

# JULES-BE: new options for crop and wood plantations and harvesting in JULES vn7.0

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# Aims

- **Representation of bioenergy plant species in JULES**
- **Physical/mechanistic representation of harvests in JULES**
- **Develop new functionality in JULES for bioenergy yields**
- **Model integration with UKESM**
- **Interrogation of large-scale bioenergy scenarios in UKESM, under climate change**
- **Explore effects on climate system (biophysical e.g. albedo, hydrology; biogeochemical e.g. reduced sinks, LUC emissions)**

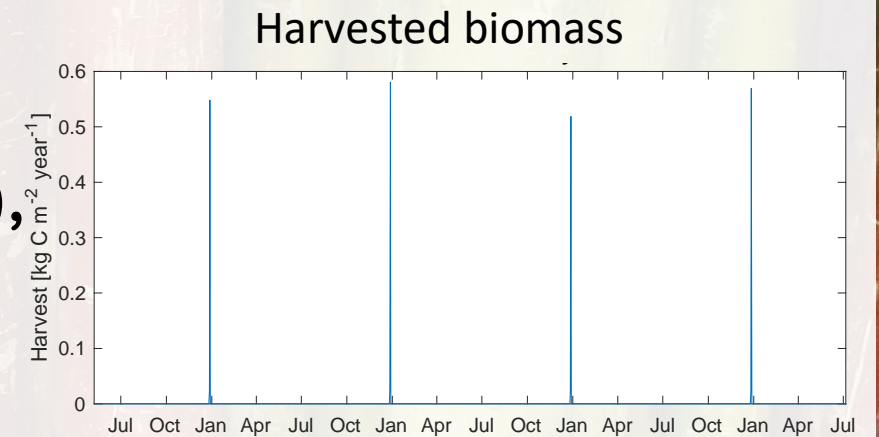
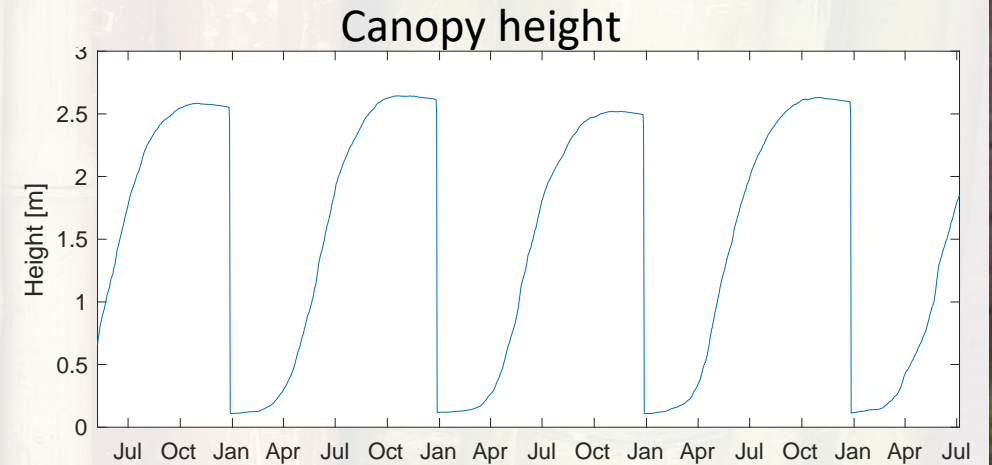
# Harvesting

- Based on TRIFFID-crop (Defines multiple separate land classes and allows continuous harvesting from litter)
- Periodic harvesting (new): PFT cut to short height at regular intervals. Harvest height, frequency and day-of-year all user-prescribed per PFT

$$harvest = \frac{(leafC_{t-1} + woodC_{t-1}) - (leafC_t + woodC_t)}{\Delta t}$$

$$lit_c = lit_c + \frac{(rootC_{t-1} - rootC_t)}{\Delta t}$$

Suitable for perennial grasses (annual harvest),  
short rotation coppicing (3-8 years),  
rotation forestry (15-50 years)

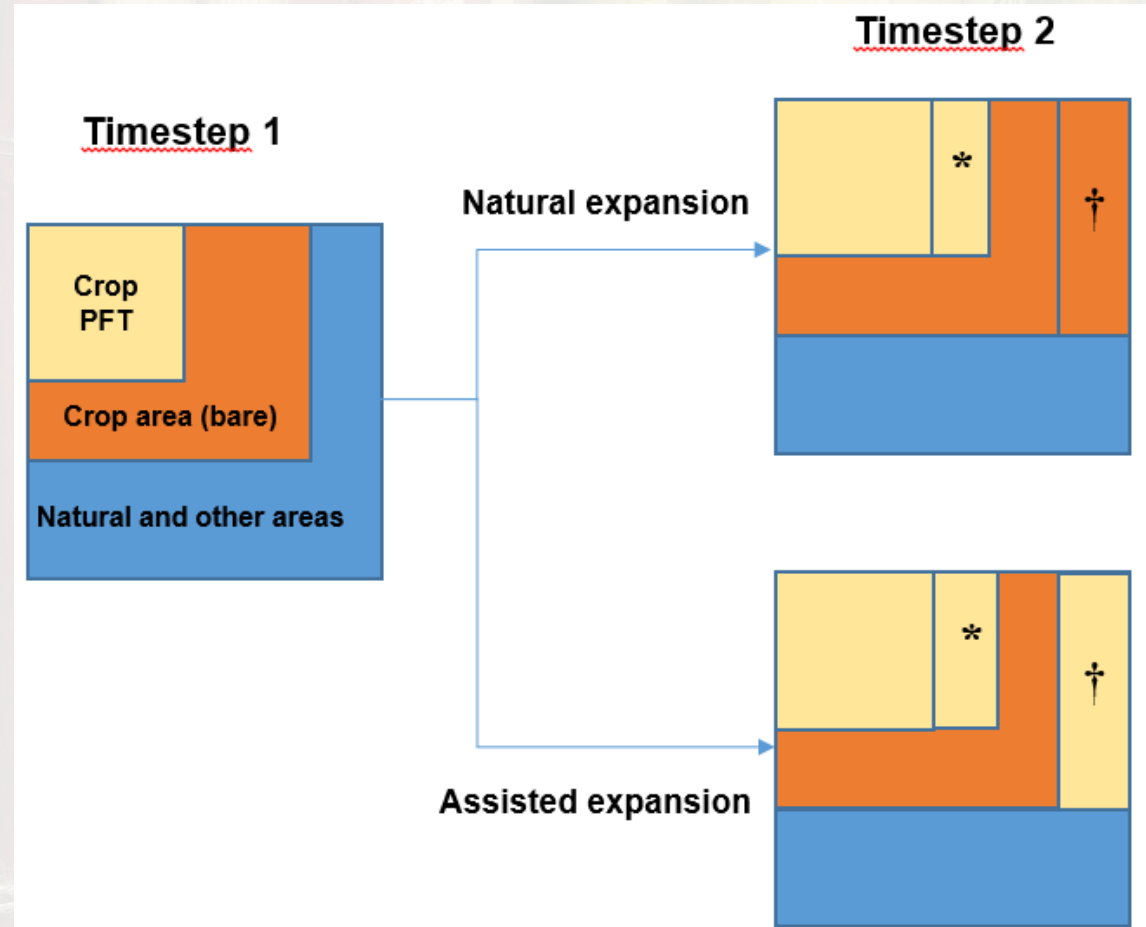


# Assisted expansion

$$C_v \frac{dv}{dt} = \lambda \Pi v_* \left( 1 - \sum_j c_{ij} v_j \right) - \gamma_v v_* C_v$$

(Clark et al. 2011, Eq. 52)

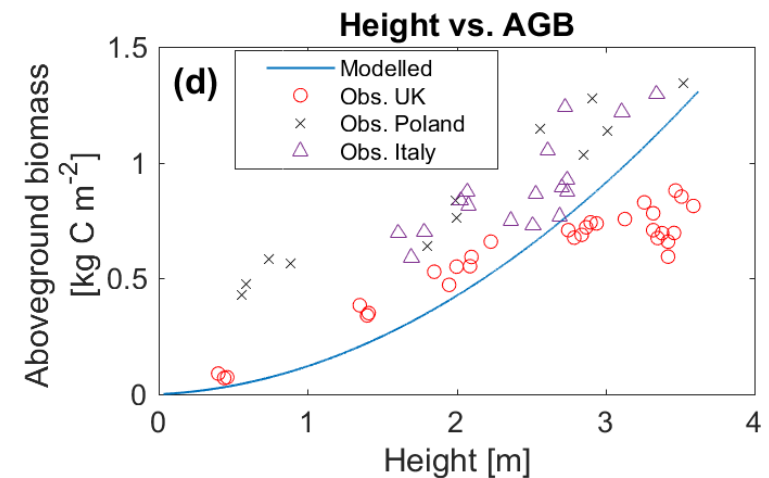
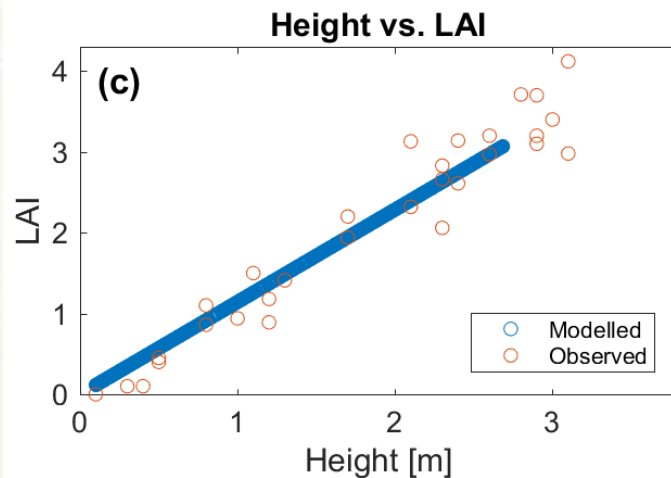
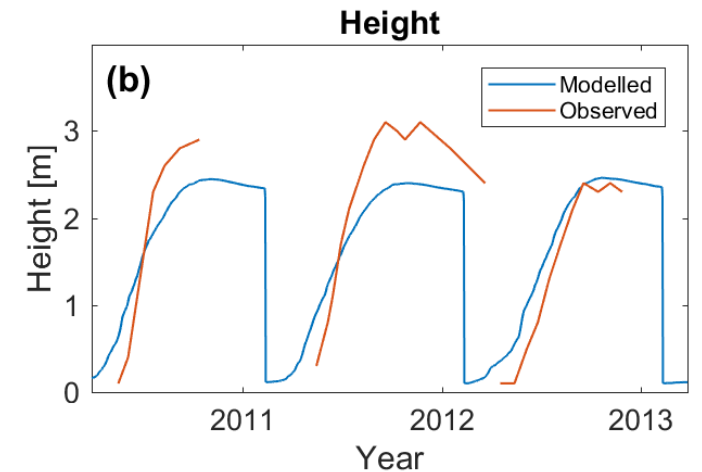
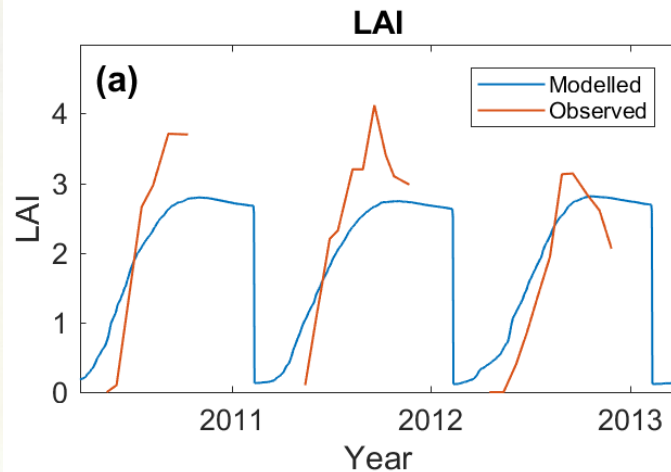
- BE crops have large  $C_v$  which restricts  $dv/dt$
- Workaround: When crop area increases, crop PFTs fill new area (instead of bare soil)
- Simulates plantation of new crop areas



# Miscanthus PFT

- Fast-growing perennial C4 grass with high lignin content
- Typically yields 10-20 tonnes DM ha<sup>-1</sup> year<sup>-1</sup>
- Cold-tolerant and suitable for poor soils
- PFT params tuned to optimise height:AGB relationship

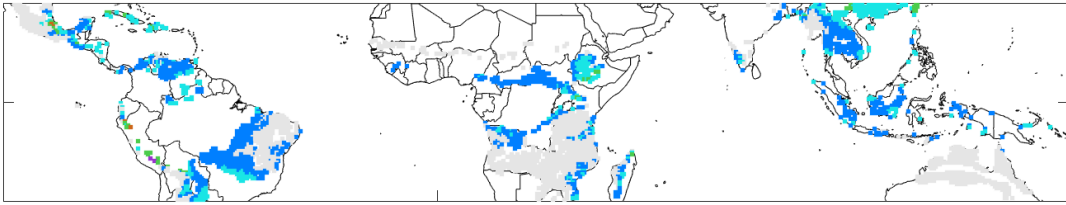
*Littleton et al., 2020 (GMD)*



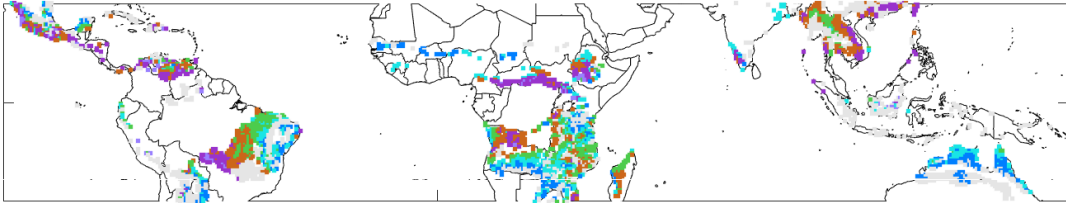
# Miscanthus yields (RCP2.6)

2040s:

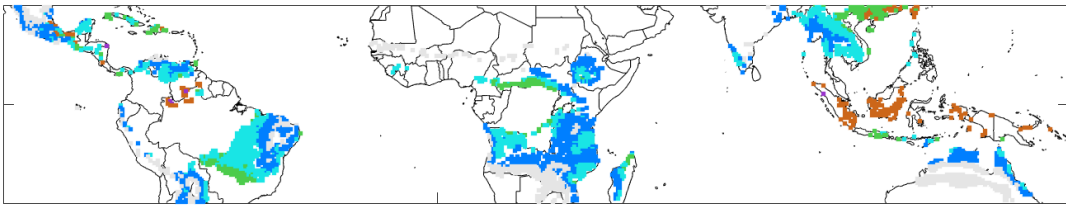
MiscanFor



JULES

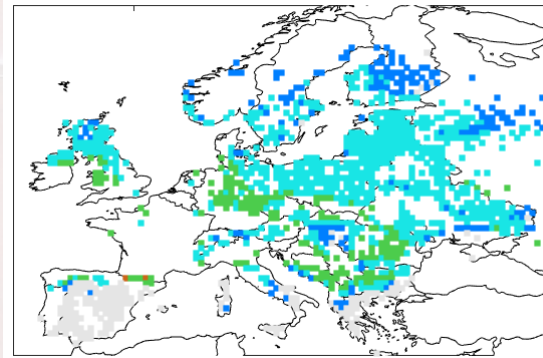


IMAGE

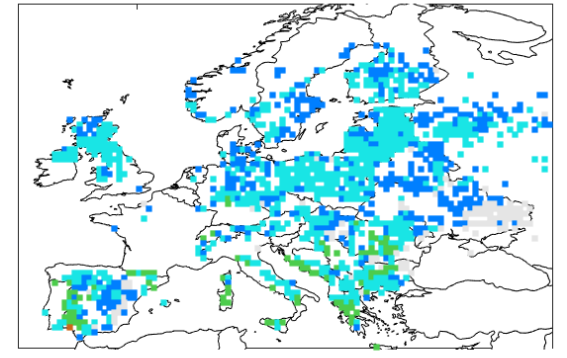


2090s:

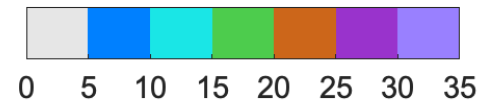
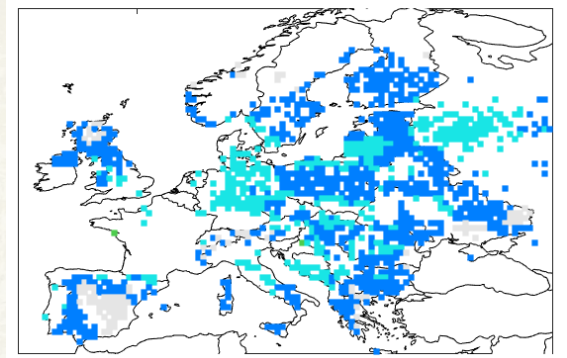
MiscanFor



JULES



IMAGE



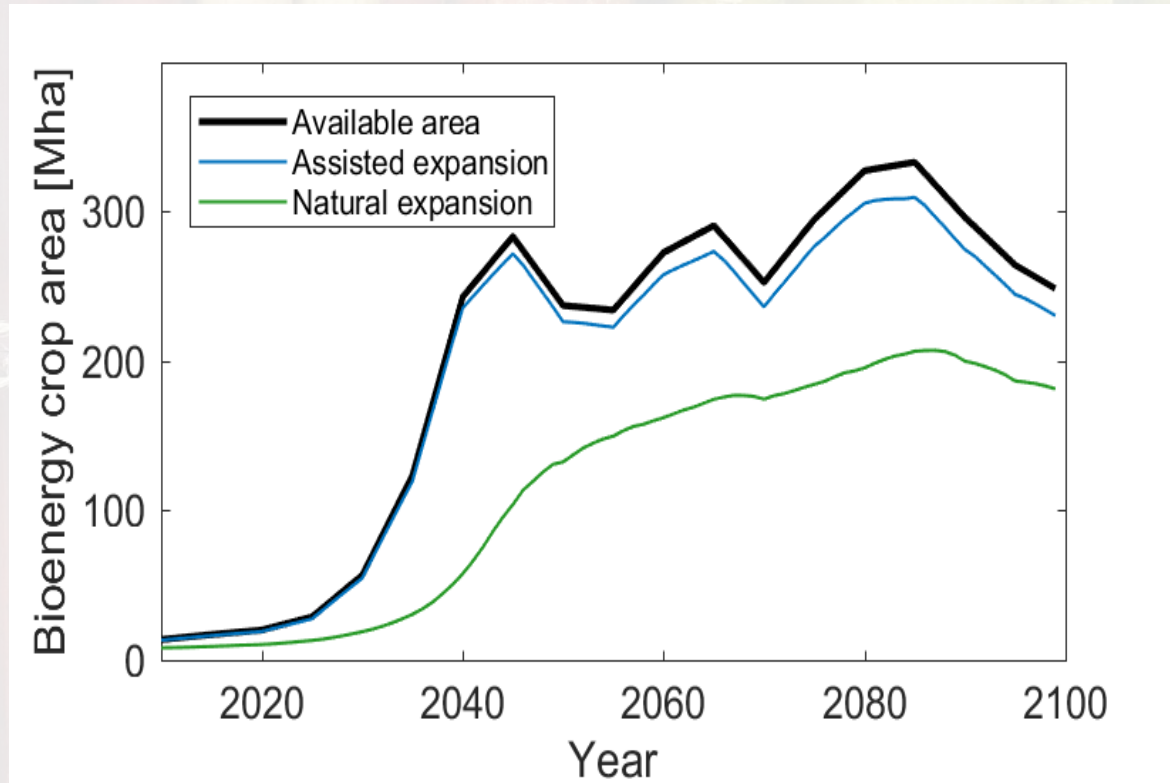
**BE crop yield**  
**[tonnes DM ha<sup>-1</sup> year<sup>-1</sup>]**

*Littleton et al., 2022 (GCBB)*

# Assisted expansion

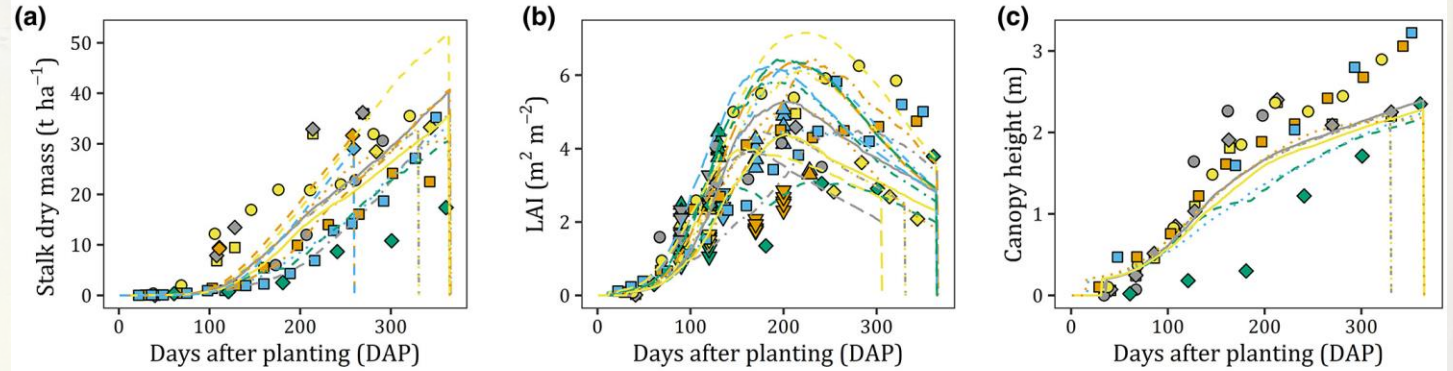
- Assisted expansion option facilitates simulating rapid land-use transitions
- Here BE crop area increases ~250 Mha over 2025–2045
- Allows crop area to die back in unsuitable environments, preserving benefit of dynamic vegetation

RCP2.6-SSP2

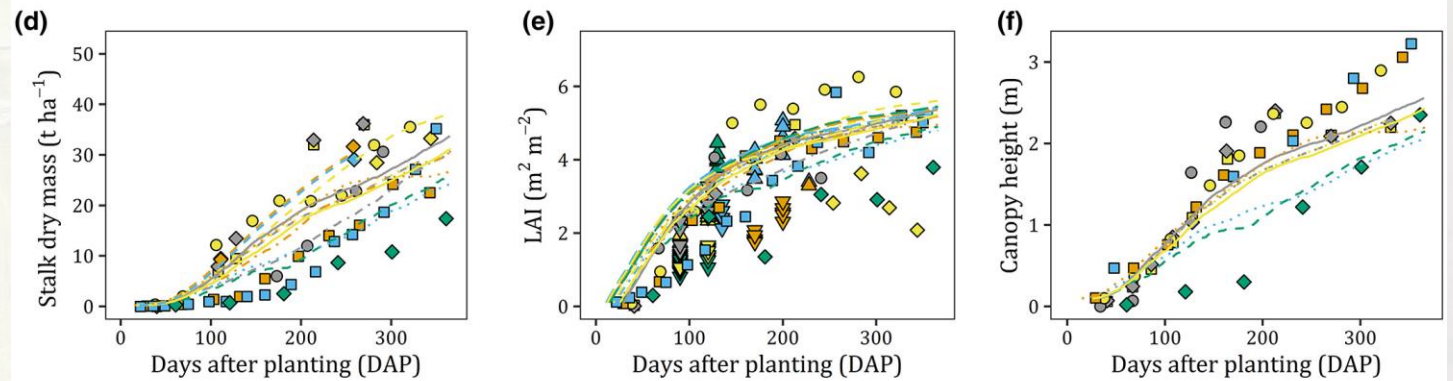


# Sugarcane PFT

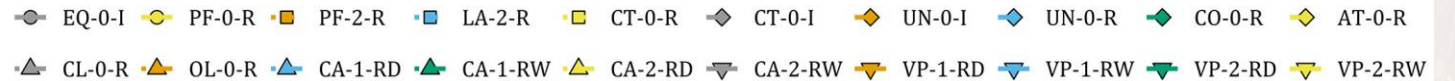
JULES-crop →



JULES-BE →



*Viana et al., 2022 (GCBB)*



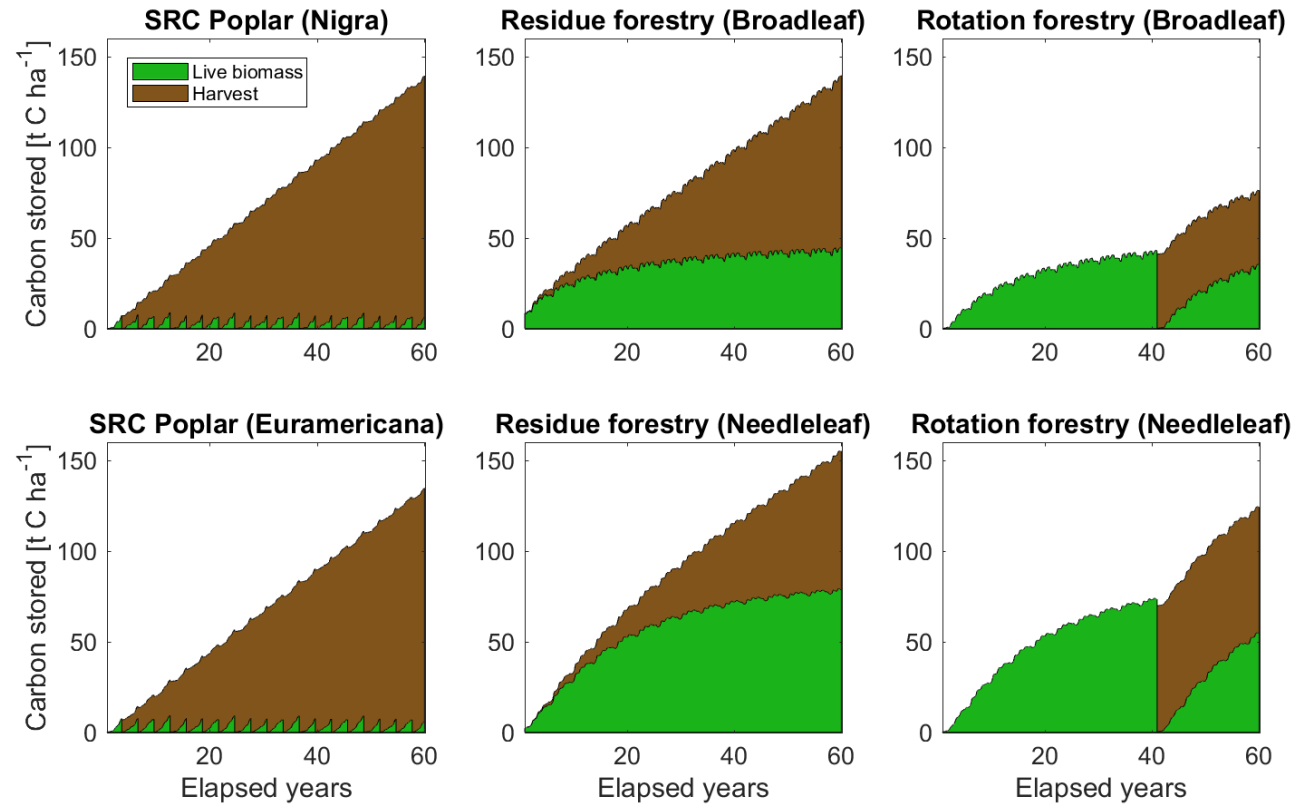


# SRC and forestry

Illustrated examples of:

- Short-rotation coppice
- Residue forestry
- Rotation forestry

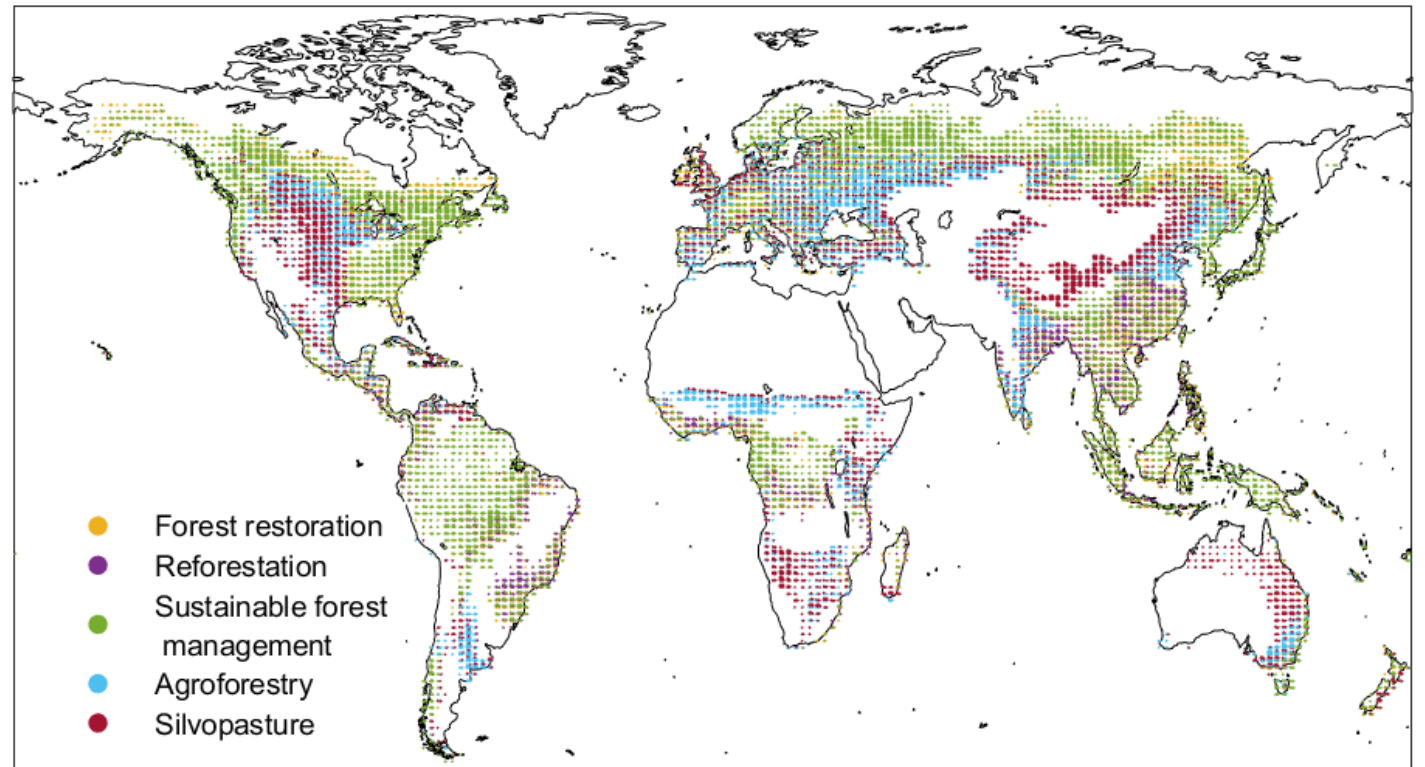
Further tuning required  
for these PFTs and harvest  
options



# Forest restoration and agroforestry

The biocrop land class can also be used to represent agroforestry or managed forestry

Used here for agroforestry and silvopasture alongside natural forest regeneration



*Littleton et al., 2021 (ERL)*

# Inputs and outputs

## Required inputs:

- harvest day-of-year for each cell and PFT (ancillary)
- frac\_biocrop (ancillary or prescribed)
- some PFTs assigned to crop=3 (triffid params)
- Harvest height and harvest frequency (triffid params)
- l\_ht\_compete, l\_trif\_crop and l\_trif\_biocrop enabled
- l\_ag\_expand optional

## Output variables (kg C or N m<sup>-2</sup> (360days)<sup>-1</sup>):

- harvest\_biocrop
- harvest\_biocrop\_gb
- harvest\_biocrop\_n
- harvest\_biocrop\_n\_gb

# Next...

- **Evaluation rose suite**
- **Integration into the UM**
- **AMIP-style simulations to explore biophysical impacts**
- **Conservation of biomass for I\_ag\_expand**
- **Simulations tailored to UK managed forestry**
- **European agroforestry**