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

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• 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)
• link structure to function, accounting for feedbacks between them

• link 'fast' (physiology, biogeochemistry) and 'slow' (demography, composition) ecosystem processes

• account for transient ecosystem dynamics when driving conditions (climate, CO2) are changing rapidly

Simulated natural vegetation of Lithuania

LPJ-GUESS – global land ecosystem model*

Soil organic matter

Soil biogeochemistry

Population dynamics & disturbance

Primary production & growth

Plant biogeography

\( \text{CO}_2 \)

N-deposition

Climate land use

Vegetation

*Smith et al. 2001, 2014

www.nateko.lu.se/lpj-guess
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Simulation of natural vegetation of Lithuania

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- Soil organic matter
- Soil biogeochemistry
- Population dynamics & disturbance
- Plant biogeography
- Primary production & growth

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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 CO₂ emission scenario (2 climate models):

Managed land version accounts for land use*

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)*
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)
1. Thinnings
2. Continuous cuttings

Timing
Strength
Age preference
Size preference
Species preference

Change to continuous cuttings after 70 years

Clearcut year: 1901
Plant P. abies

Spontaneous regeneration of F. syvatica

Rotation period: 70 y
Continuous cutting loop: 20 y
**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.

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![Graph showing carbon mass changes over time for different species: F.sylvatica, Q. robur, Betula, Abi_ab, Fej_syl, Pia_neb, Pin_syl, Quc_robr, C3_gr, Bet_spp, Broad.](image)
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**Graph:**
- **Legend:**
  - Abi_ab
  - Fag_syl
  - Pin_nbi
  - Pin_syl
  - Quc_rob
  - C3_gr
  - Bae_spp
  - Broad

- **Graph Description:**
  - RCP 6.0. P. abies 70y 10% young unselected first every 10y, then 20% old first every 20y
  - **1: Thinnings**
  - **2: Continuous cuttings**
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**Harvest C (kg/m²)**

1: Thinnings
2. Continuous cuttings
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![Graph showing harvest C (kg/m²) over time](image)
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RCP 6.0. P. abies clearcut 70y, thinning 0.1:10% 0.35:30% 0.65:30% young unselected first -> Fagus(-Picea) continuous cutting

Management 1:
2 rounds of P.abies planting, thinning + clearcut

Management 2:
Planting F.sylvetica (+ P. Abies) + continuous cutting
Future forest management development in LPJ-GUESS?

"Automatic" thinning and harvest model logic (not requiring detailed management input, in European-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.