Simulating forest management using LPJ-GUESS: current and future perspectives of the model

Mats Lindeskog

Ljubljana 180425

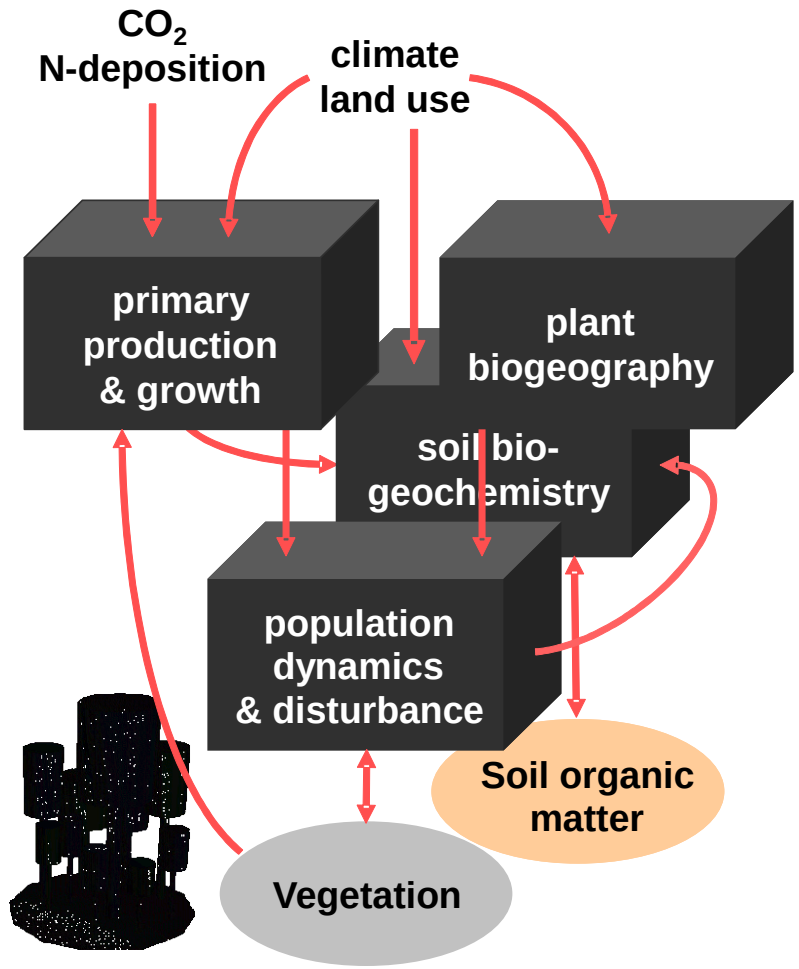
FORECLIM

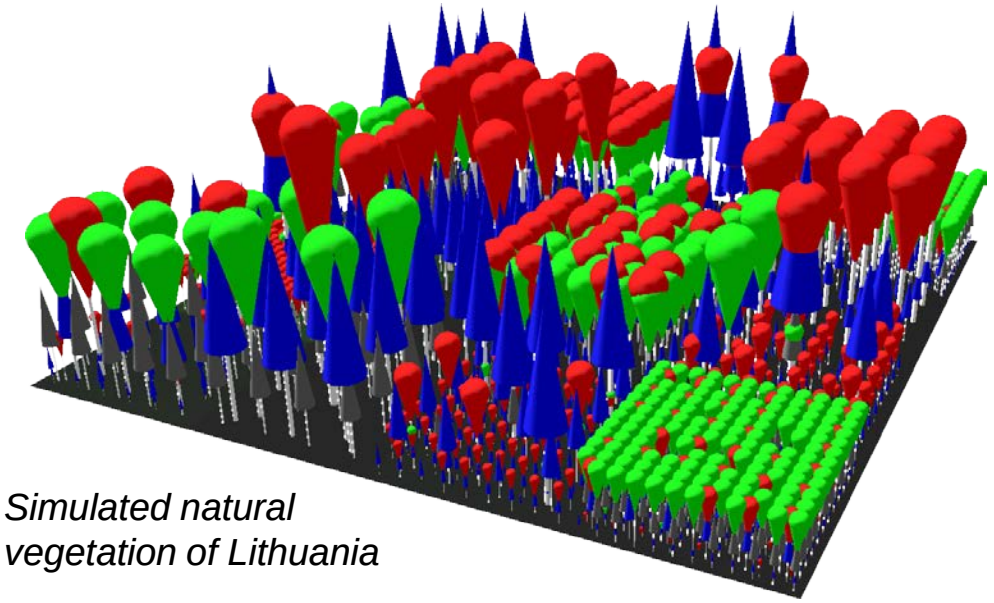
Forestry research
at
Physical Geography and Ecosystem Science
Lund

- Ecosystem ecology: Vegetation modelling (LPJ-GUESS)
  - Mosaic landscape: LULCC (land use & land cover change): cropland, pasture, man. forest
  - Managed forest: continuous cover, clearcut
- Biogeochemical cycles in forests (Cecilia Axelsson)
  - Weathering for sustainable forestry
  - Effects of whole-tree harvesting on nutrient cycling and acidification
  - Development of methods for sustainability analysis for harvesting of forest fuels
- Biogeophysics and Climatology
  - Effects of forest management on greenhouse gas fluxes in boreal forests (Patrik Vestin)
  - Storm damage to Swedish forests (Fredrik Lagergren)
  - Spruce bark beetle damage to Swedish forests (Anna Maria Jönsson)
  - Tree water use efficiency (Maj-Lena Linderson)

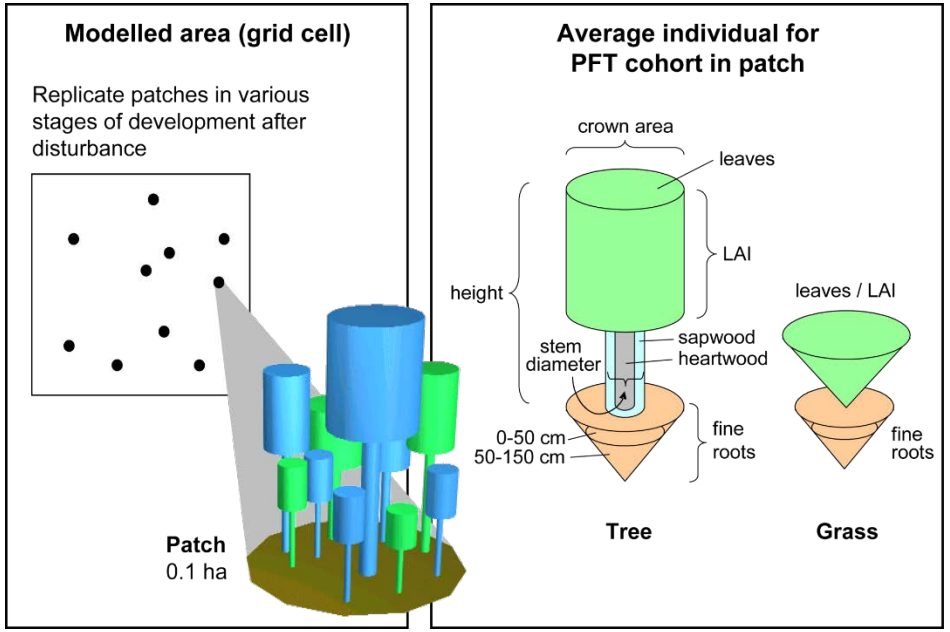
LUND UNIVERSITY

LPJ-GUESS – global land ecosystem model*



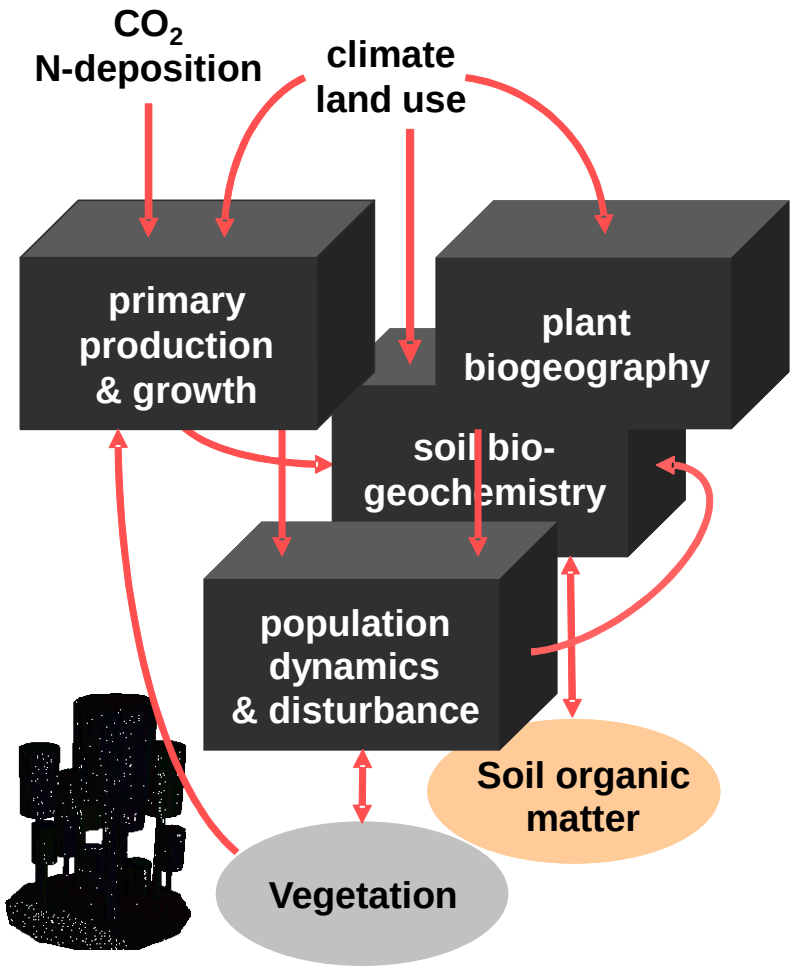


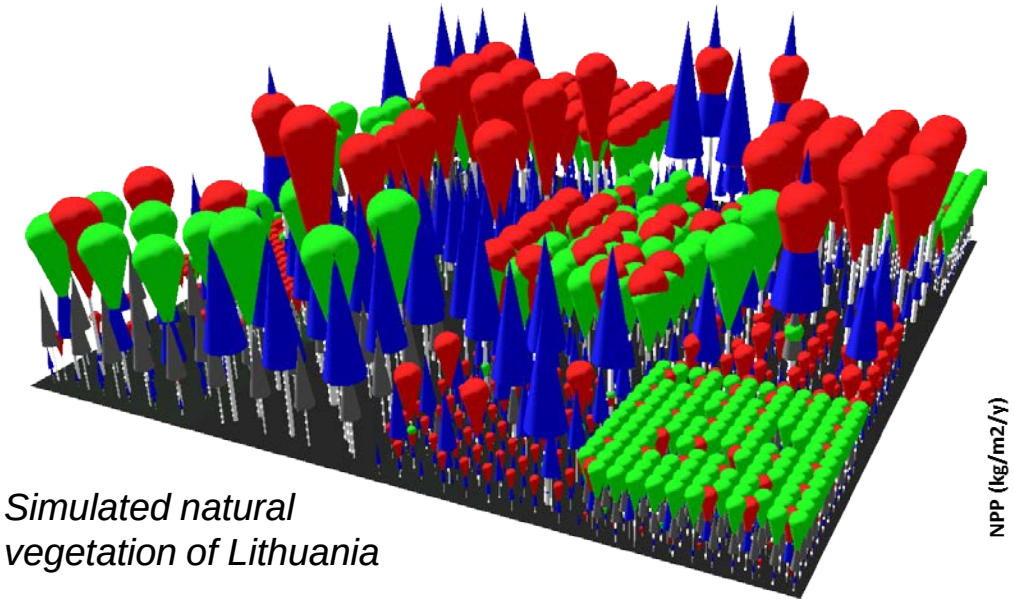
Simulated natural vegetation of Lithuania



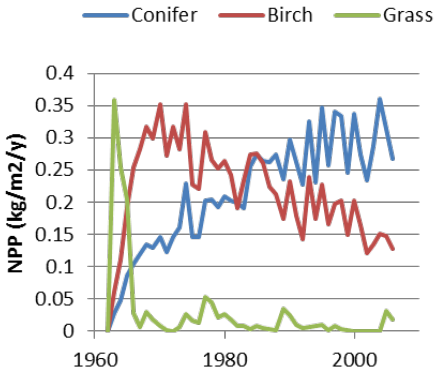
*Smith et al. 2001, 2014
www.nateko.lu.se/lpj-guess

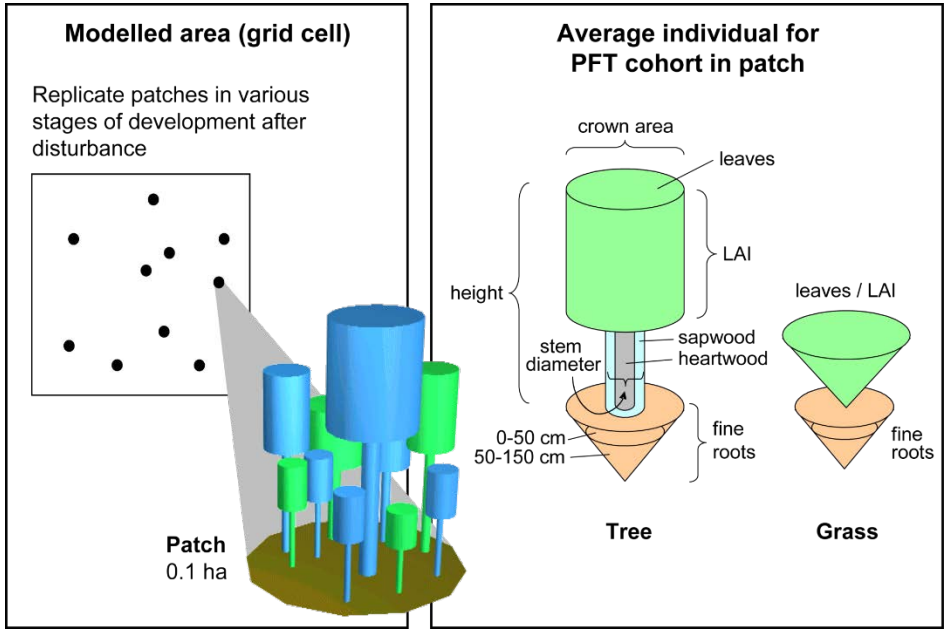
LPJ-GUESS – global land ecosystem model*





Simulated natural vegetation of Lithuania

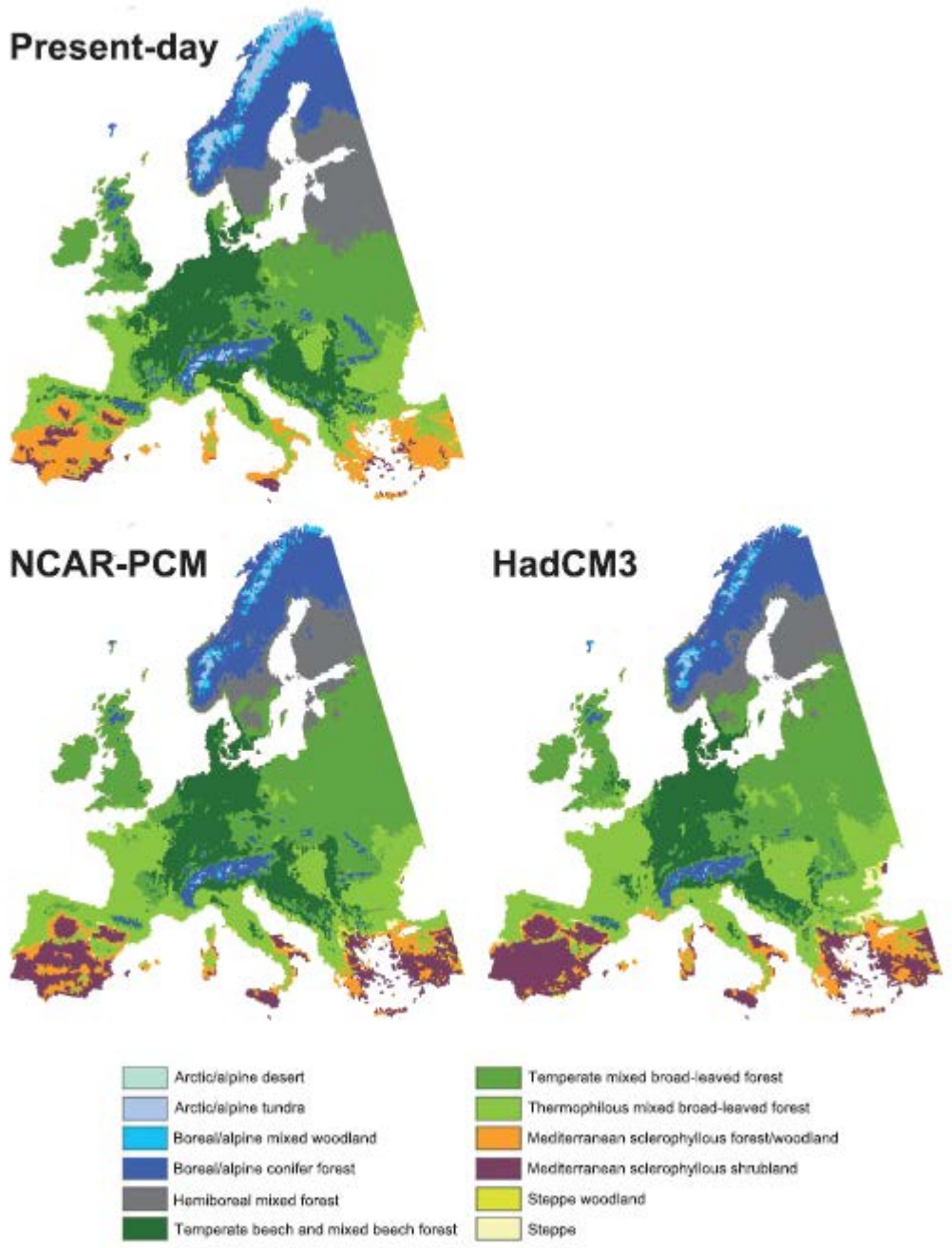




*Smith et al. 2001, 2014
www.nateko.lu.se/lpj-guess

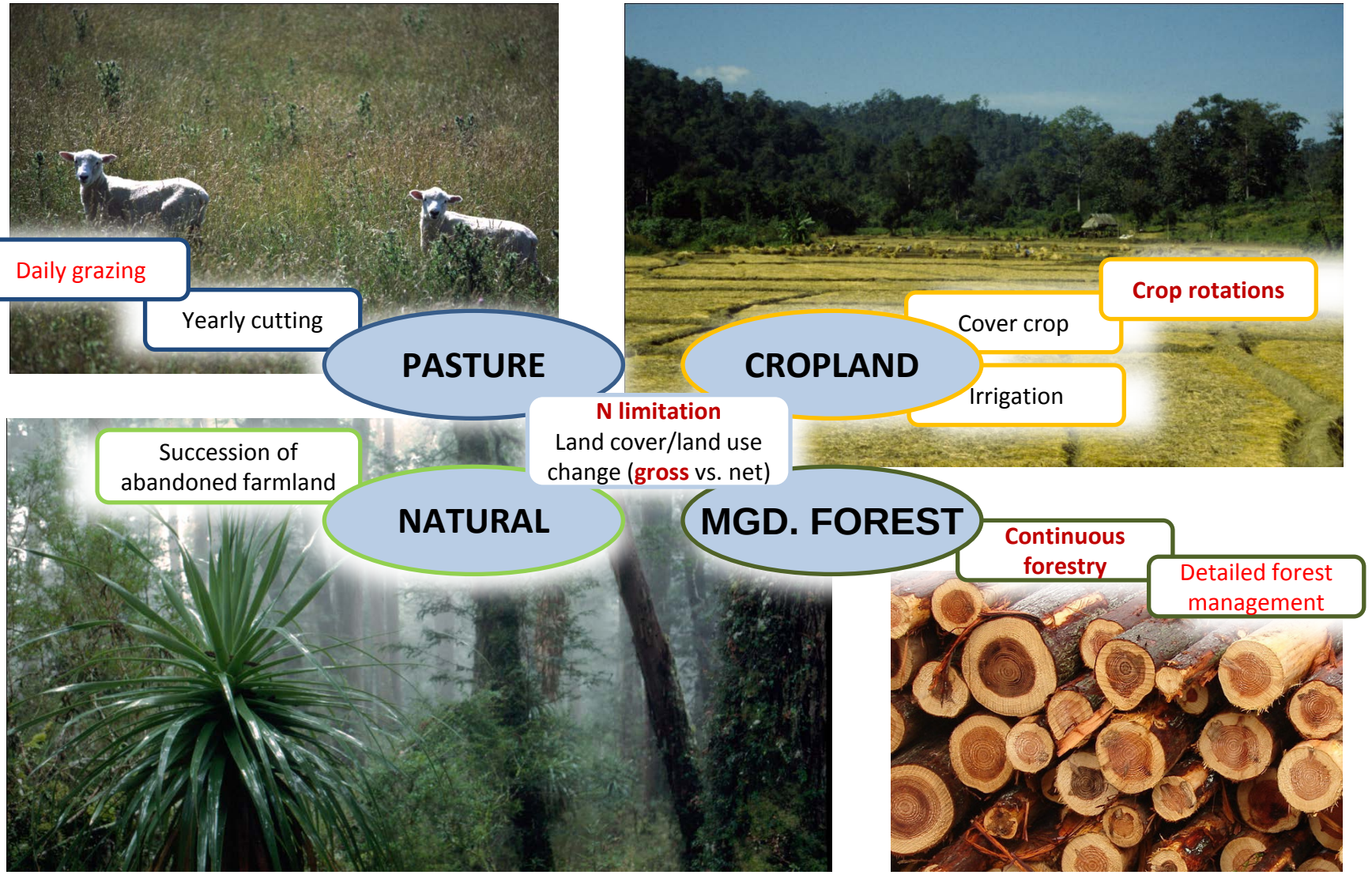
LPJ-GUESS: process-based model suitable for projections of future vegetation and carbon pools

Modelled potential natural vegetation (PNV) for present day and a business-as-usual CO_2 emission scenario (2 climate models):



Hickler et al. 2012. *Global Ecol. Biogeogr.* 21: 50-63.

Managed land version accounts for land use*



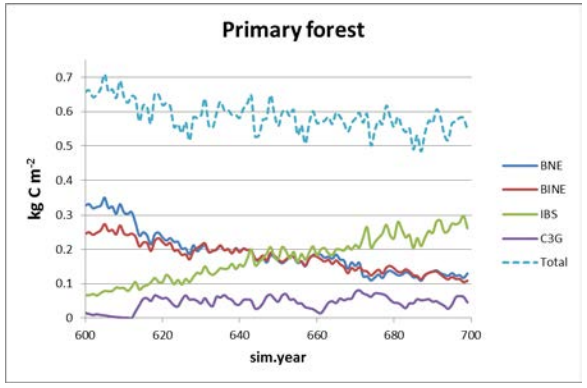
*Lindeskog et al. 2013. *Earth System Dynamics* 4: 385-407
Olin et al. 2015. *Biogeosciences* 12: 2489-2515

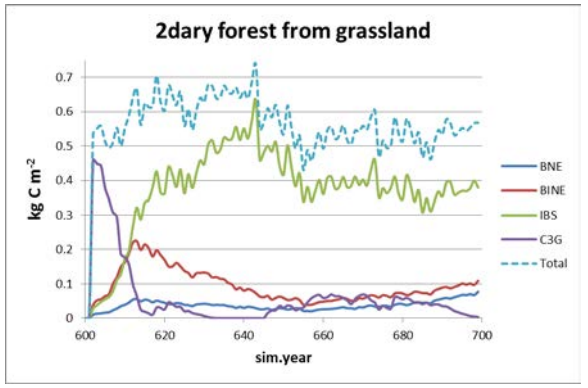
Impact of management history on regenerating stand productivity

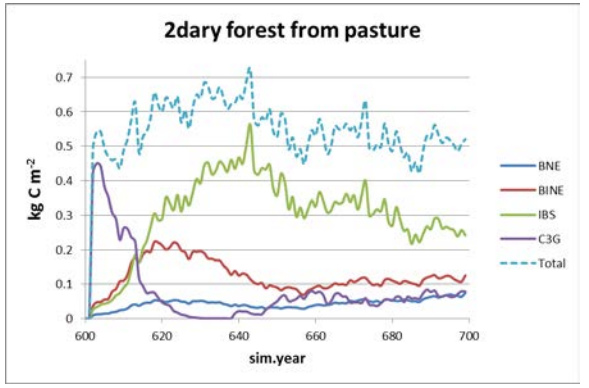
PNV -> 100 y grassland -> 100 y regrowth (30°lon, 65°lat)

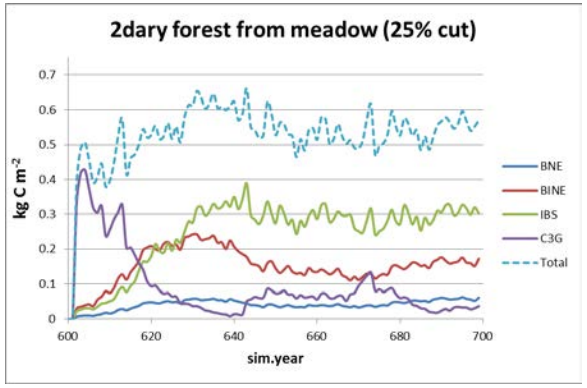
1977-2006 climate recycled during regeneration, 20 patches

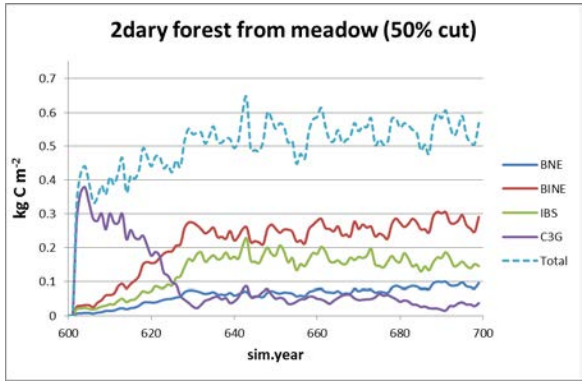
NPP

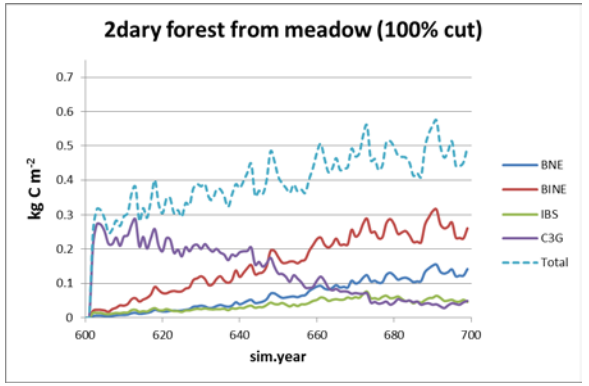








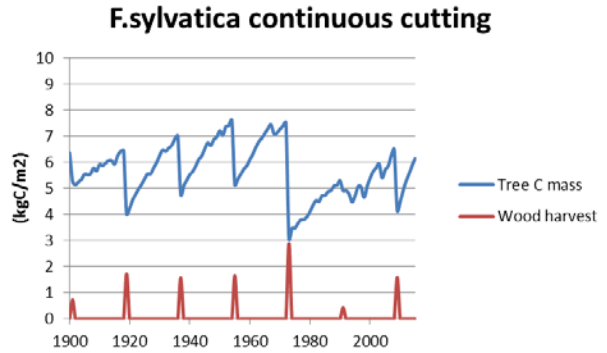




Wood harvest in LPJ-GUESS:

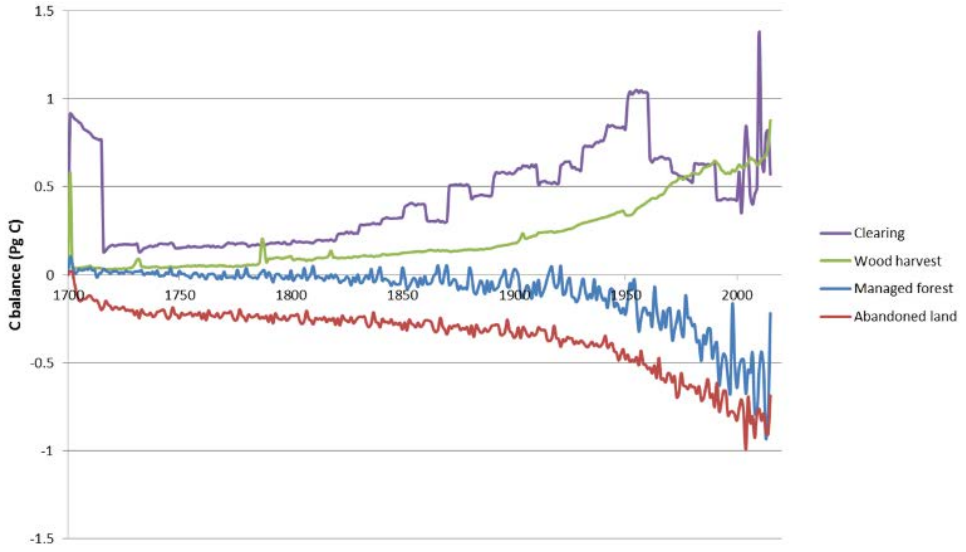
Detailed forestry:

stand types/management types with:
planting systems (pft selections)
establishment rules (e.g. all natural pft:s)
harvest systems (clearcut, continuous)
N fertilisation



Simple forestry used with global wood harvest data (e.g. LUH2):

clearcut + creation of new stand



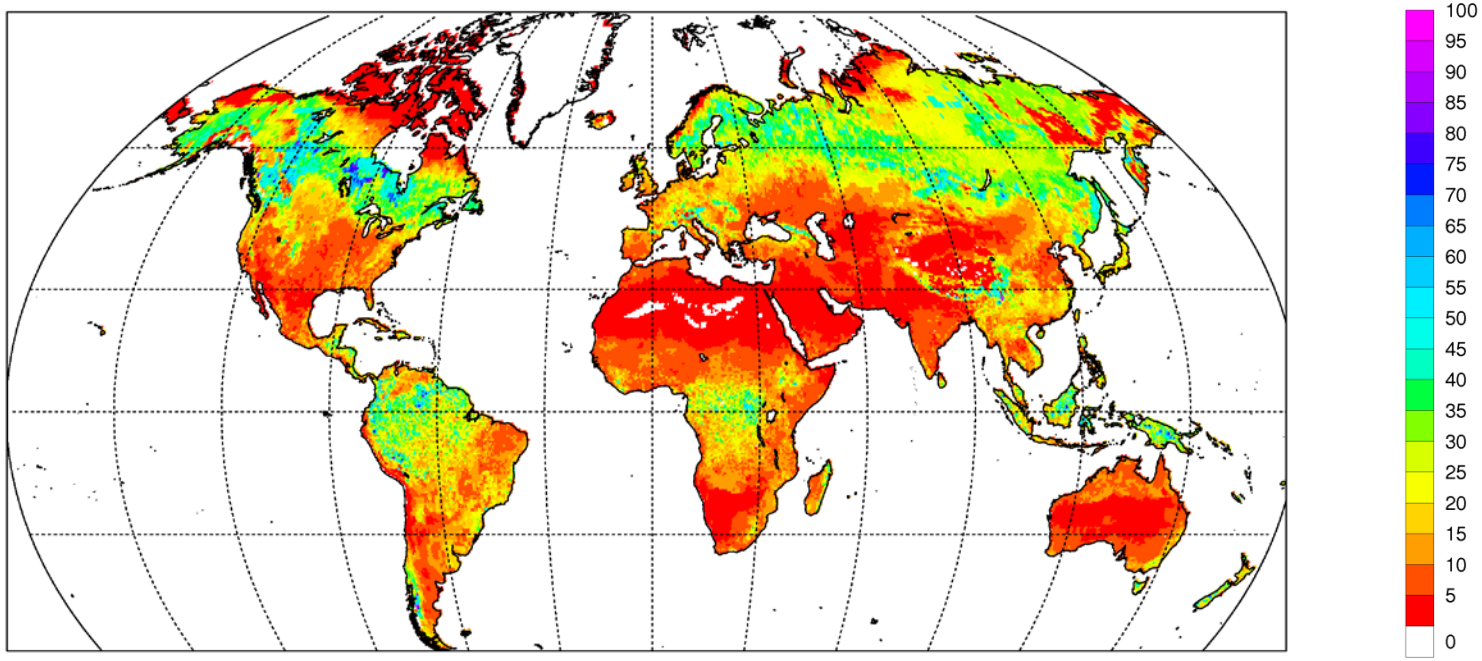
LUH2 global 1700-2105 land cover/land use database (Hurtt et al.) input to LPJ-GUESS

- Net land cover fractions (cropland, pasture, natural)
- Gross land cover transitions
  - primary/secondary natural land
- Wood harvest area fractions
  - primary forest
  - primary non-forest
  - secondary mature forest
  - secondary young forest
  - secondary non-forest

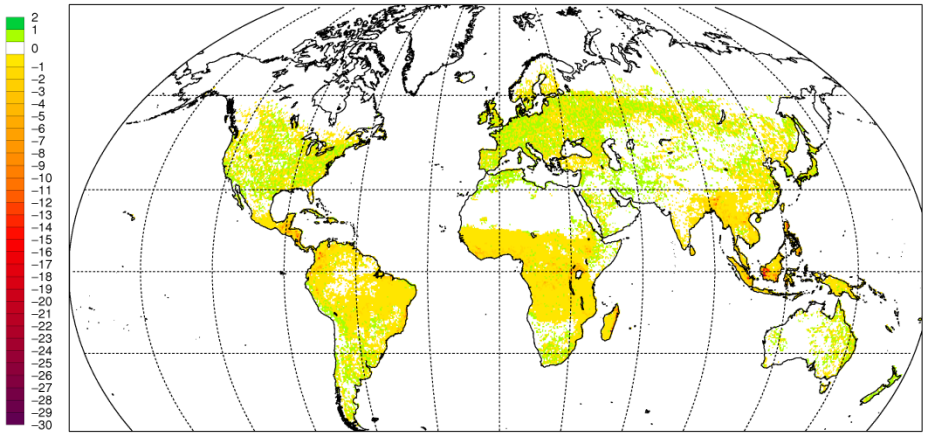
*based on HYDE (Klein Goldewijk et al., 2011)

LUH2: Total C pool 2006 (kg/m^2)

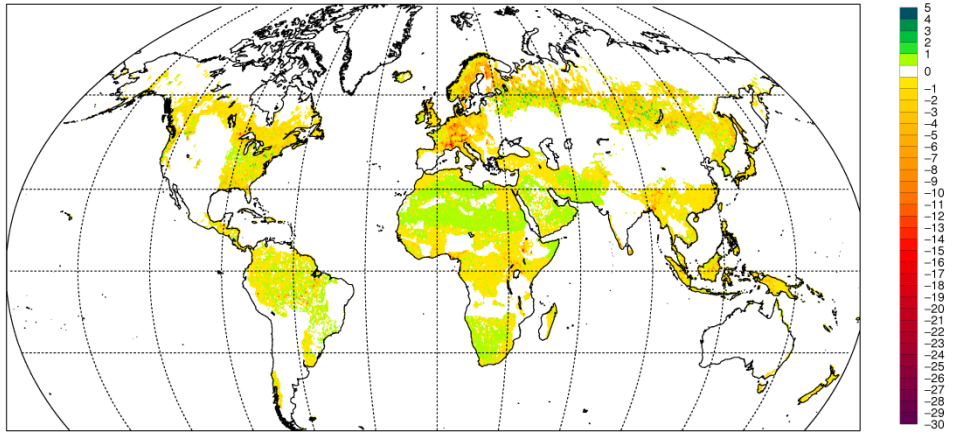
net LUC



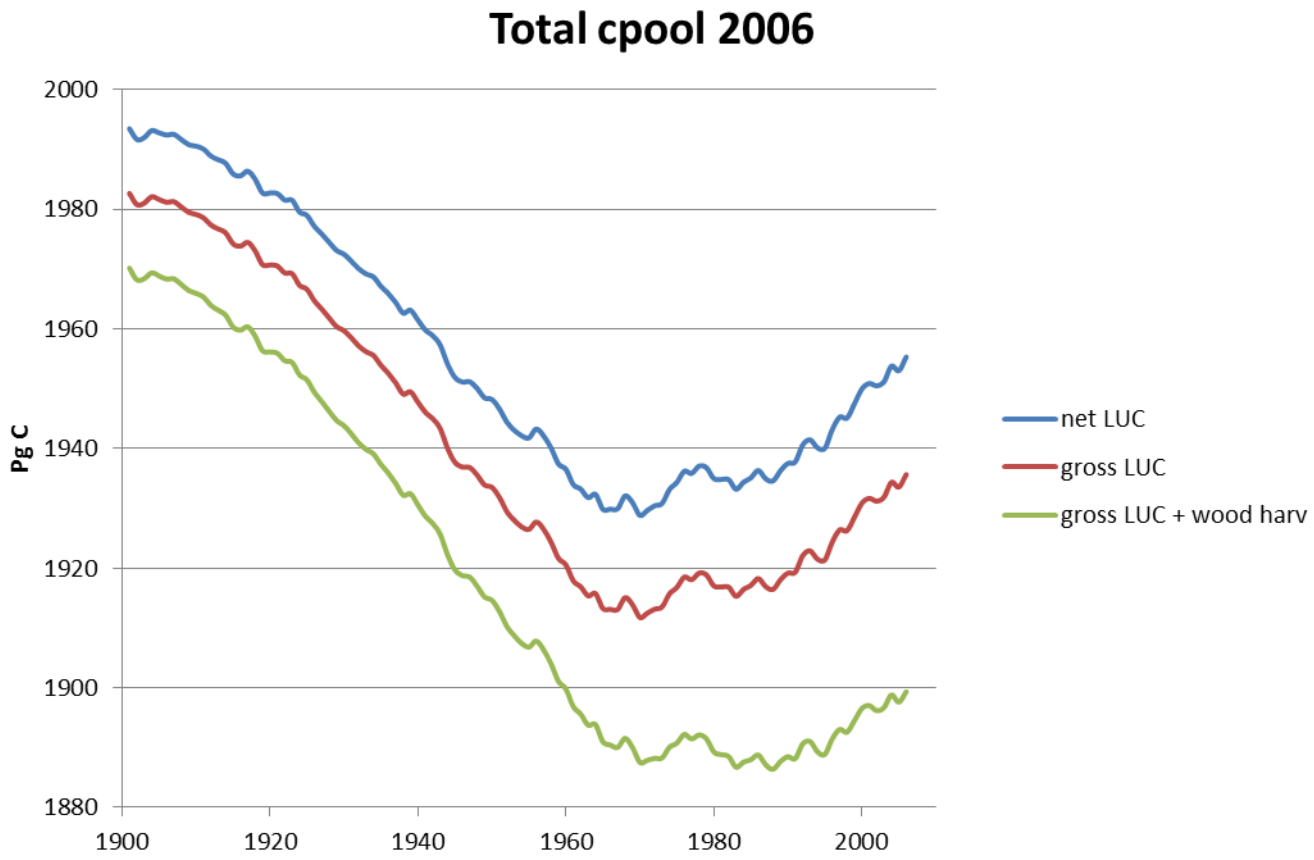
gross-net LUC



gross LUC w.-w/o wood harv.

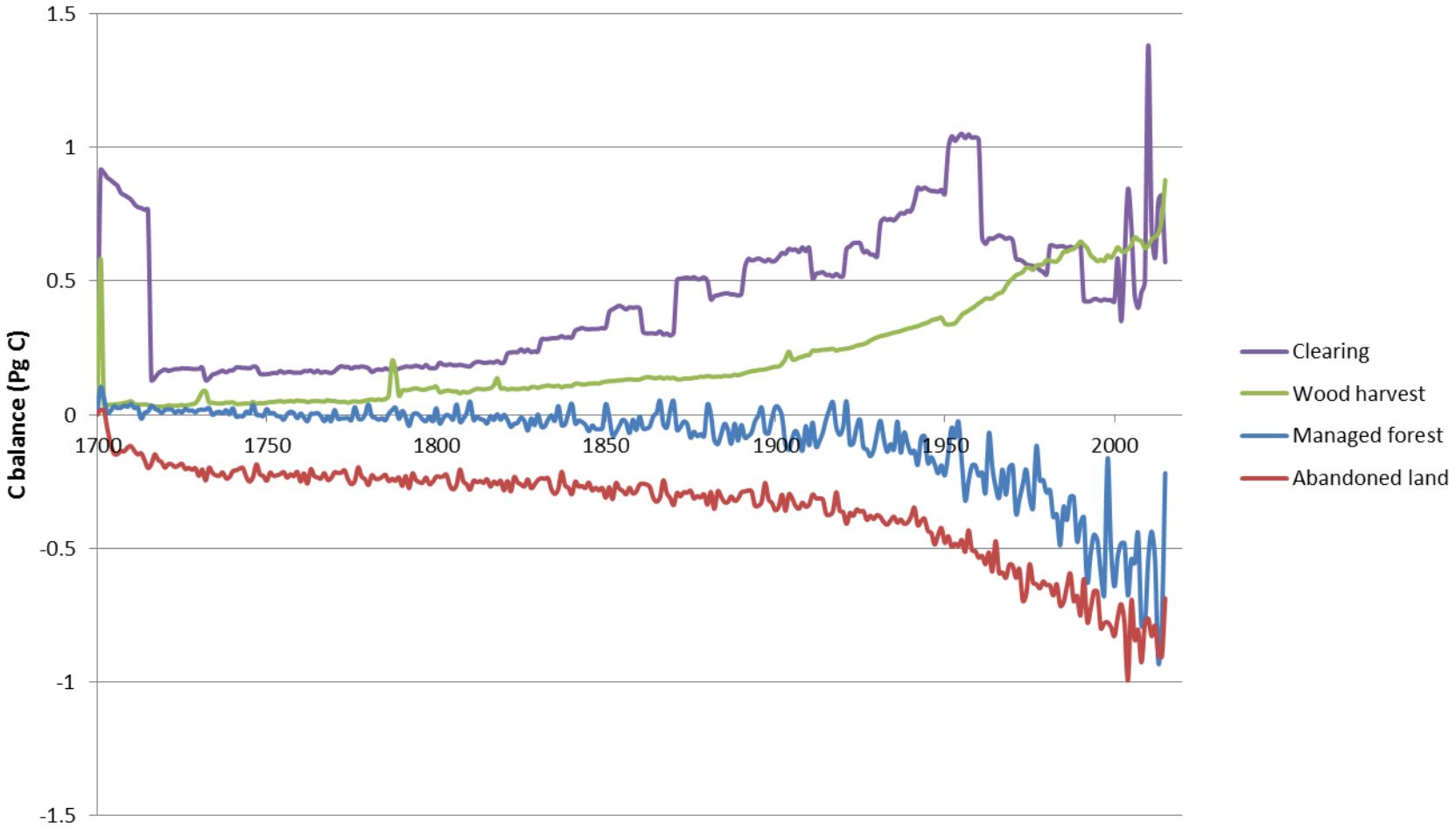


Effect on LUH2 input on global terrestrial C pool



minimum stand cutting age: 5 y

Global secondary forest C fluxes
LUH2 gross luc + wood harvest(area)



minimum stand cutting age: 15 y,
disturbance in stands after wood cutting

Detailed management: recreate current state of forest

Forest age:

Clearcut specified year, planting or natural regeneration

Species composition:

Species selection for planting and regeneration

Previous history:

PNV, cropland, pasture

Detailed management: thinning/harvest options

Prescribed rotation period (70)

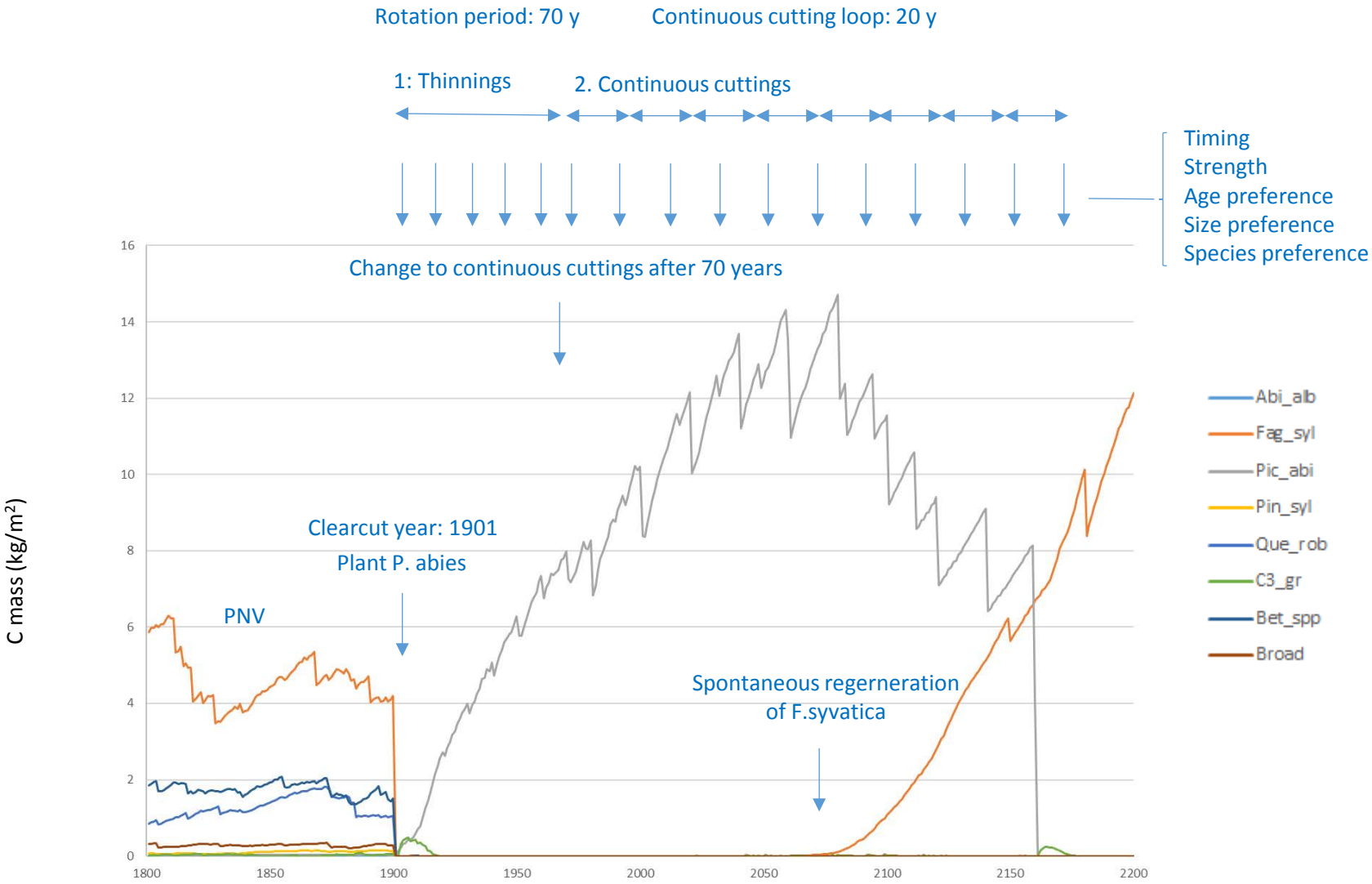
Prescribed thinning events:
Thinning timing (fraction of rot.period) (0.1, 0.3, 0.6, 0.8)
Thinning strength (fraction of wood cut) (0.4, 0.2, 0.2, 0.1)
Thinning preferences:

- young/old trees first (y, y, y, -, -)
- OR small/big trees first (s, s, s, b, b)
- selected/unselected trees first (uns, uns, uns, -, -)
- diameter limit (0.3)

Separate cutting schemes for ramp and full cover periods (after N years)

Change to another management (at year X)

Cutting parameters example



History

PNV
Managed land (cropland,pasture)

Initiation

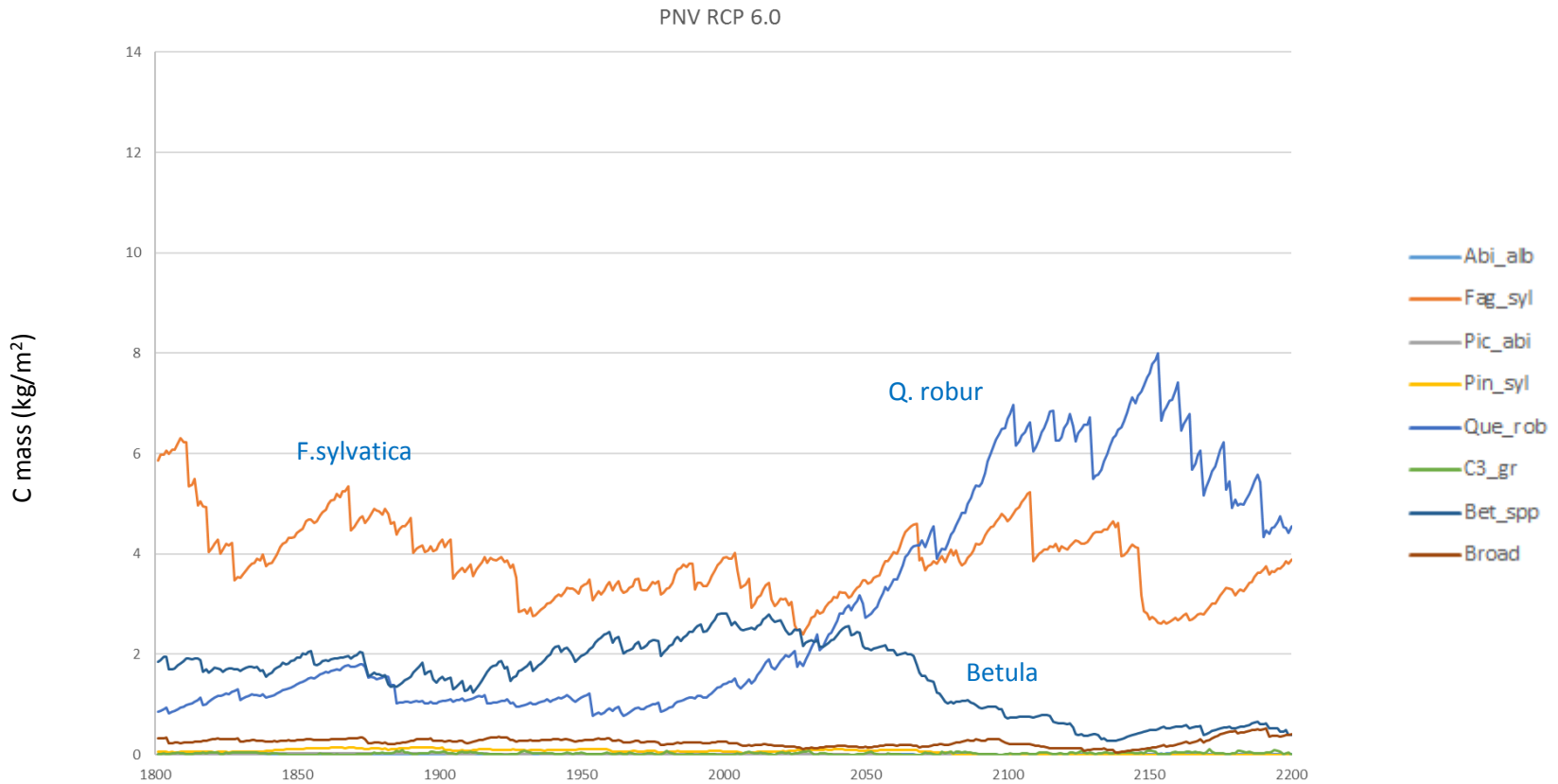
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting, selected species
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

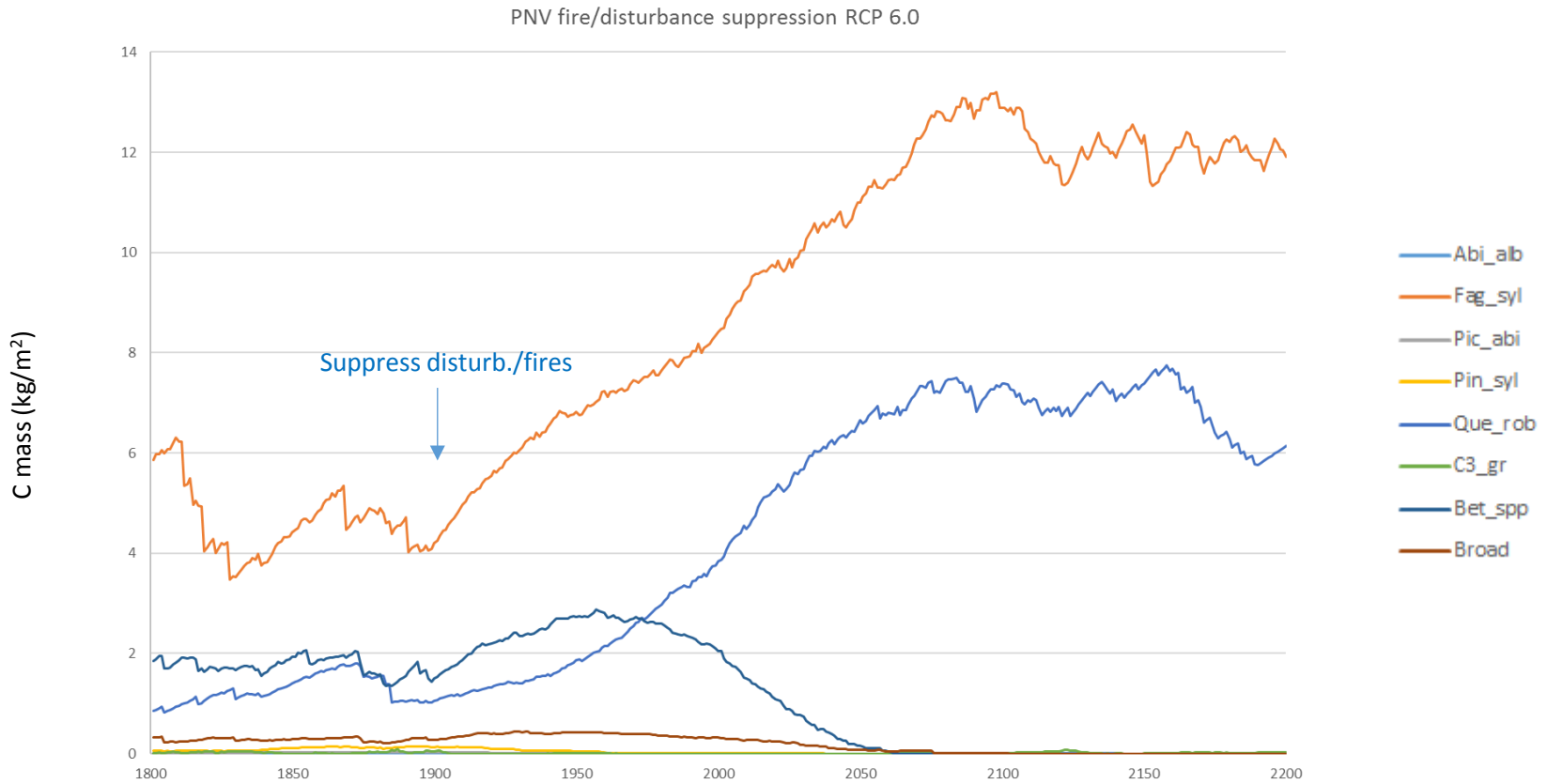
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

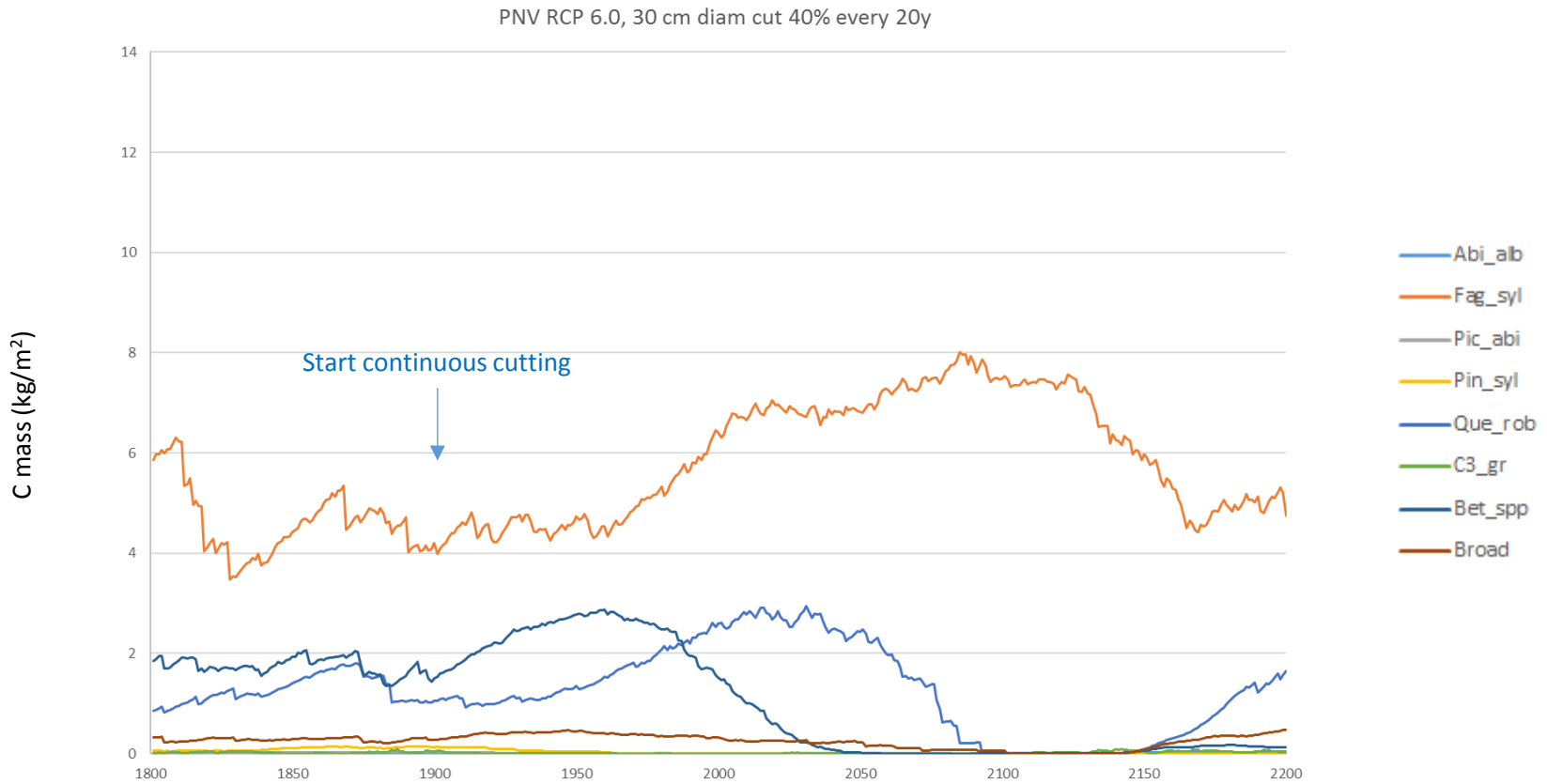
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

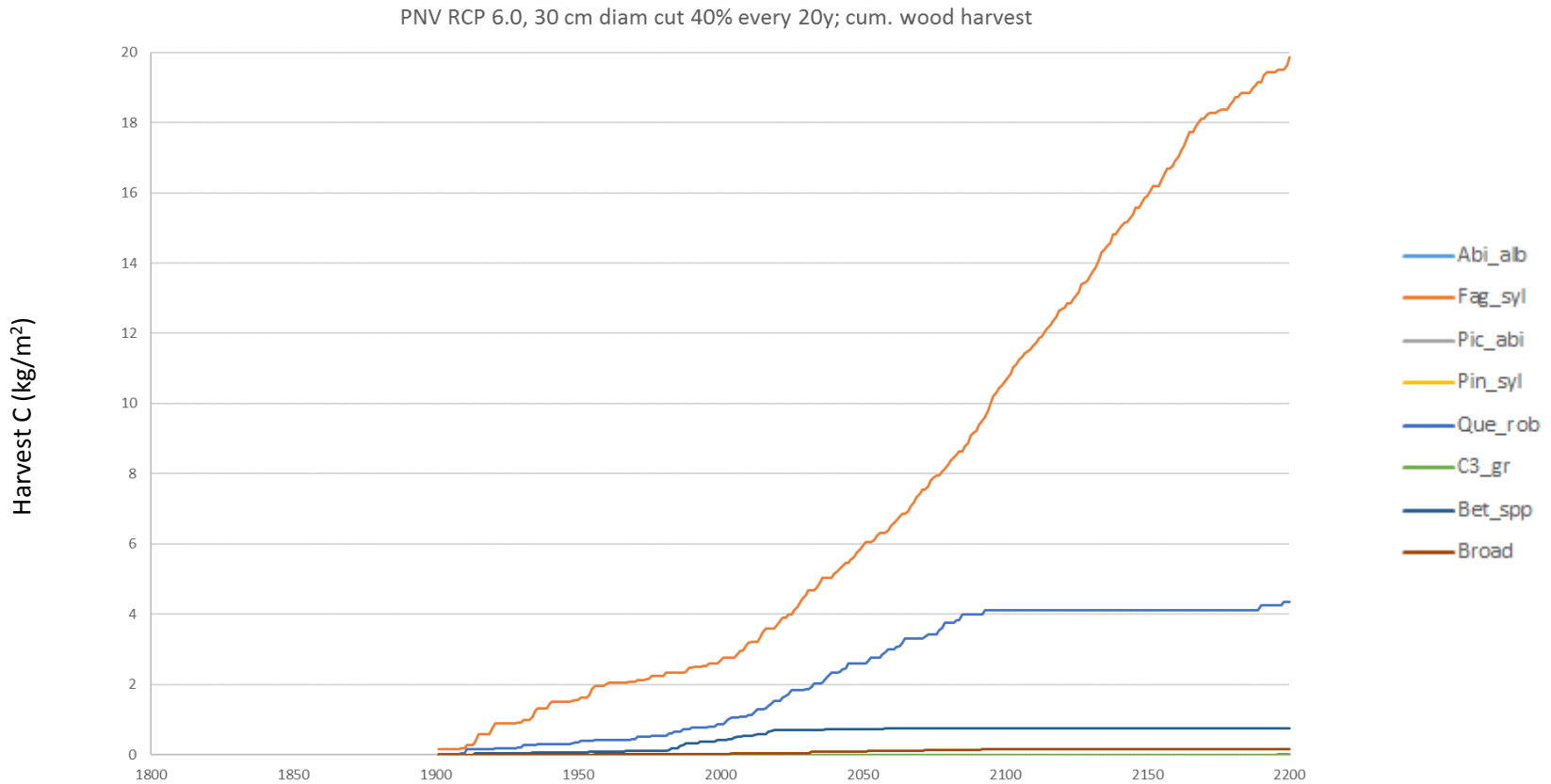
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

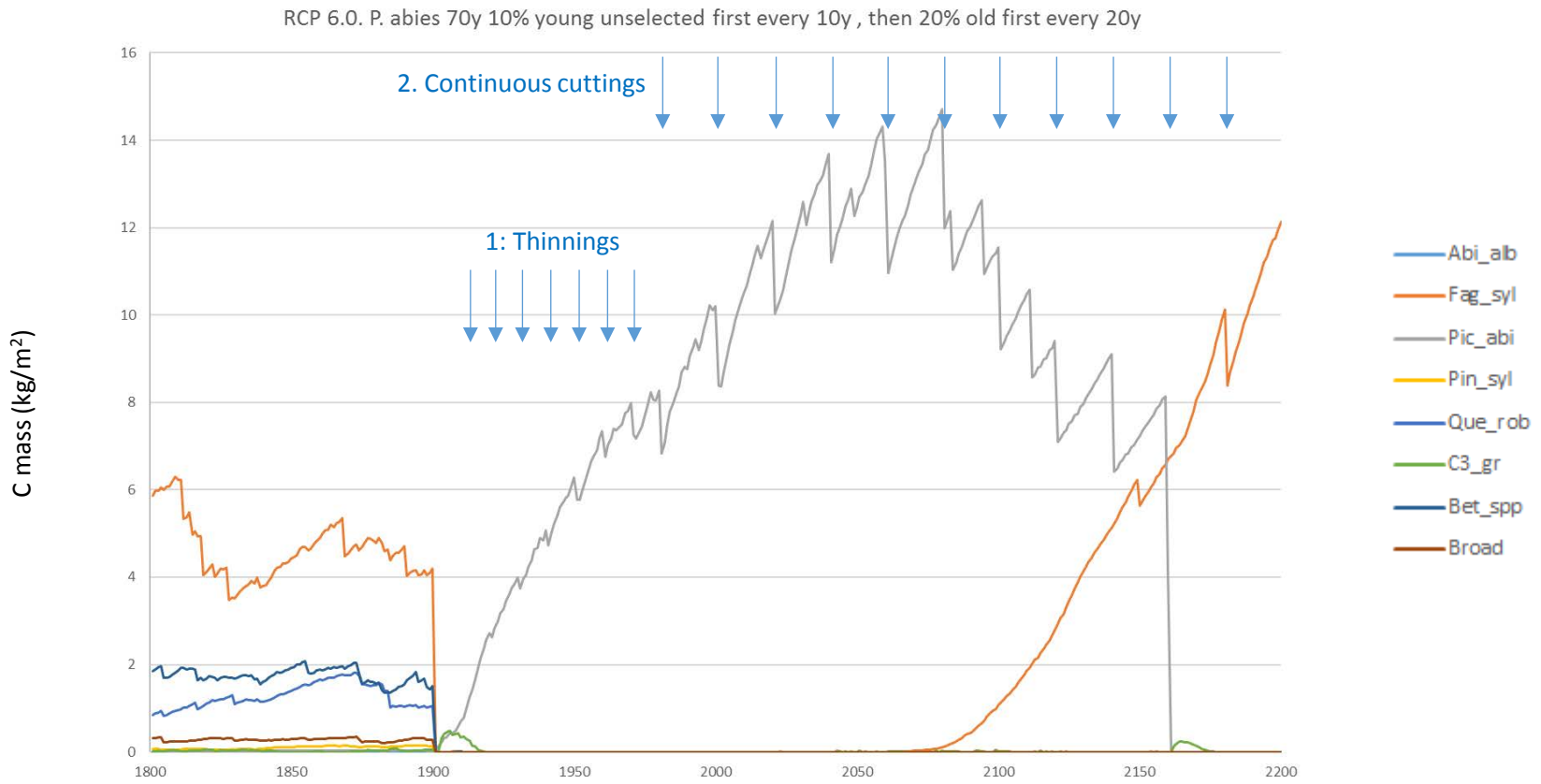
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting, selected species
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

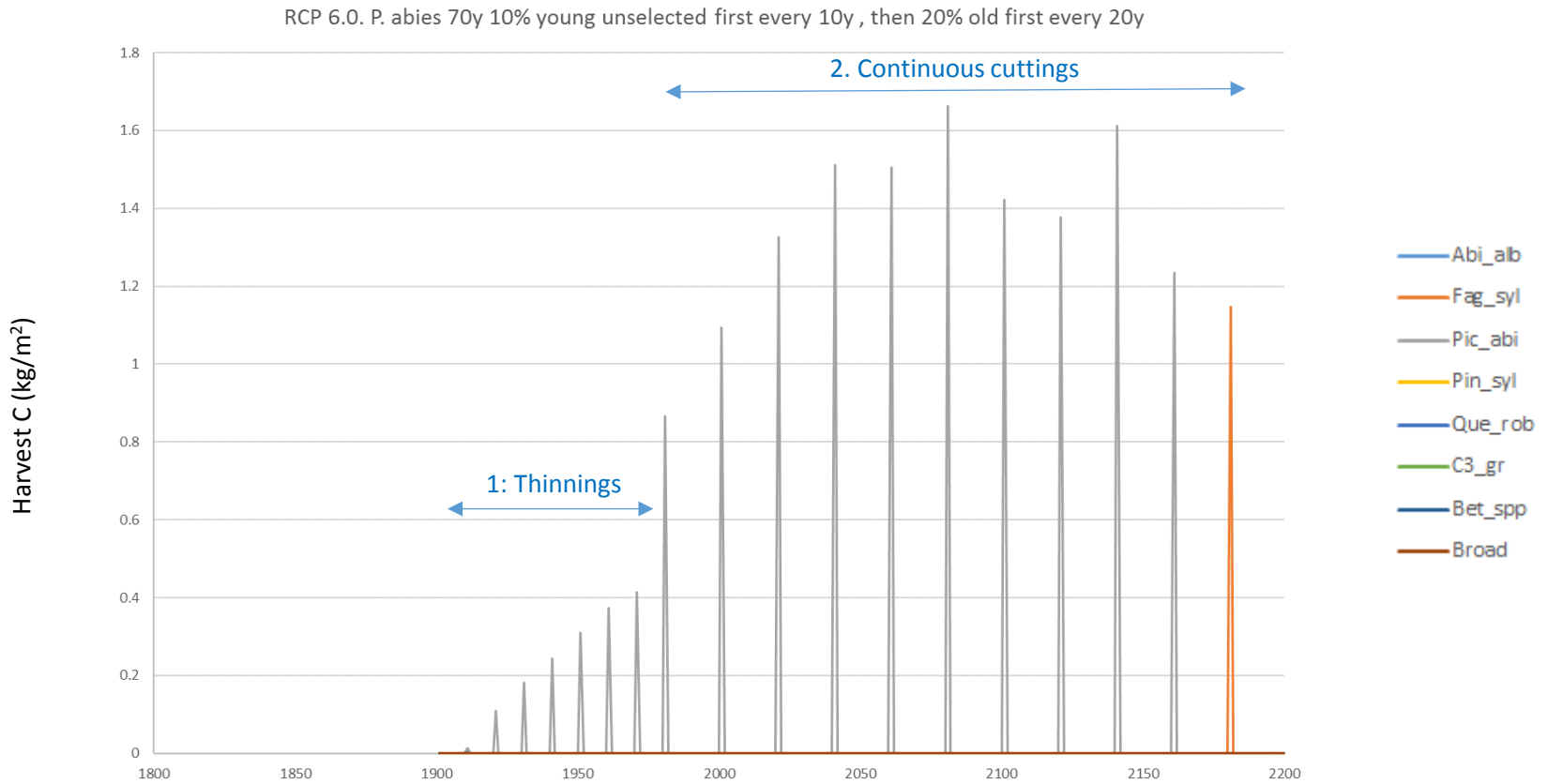
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting, selected species
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

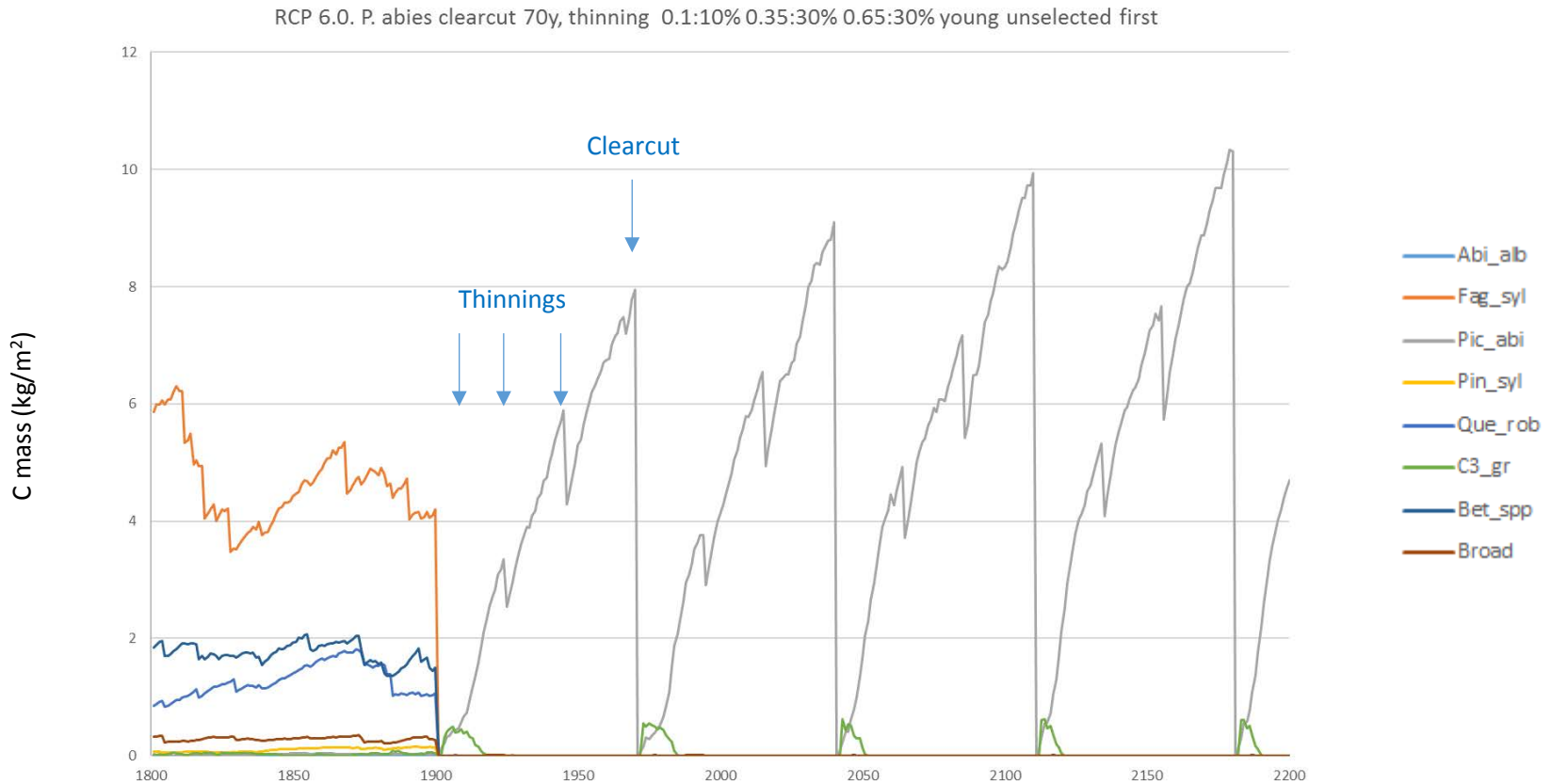
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting, selected species
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

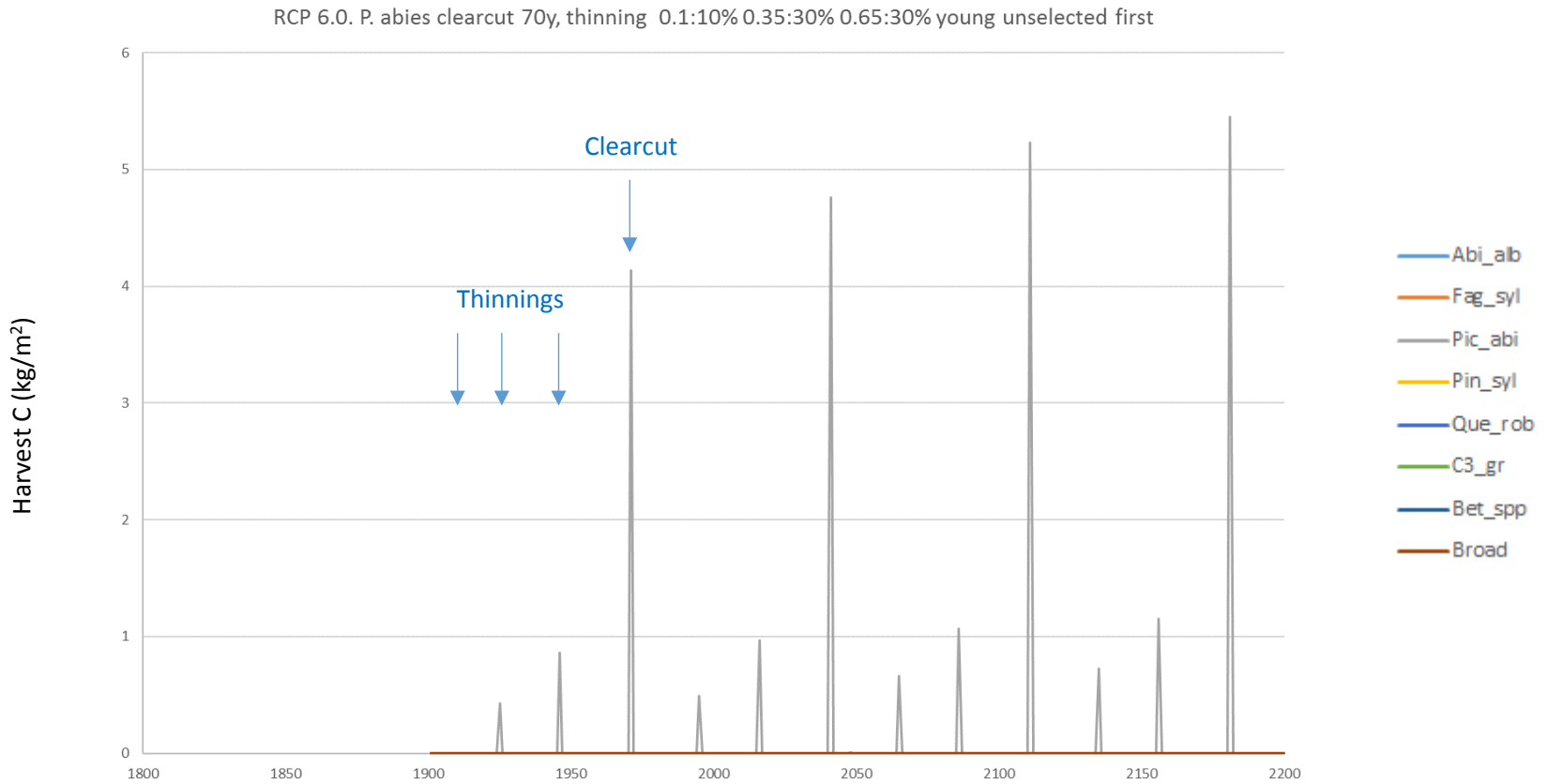
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting, selected species
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

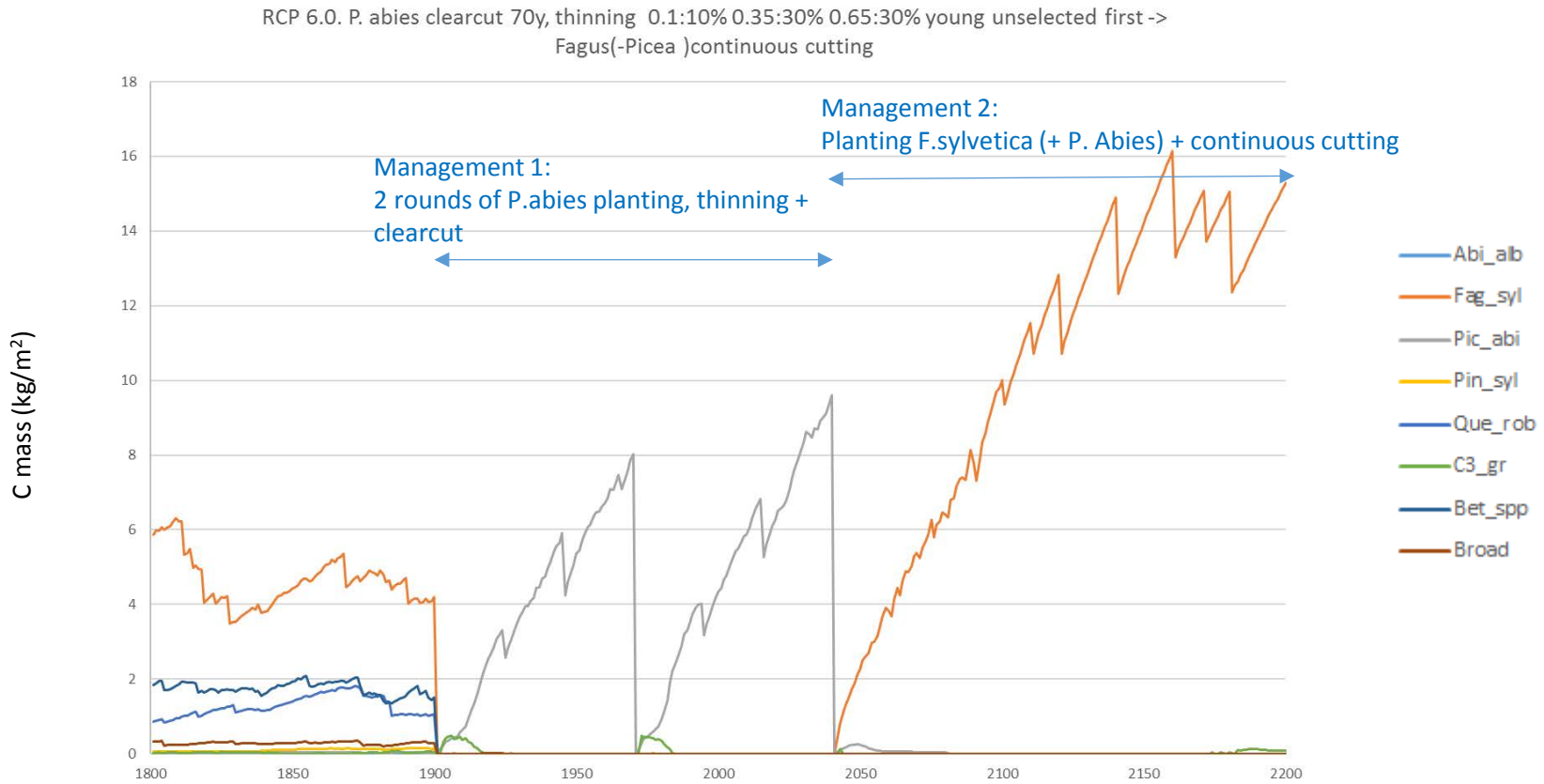
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting, selected species
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



History

PNV
Managed land (cropland,pasture)

Initiation

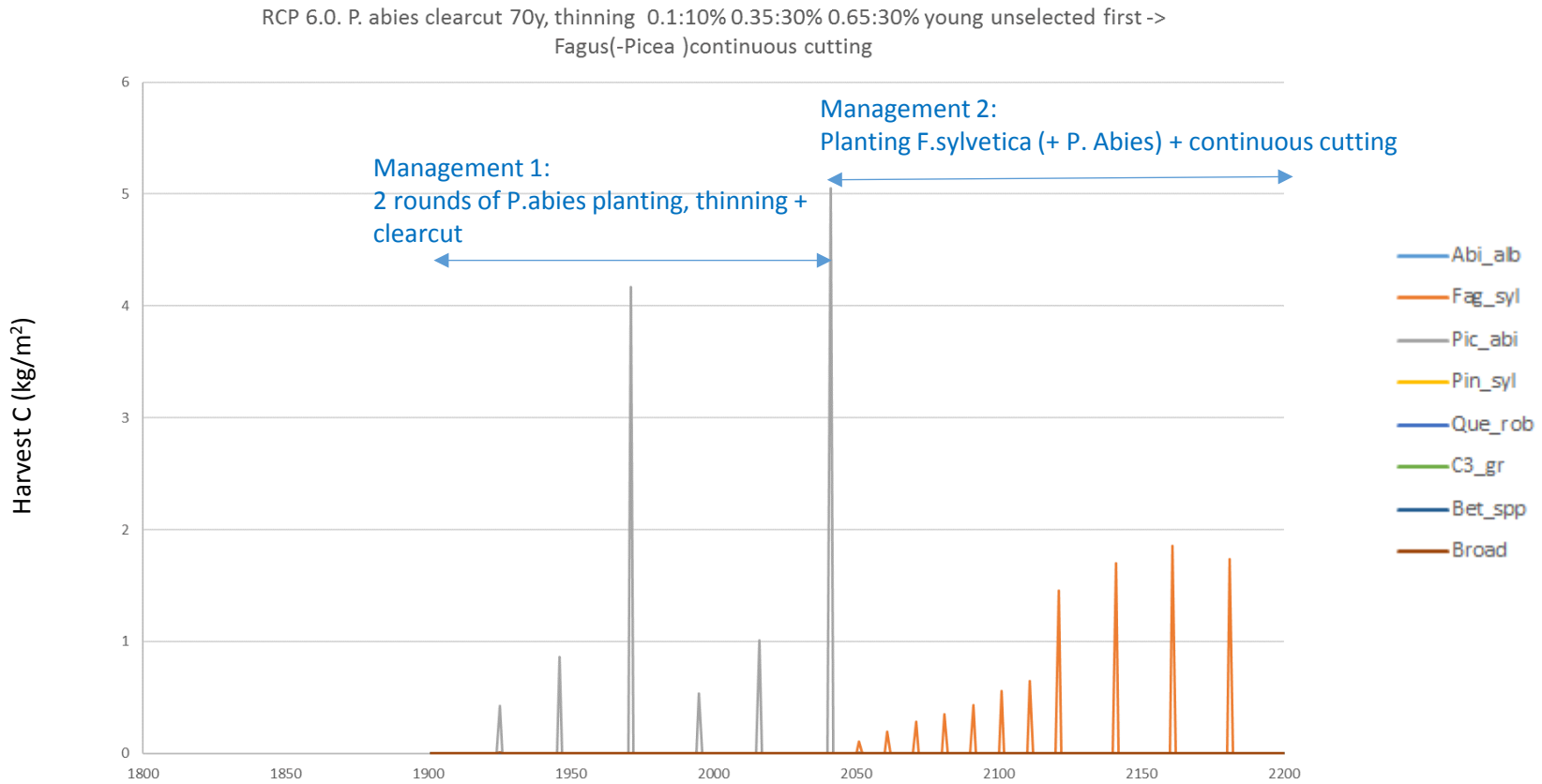
Clearcut, Planting
Cut unselected spp
Do nothing

Management

Thinnings, Clearcut
Continuous cutting, selected species
Reestablishment (selection, all, none spp)
Fire/disturbance suppression
N fertilisation

Management change

Change selection
Change thinning int.



Future forest management development in LPJ-GUESS ?

”Automatic” thinning and harvest model logic (not requiring detailed management input, in Europan-scale simulations). (Thinning when crown cover reaches target, etc.)

Better recreation of current forest structure.

- Using more precisely selected thinnings to reach target (fraction of each major tree species).

More detailed age structure than age of oldest trees (created at clearcut) probably difficult to achieve in the model.