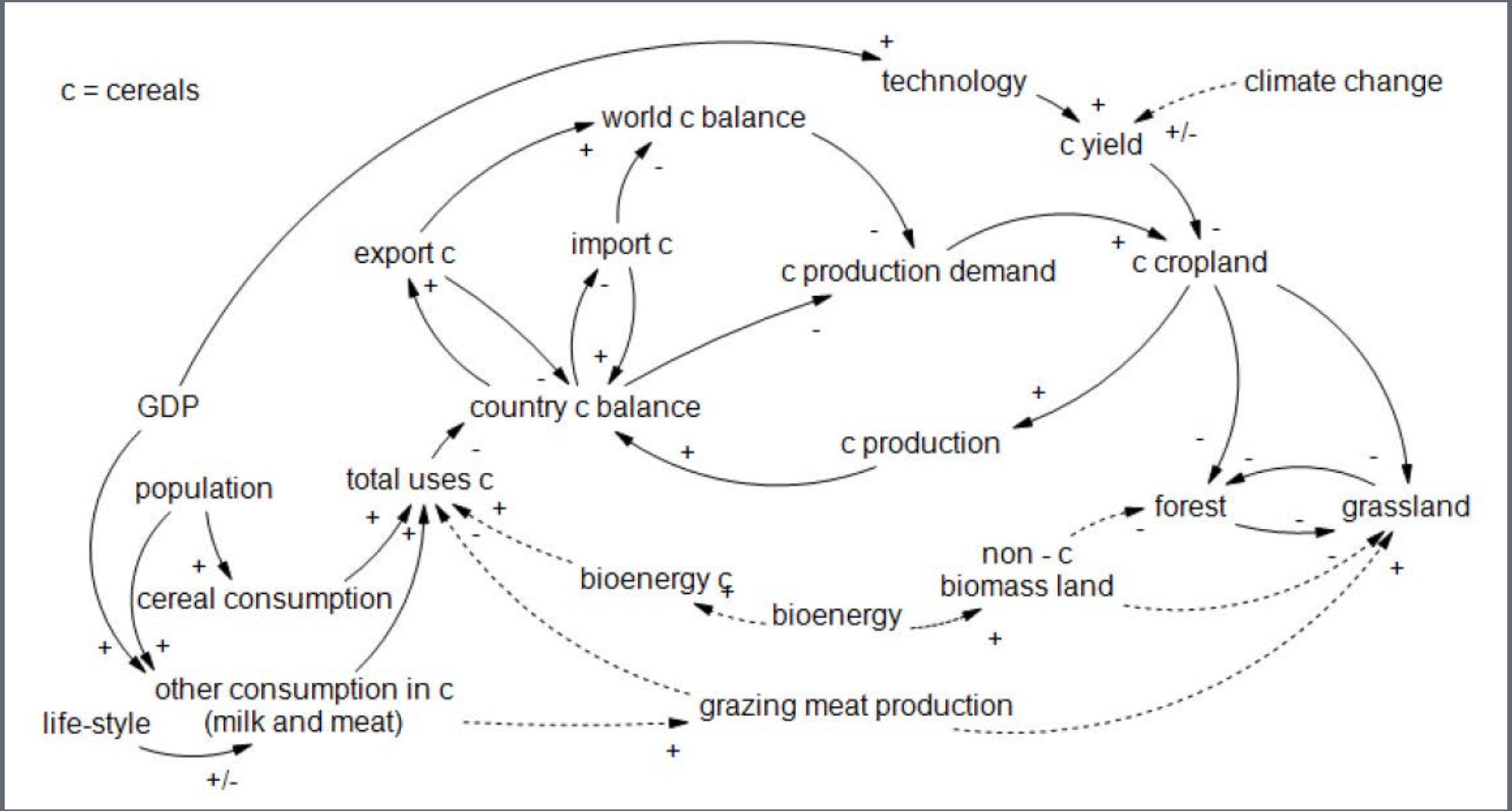
Pro's

1. Global scale applications
2. Cross-sectoral integration, e.g. energy
3. Integration with macro-economic models (CGEs, PEs)

Cons

1. Top-down simple representation of land use processes
2. Little representation of human behaviour and decision making

Global land use modelling using PLUM*



Overview of the concept underpinning *PLUM (Parsimonious Land Use Model) in the form of a causal loop diagram