Technical University of Munich

European forest management in a more extreme climate: Modelling solutions for risk resilient management

Anja Rammig[a], Ekaterina Sycheva[a], Claudia Chreptun[a], Mats Lindeskog[b], Andrej Ficko[c], Ben Smith[b] , Thomas Knoke[a]

[a]Technical University of Munich, TUM School of Life Scienes Weihenstephan, Freising, Germany; [b]Lund University, Department of Physical Geography and Ecosystem Science, Sweden; [c]University of Ljubljana, Department of Forestry and Renewable Forest Resources, Slovenia

FOREXCLIM

Background

Climate change and in particular extreme weather events require the development of risk-resilient forest management strategies across Europe. Here, we introduce the concept of our recently started EU-FP7 ERA-NET "Sumforest" project "FOREXCLIM" (FORests and EXtreme weather events: Solutions for risk resilient management in a changing CLIMate).

In FOREXCLIM, we investigate the interactions between extreme weather (heat waves, drought, storm), subsequent forest susceptibility to fire and pathogens, market developments, forest management and related uncertainties to determine on how current forest management strategies should be adapted to sustain risk-resilient multifunctional forest landscapes in the future.

Currently, we are implementing forest management strategies at country level in LPJ-GUESS and simulate individual stands for input in the optimization model.

Method

In close collaboration with stakeholders, we develop a model-based strategy for identifying and operationalizing risk resilient forest management regimes.

The core of our methodological approach is a process-based forest ecosystem model (A) coupled with a multi-objective, risk-sensitive optimization for robust forest functioning and ES provisioning (B). The goal is to derive the optimal forest management under changing climate and timber markets. For model evaluation, we mainly rely on data from national forest inventories. Our assessment will provide optimal silvicultural management regimes for integrated management of forests, i.e. fulfilling multiple ES provision goals.

A: Implementing forest management strategies in the process-based ecosystem model LPJ-GUESS[1]

Work by Ekaterina Sycheva

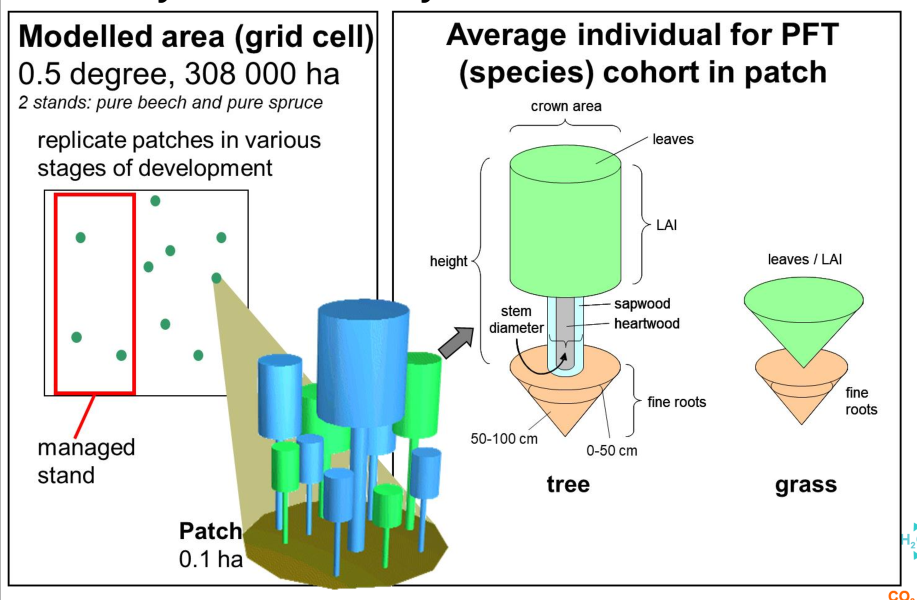

Figure 1:Vegetation representation in LPJ-GUESS in cohort mode[1]

- Pure or mixed stands per grid cell (Fig. 1)
- Similar climate conditions and soil properties for all stands in a grid cell
- Competition within stands, no competition between the stands or grid cells

Different management strategies for pure or mixed forest stands in LPJ-GUESS:

- ✓ Different thinnings (intensity and structure)
- ✓ Continuous cover forestry
- ✓ Planting of mixed forest stands

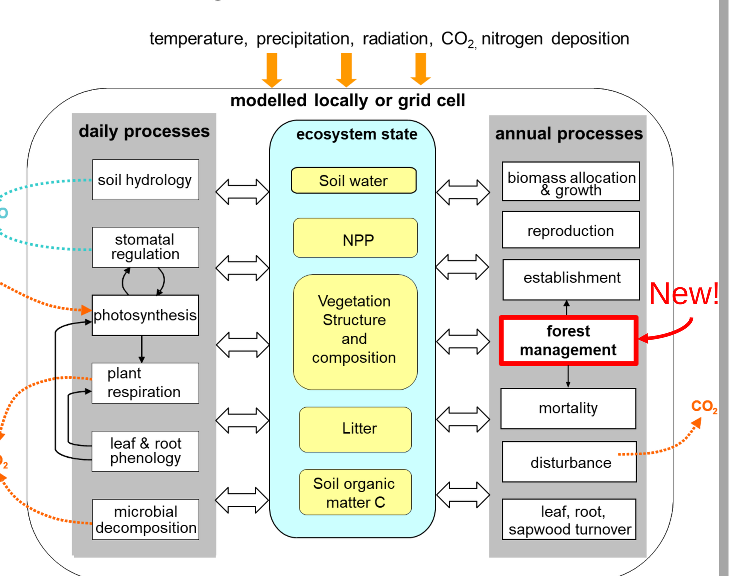

Figure 2: Schematics of modelled processes in LPJ-GUESS with forest management.

B: Multi-objective, risk-sensitive optimization for robust forest functioning: YAFO[2,3]

Work by Claudia Chreptun

- Provides financially optimized scenarios of forest management on forest enterprise level for decision-support
- Integrates uncertainty of timber price fluctuations and natural calamities via Value-at-Risk-Approach
- Optimization also possible with including aspects of ecosystem services
- Shows effects of decisions in optimized management plans differentiated for time and amount of area
- First step: Optimize management strategies for forest enterprise in Germany based on output from LPJ-GUESS → evaluate impact of different climate scenarios and changed frequency of extreme events

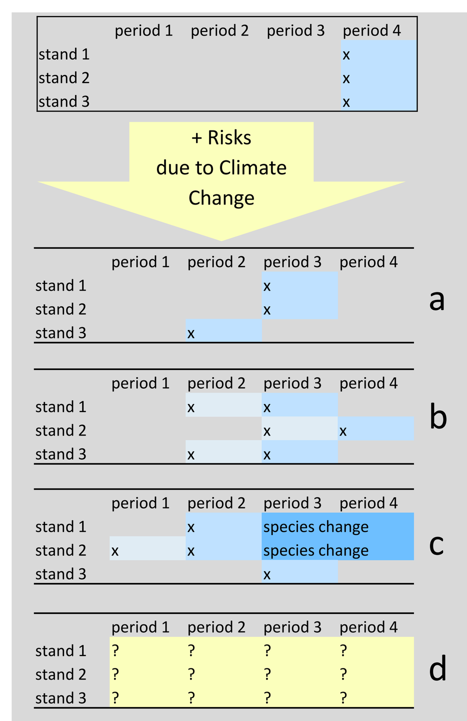

Fig. 3: Possible changes in optimized management plans with climate change effects: x: „harvest" a: earlier harvest points, b: splitted harvest intensity, c: species change, d: unexpected solutions.

Preliminary results

Simulations at country level

- In our simulations, maximum yield is achieved with moderate thinning (Fig. 4), because it triggers tree growth and reduces competition. With heavy thinning we obtain larger trees with better quality but smaller total yield, resembling growth pattern as in yield tables[4].
- Next steps: Simulate pure and mixed stands of different tree species, and their management in more detail, and climate change impacts.

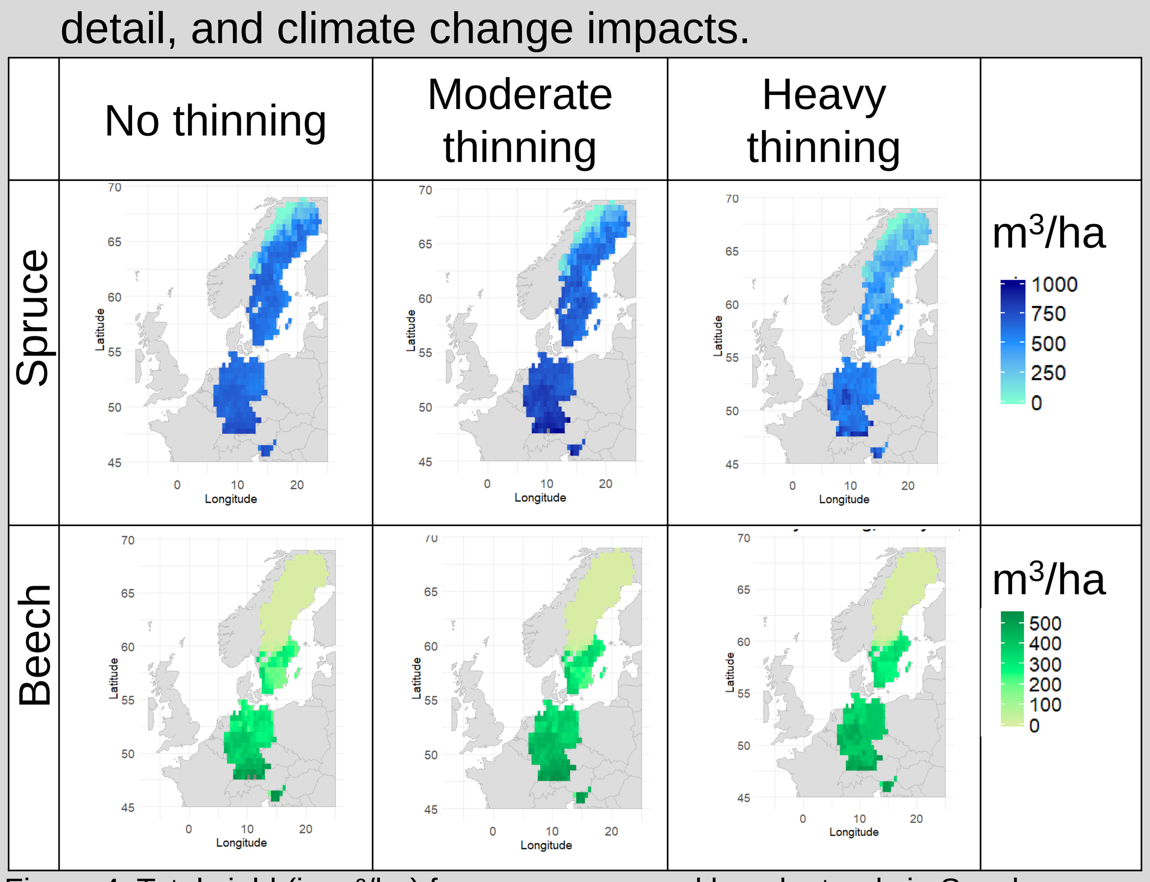

Figure 4: Total yield (in m³/ha) for pure spruce and beech stands in Sweden, Germany and Slovenia simulated by LPJ-GUESS with different management options/ thinning intensities. Simulation period was 1901-2021 driven by repeated CRU-NCEP[5] climate data. Simulation results are for 120 years old stands

Table 1: Non-exhaustive overview over different stand types, volume and management strategies in Germany, Sweden and Slovenia. Based on national information, LPJ-GUESS will be implemented to simulate the most relevant management strategies and stand types.

	Gemany	Sweden	Slovenia
Average volume of 120 years old mature stand [m³/ha]	Beech 454* Spruce 585*	Beech 360** Spruce 605-540 **	Beech 500-700*** Spruce up to 900***
Main management system	Continuous cover forestry	Clear-cut system	Continuous cover forestry
Harvest criteria	Dbh, stand structure	Rotation period	Stand structure
Main stand type	Monocultures; mixed stands	Monocultures	Mixed stands
Management area	Small – medium scale	Large scale	Small – medium scale
Regeneration	Natural/planting	Planting	Natural
Rotation period [years]	80-120	60-80	80-120
Main adaptation strategies for climate change	Convert monocultural (spruce-) stands to mixed stands to increase forest stability and resistance to climate change, add suitable species that are better adapted.	Expecting better growth conditions mainly for spruce. Convert pure spruce stands into mixed birch-spruce to increase stability.	Maintain stable structure of mixed forests, add climate adapted species.

**Dritte Bundeswaldinventur (2012): bwi.info/Tabellenauswahl.aspx*

***www.skogskunskap.se/rakna-med-verktyg/mata-skogen/virkesforrad/, calculated based on average site index, average Basal area*

****Forest Management Plans, Slovenian Forest Service*

Simulations at forest enterprise level

- We simulate forest stand developement of a forest enterprise in Southern Germany with 42 stands and 200 hectar using LPJ-GUESS (Fig. 4).
- Thinning mode: Every 5 years 10% of the biomass is harvested, first not wanted species.

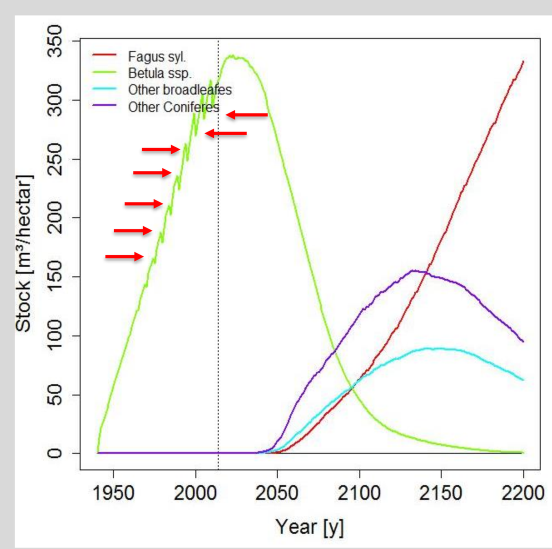

Figure 4: Simulated forest stand development based on LPJ-GUESS exemplary for one stand of broadleaved tree species with low life expectation in Southern Germany. Such model output will be used as input for YAFO. Age in 2014: 74 years. Red arrows mark thinning events.

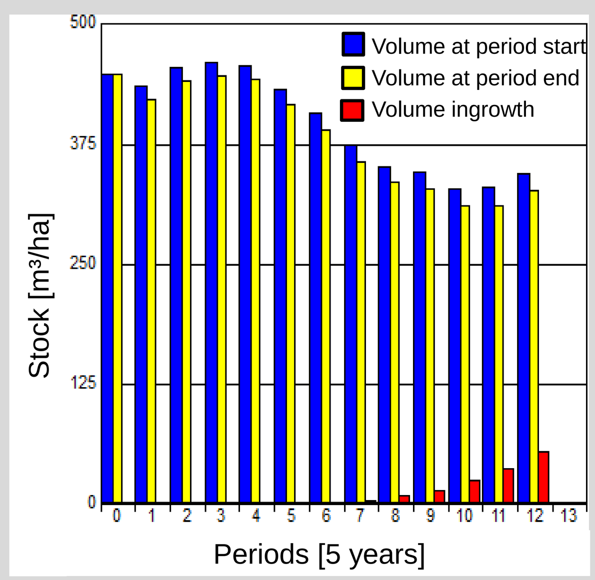

Figure 5: Exemplary output from YAFO. Volume development for a forest enterprise with 42 stands. Optimization of harvest points and area with the Value-at-Risk approach over 13 periods á 5 years.

Literature

[1]Smith et al. (2014). Implications of incorporating N cycling and N limitations on primary production in an individual-based dynamic vegetation model. Biogeosciences 11, 2027–2054.

[2]Härtl et al. (2013). Risk-sensitive planning support for forest enterprises. The YAFO model. Computers and Electronics in Agriculture 94, 58–70.

[3]Härtl et al. (2016). Multifunctionality in European mountain forests — an optimization under changing climatic conditions. Canadian Journal of Forest Research, 46, 163–171.

[4]Schober (1975). Ertragstafeln wichtiger Baumarten bei verschiedener Durchforstung. Sauerländer's Verlag. Frankfurt a.M.

[5]Mitchell and Jones (2005). An improved method of constructing a database of monthly climate observations and associated high-resolution grids. International Journal of Climatology, 25, 693-712.

Contact:
Anja.Rammig@tum.de
www.forexclim.eu

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