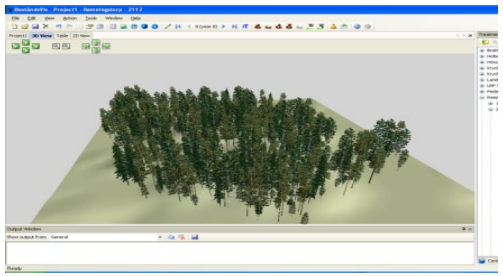
Decision support for sustainable forest management

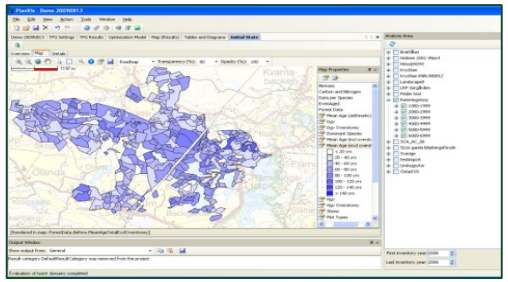
Jeannette Eggers

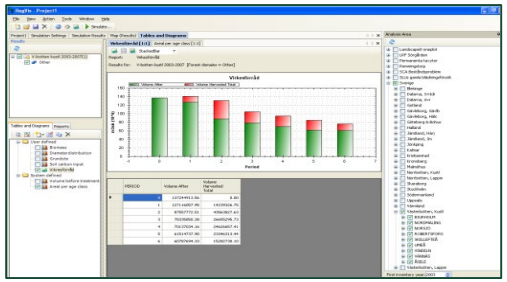
What is Heureka

Decision support system for Swedish forests

- projections of forest conditions and consequences for ecosystem services on the basis that the forest is managed in different ways

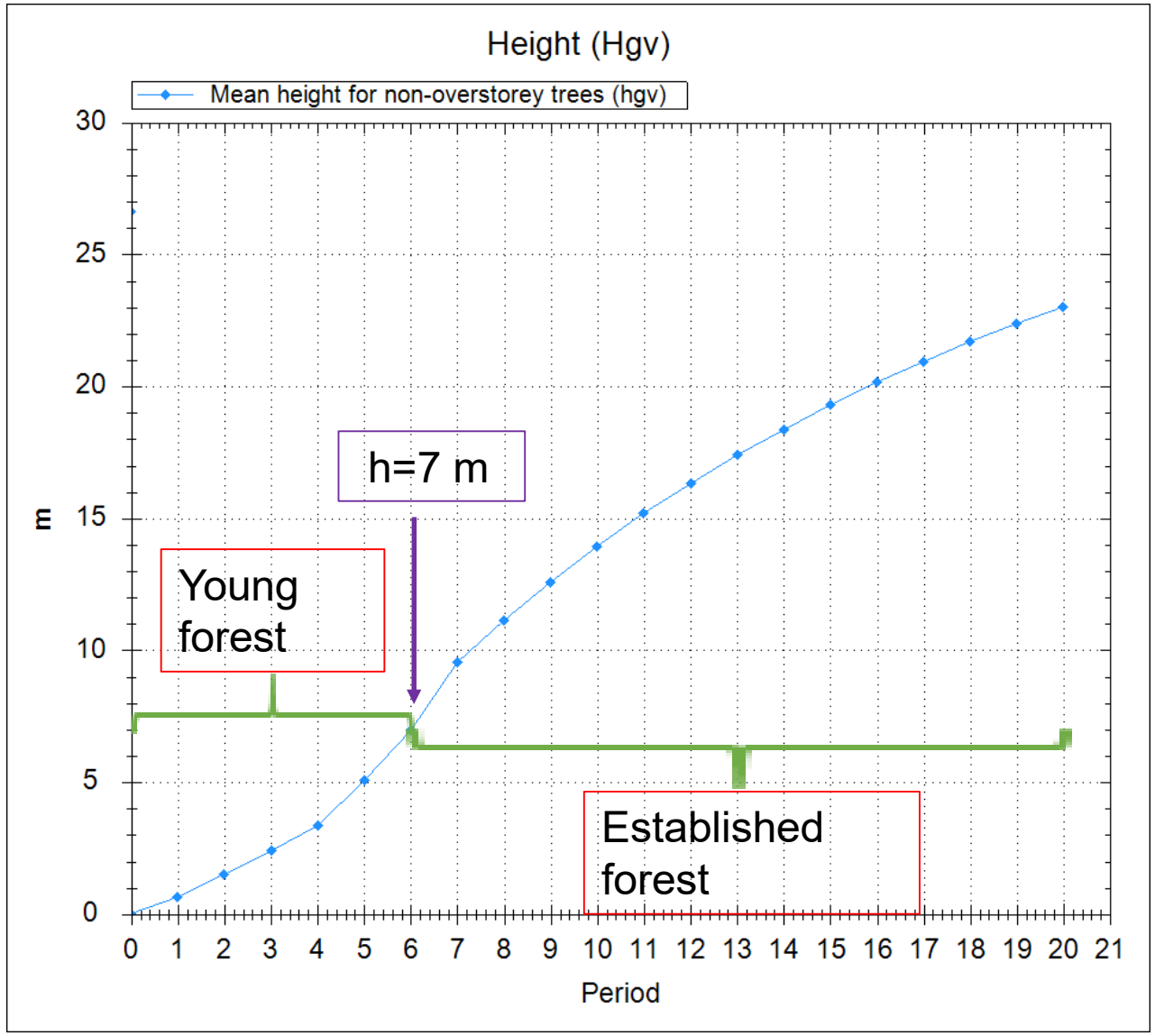






Decision support system = Computer based system that, with help of models to describe the forest's future management and development, support decision-making.

Core: empirical regression functions



- Functions based on NFI data
- Different functions for young and established forest
- Functions for growth, mortality, in-growth etc.

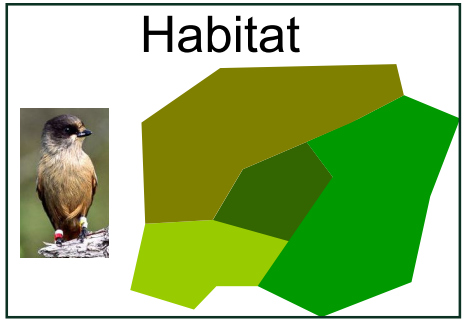
Stand simulator

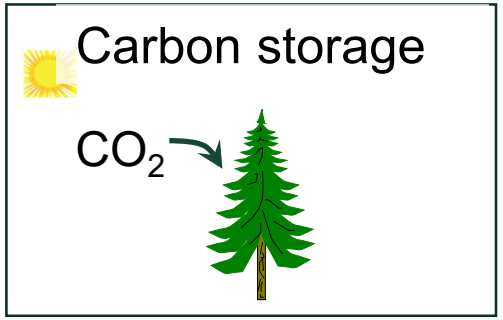

Timber


Forest fuel


Standing volume


Recreation


Habitat

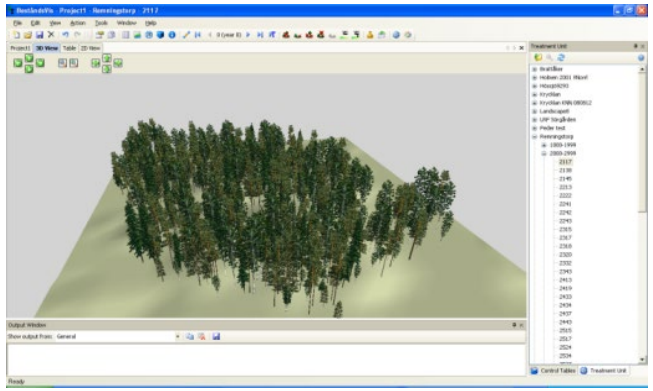

Carbon storage
CO_2


Dead wood

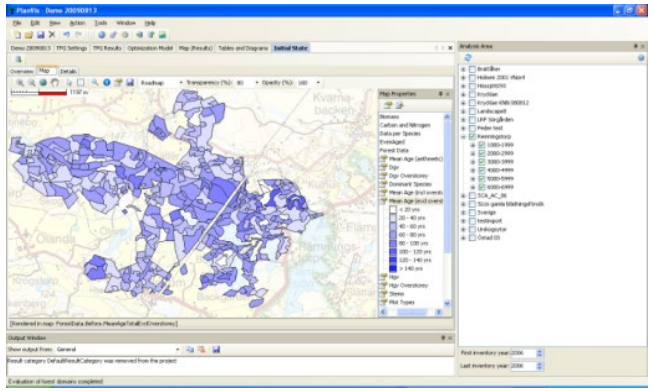

Birch volume


Cost and income

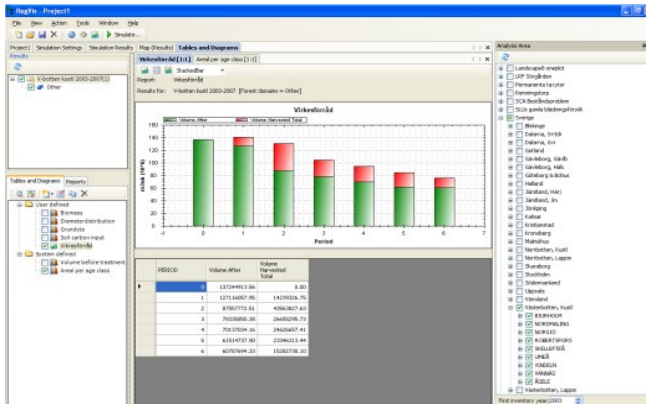
Four applications



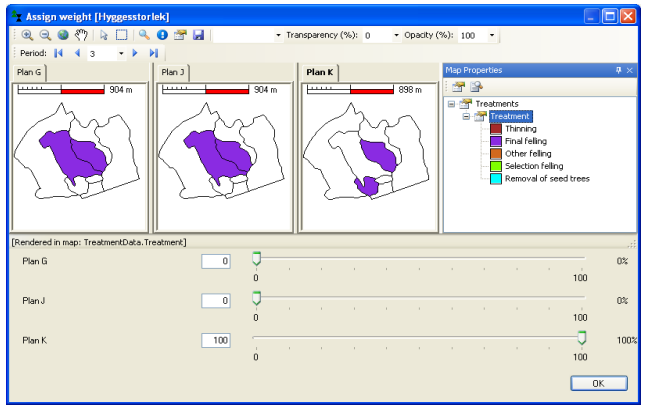
StandWise



PlanWise



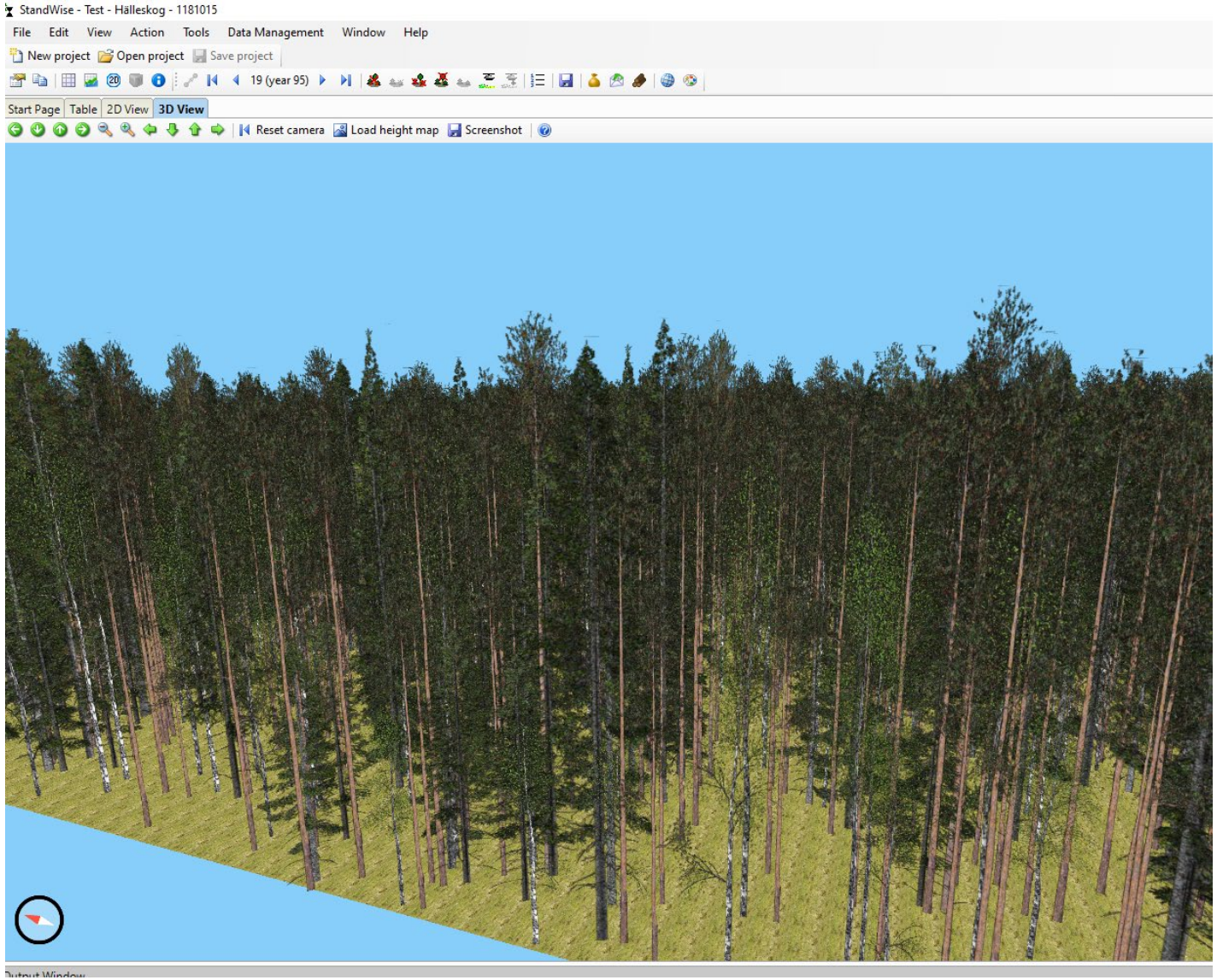
RegWise



PlanEval

StandWise

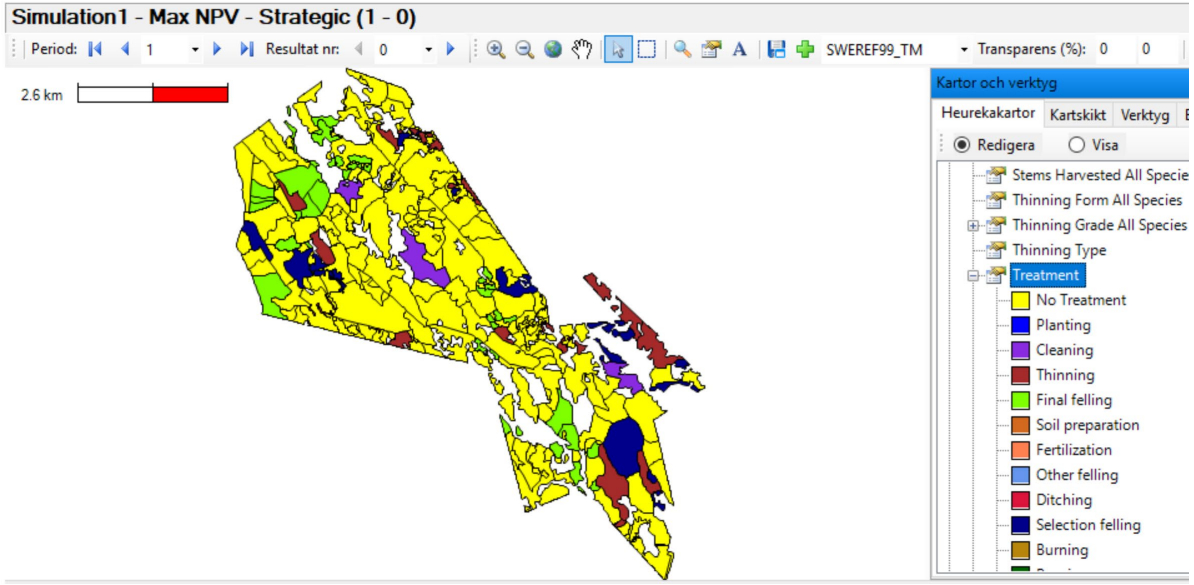
- Interactive stand simulator



PlanWise

Planning of forestry (PlanWise)

- For deciding what to do, when to do it and where to do it

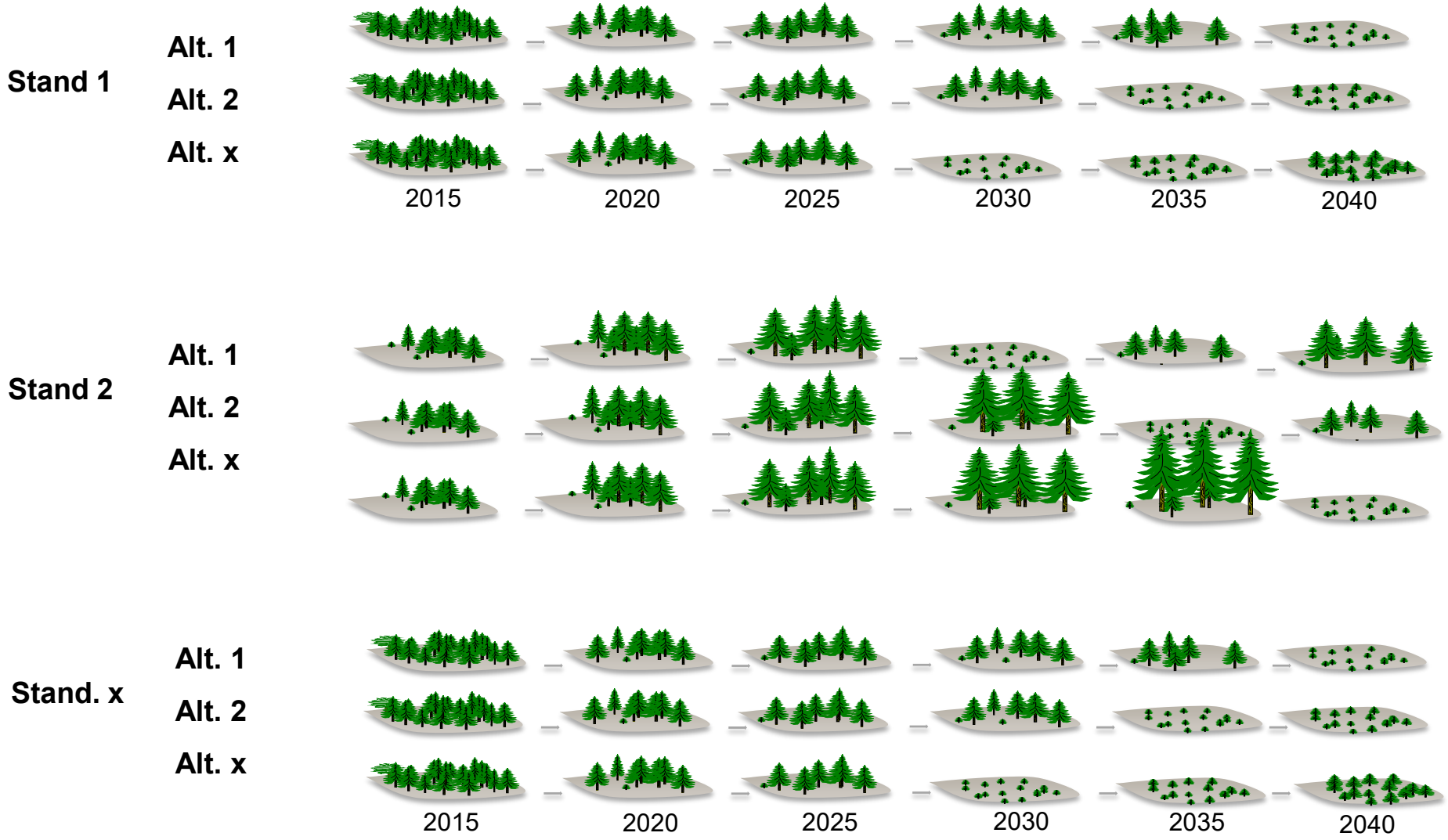


Maximize harvest volume

subject to:

- *a certain area should be managed with nature conservation forestry*

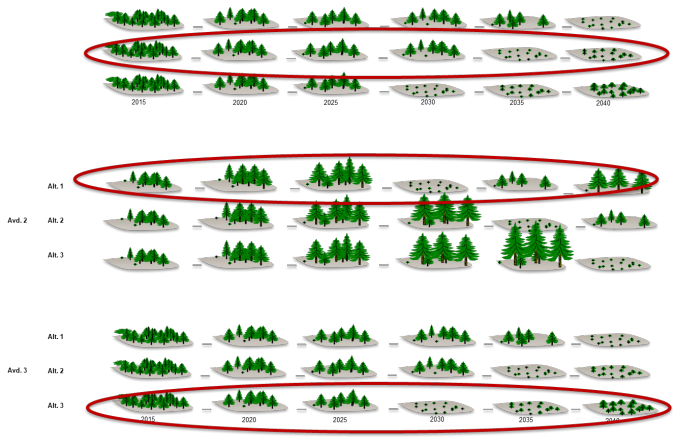
Result of the stand simulator

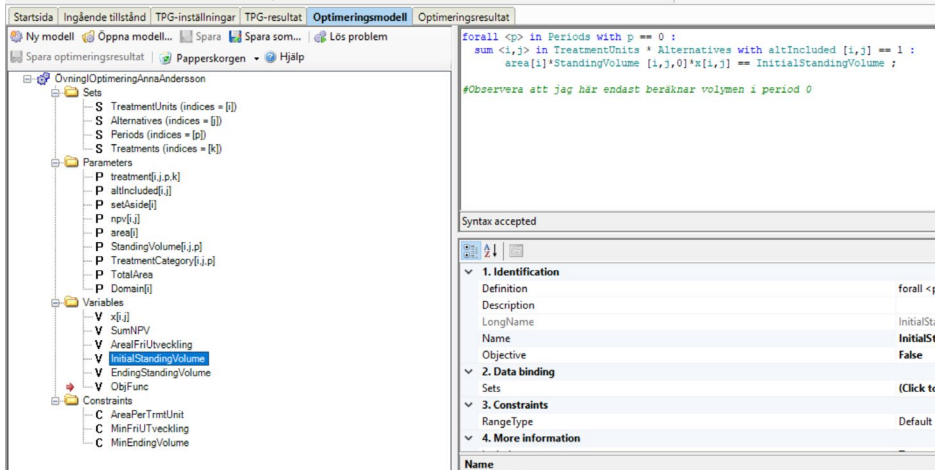


Information about forest condition and production of different ecosystem services

Optimizing tool

- Select alternative for each stand with help of linear programming (LP) or mixed integer programming (MIP)





RegWise

Scenario analysis (RegWise)

- How much could be harvested if we continue to manage the forest the way we do today?
- What will be the consequences if we use continuous cover forestry instead of even aged forestry?

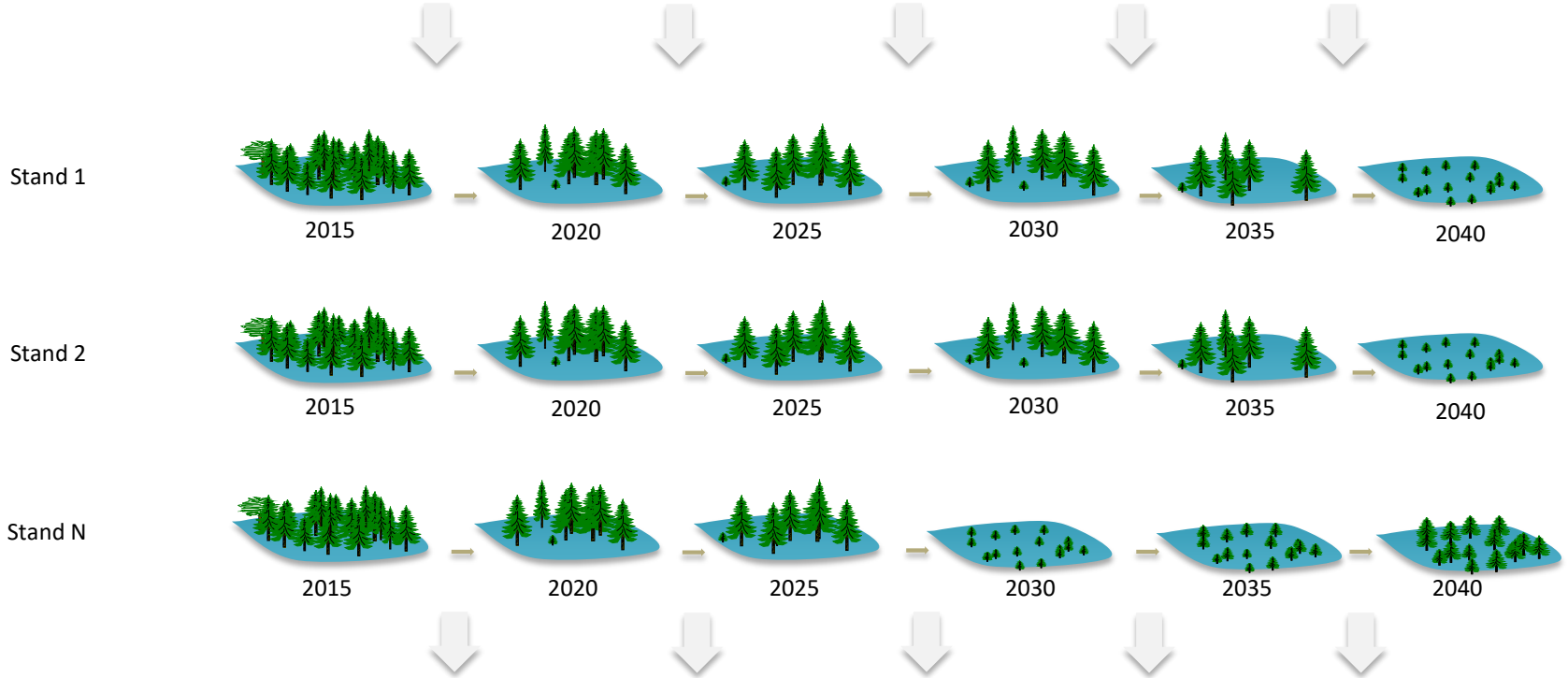
Actions, such as

- Planting
- Thinning
- Final felling
- Prescibed burning

RegWise

Models for

- Growth
- In-growth
- Natural mortality
- Deadwood decomposition



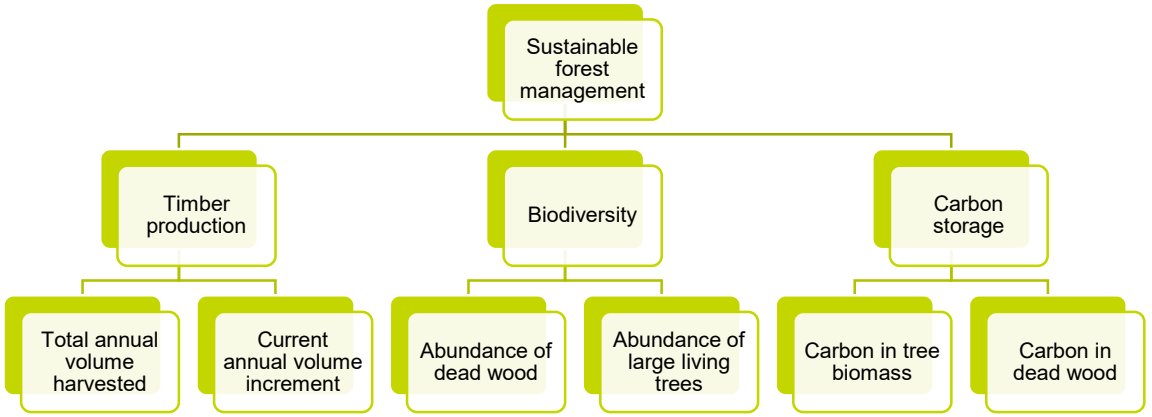
Ecosystem services or products:

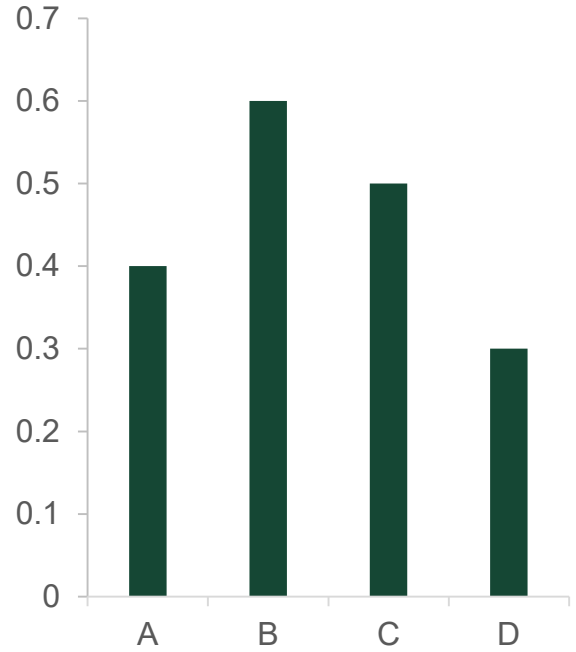
- Felling volume
- Biofuel
- Carbon sequestration
- Habitat

PlanEval

Ranking of scenarios created in PlanWise and RegWise

1. What objectives are there?
2. How well do the alternatives/scenarios fulfill each of the objectives?
3. How important are the objectives?





What can be done in Heureka?

- Simulate different management system (even-aged forestry, CCF and unmanaged) and variations thereof
- Simulate different nature conservation strategies (buffer zones, blue targeting, retention trees, high stumps..)
- Simulate different fertilization policies
- Simulate different biofuel extraction policies
- Include costs,prices & price trends
- Climate change……

What needs to be further developed/improved?

- Climate change impacts
- Risks & Uncertainty
- Alternative management strategies
- Impact of forest condition on field layer

On-going/planned Heureka development

- 3PG-Heureka to better account for climate change impacts
- Risk susceptibility indices (storm, spruce bark beetles…)
- Include harvested wood products & substitution factors in Heureka
- Monte Carlo functionality (RegWise)
- Empirical bilberry and lingonberry cover (%) and yield models (kg/ha or index) under development & to be implemented Heureka
  - based on relationship between berry cover/yield and forest attributes.
  - data source: NFI field data, weather data, remote sensing data

How is Heureka used today?

- Forest companies (Holmen, SCA, Sveaskog etc.)
  - Harvest level
- State Forest Agency
  - Forest Impact Assessment
- Environmental Protection Agency
  - Carbon reporting, forest reference level
- County boards
  - Development of species habitat over time
- Privat forest owners
- Research projects

Usage

Journal Articles	77
Reports	30
Student theses	41

Publications

LAST CHANGED: 21 SEPTEMBER 2021

Publications in which Forest Sustainability Analyses (SHa) or the Heureka system have been involved. Membership to the Scientific Journals might be needed in order to read the articles.

- Journal Articles +
- Reports +
- Poster +
- Proceedings +
- Student theses +
- Popular science articles +
- In media +

https://www.slu.se/en/departments/forest-resource-management/program-project/forest-sustainability-analysis/sha/publications/

Renewable and Sustainable Energy Reviews

Journal of Environmental Management

Water Resources Research

Diversity and Distribution

Environmental Research Letters

Journal of Land Use Science

Forest Ecology and Management

European Journal of Forest Research

Biomass and Bioenergy

Sustainability

Journal of Applied Ecology

Biological Conservation

Forestry

Forest Ecology and Management

Ambio

Ecoscience

GCB Bioenergy

Scand. Journal of Forest Research

Ecology and Evolution

Forests

Forest Science

Urban Forestry & Urban Greening

PLoS ONE

Journal of Forest Science

Diversity and Distributions

Silva Fennica

PLoS ONE

WIREs Energy and Environment

Ecological Applications

Forest Systems

Can. Journal of Forest Research

Forest Policy and Economics

Math. and Computational Forestry & Natural-Resource Sciences

Environmental Management

Topics

- Silviculture
- Climate change mitigation, carbon balances
- Water protection
- Multiobjective management
- Biodiversity (habitat, fragmentation, change in forest structure)
- Reindeer husbandry
- Disturbances (potential effects, prevention)
- Participatory planning

Department of Forest Resource Management, SLU

Forest Sustainability Analysis (SHa)
- Progam manager
- Deputy program manager

Heureka system development
- Operations manager
- System developers

Research project

Commissions
incl. courses

Communication

Agreement on Heureka administration

Steering group for Heureka administration

13 parties incl. SLU

Examples from research

Scenario analysis: Impact of forest management on reindeer husbandry & forestry

Scenario	
Ref	Business as usual according to forest company's management policies
Ground lichen	Create good conditions for ground lichen
Ground and arboreal lichen	Create good conditions for ground and arboreal lichen

Background

- Forest area with >50% lichen cover has decreased with 71% within reindeer husbandry area since 1955
- Denser forests (higher standing volume)
- Ground lichen decreases when basal area >18 m^2/ha
- 96% of forest with high lichen cover is pine-dominated

DOI 10.1007/s13280-015-0759-0

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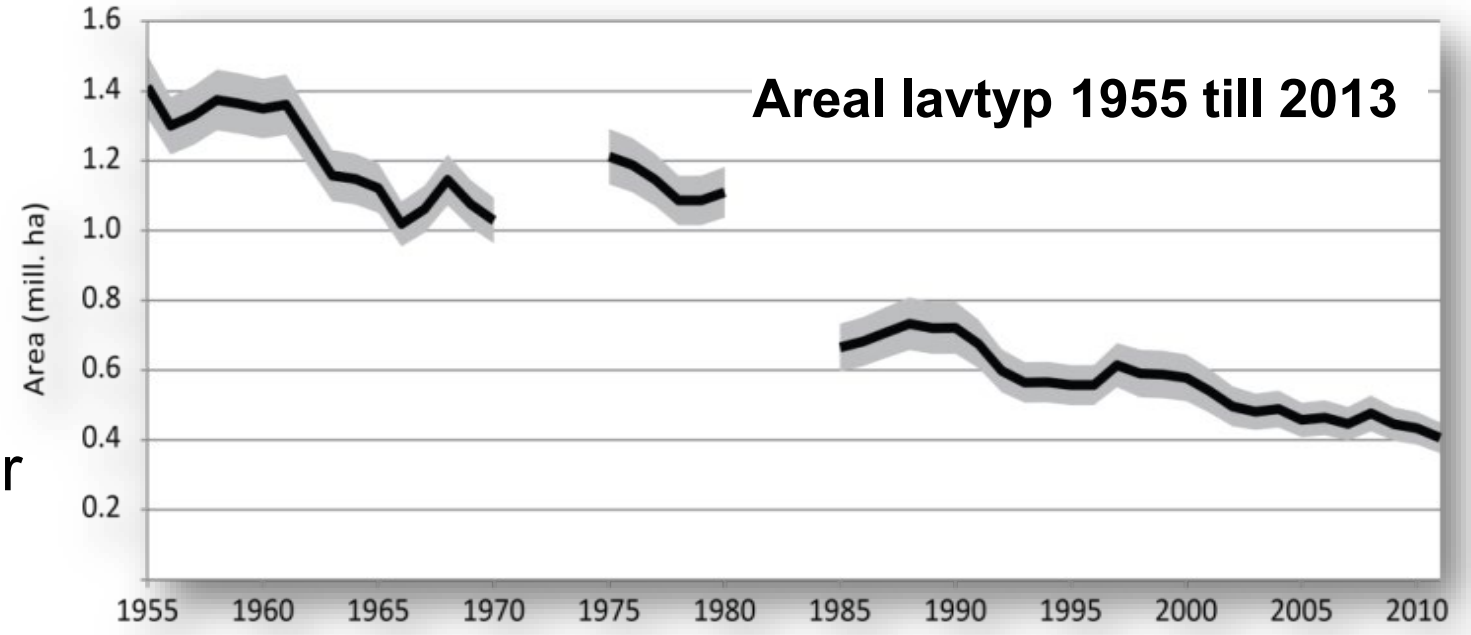
REPORT

On the decline of ground lichen forests in the Swedish boreal landscape: Implications for reindeer husbandry and sustainable forest management

Per Sandström, Neil Cory, Johan Svensson, Henrik Hedenås, Leif Jougda, Nanna Borchert



Forest management that promotes lichen growth

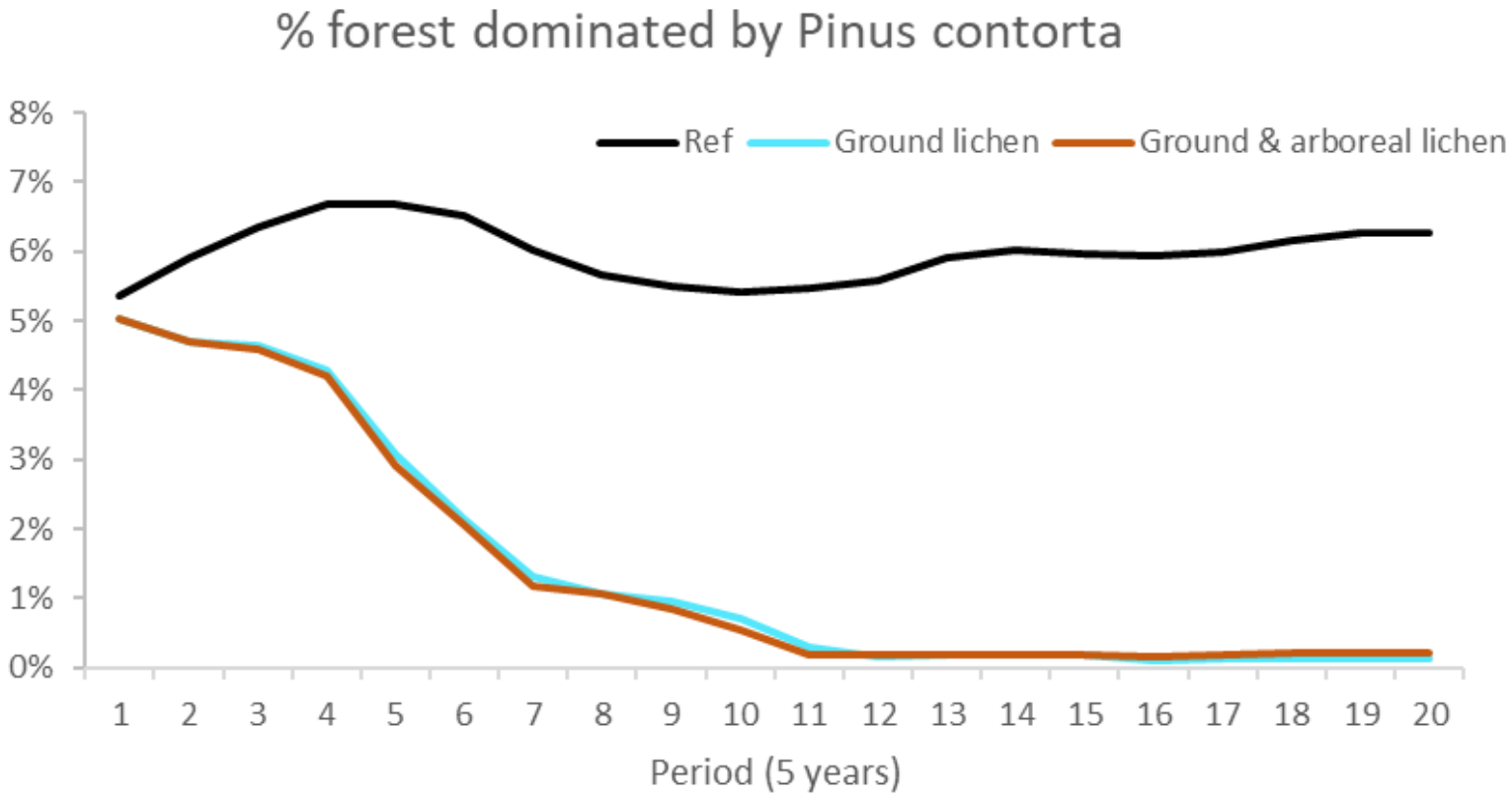
- Careful soil scarification
- Intensive cleanings and thinnings in pine forests (<= T19)
  - Low stem density in young forests
  - Thinning to keep basal area continually below 18 m^2/ha
- Gather harvest residues
- Replace Pinus contorta with P sylvestris
- Promote arboreal lichen by:
  - CCF/avoid large clearcuts
  - Prolonged rotation time
  - Leave islands of arboreal lichen forest as dispersal source

•Sandström et al. 2016. *Ambio 45(4): 415-429.*

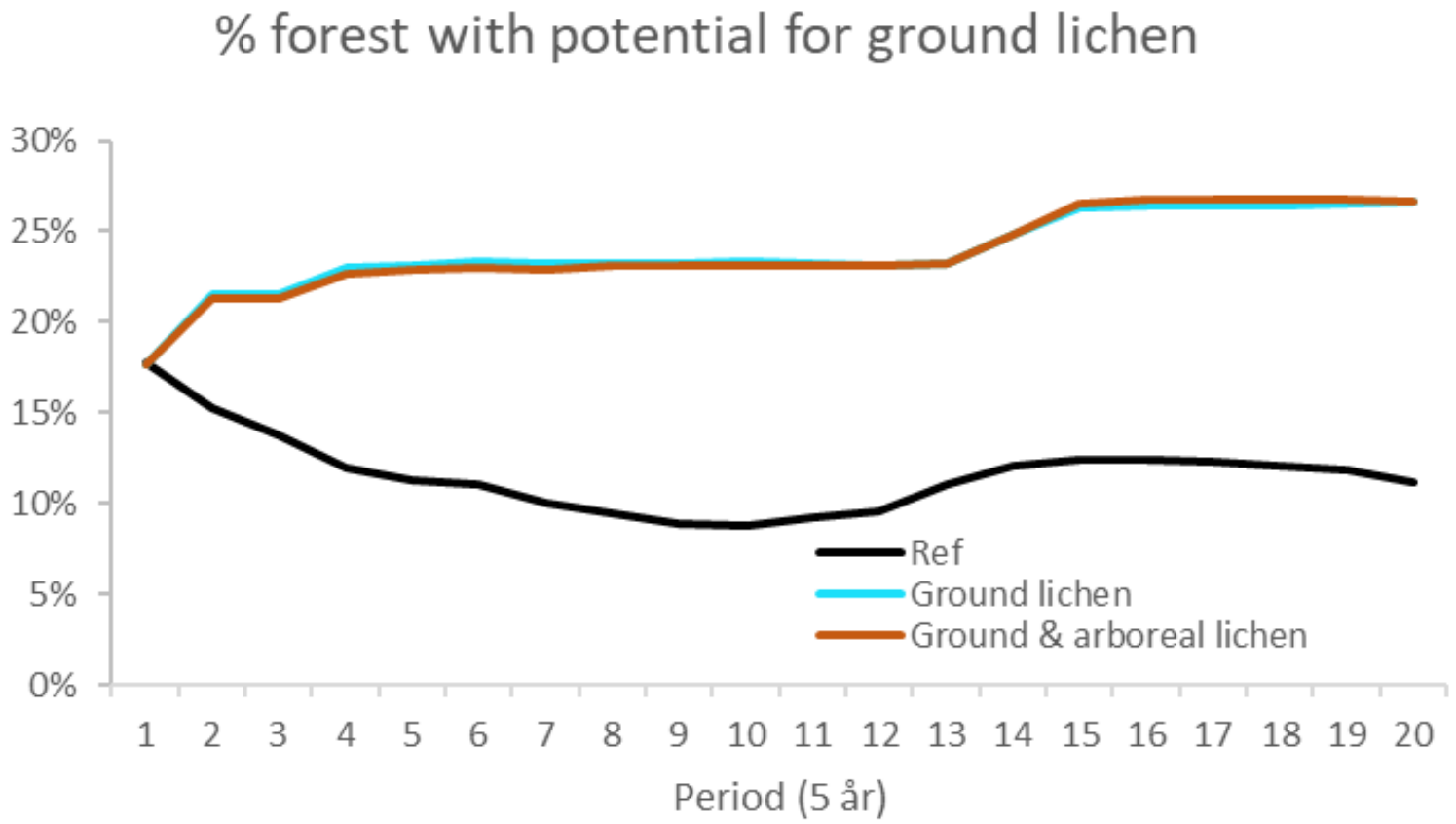
•Sandström, P. 2015. *A toolbox for co-production of knowledge and improved land use dialogues*. SLU, Umeå, Sweden.

•Jonsson Cabrajic et al. 2010. *Ecography* 33: 949-960.

Pinus contorta



Forest with potential for ground lichen growth

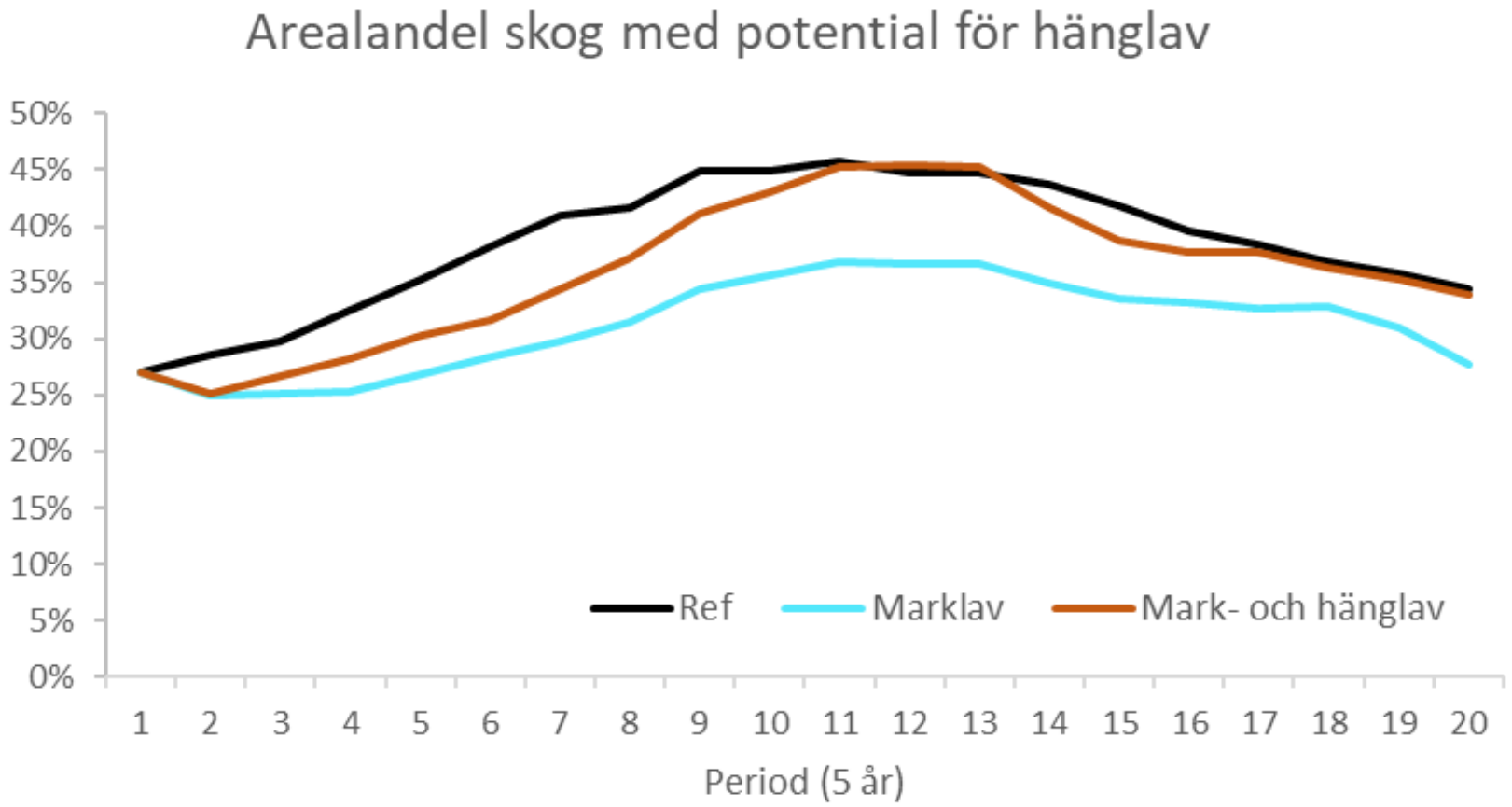


- Pine forest (SI12-19)
- Dry and mesic soil

&

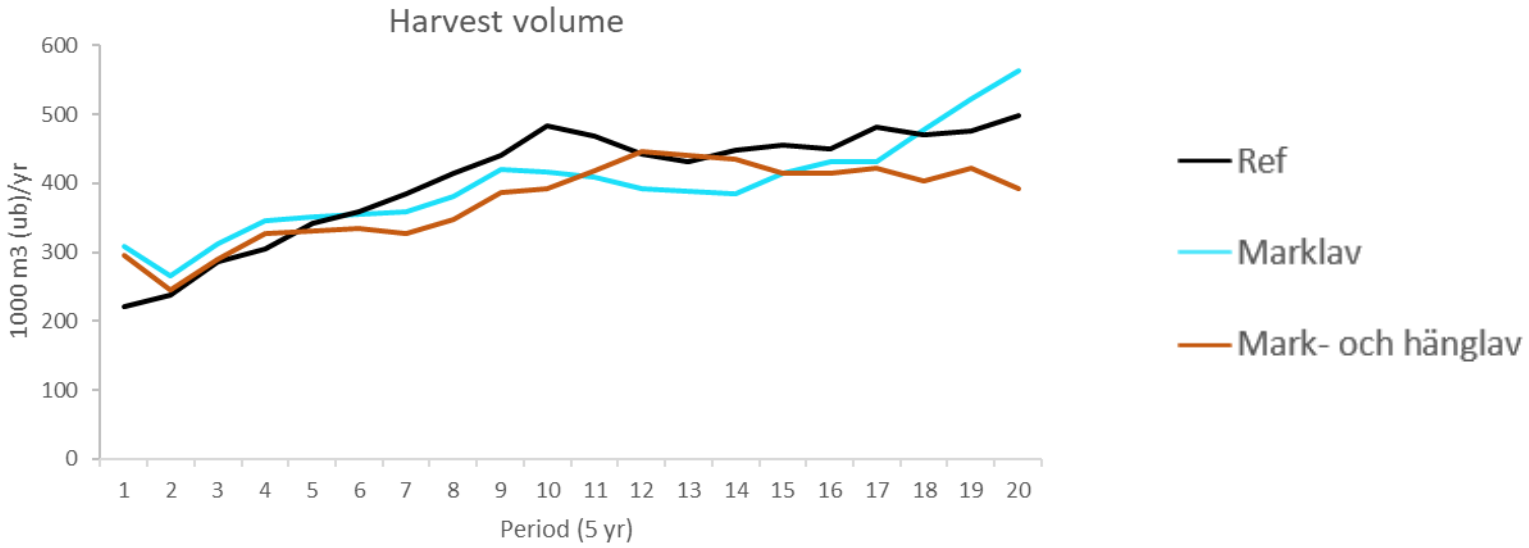
- Basal area under 18 m²/ha

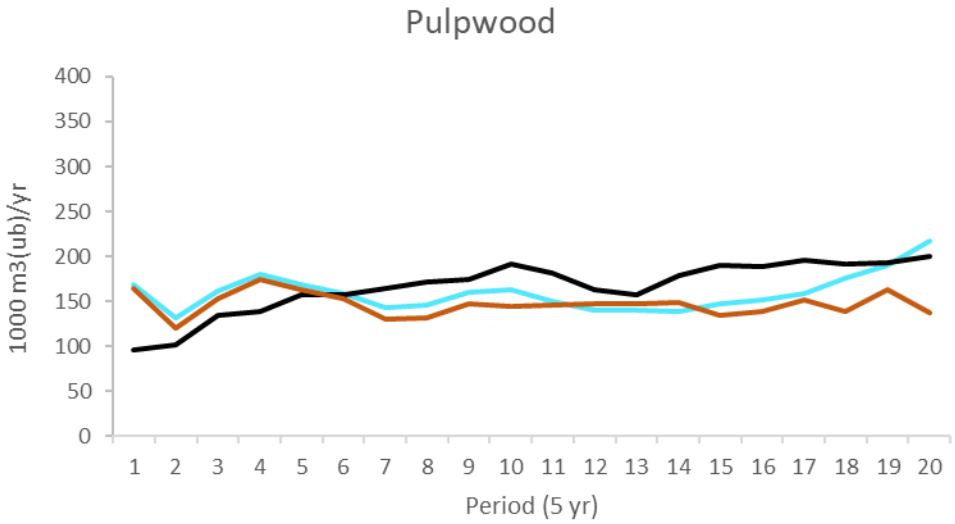
Forest with potential for arboreal lichen growth

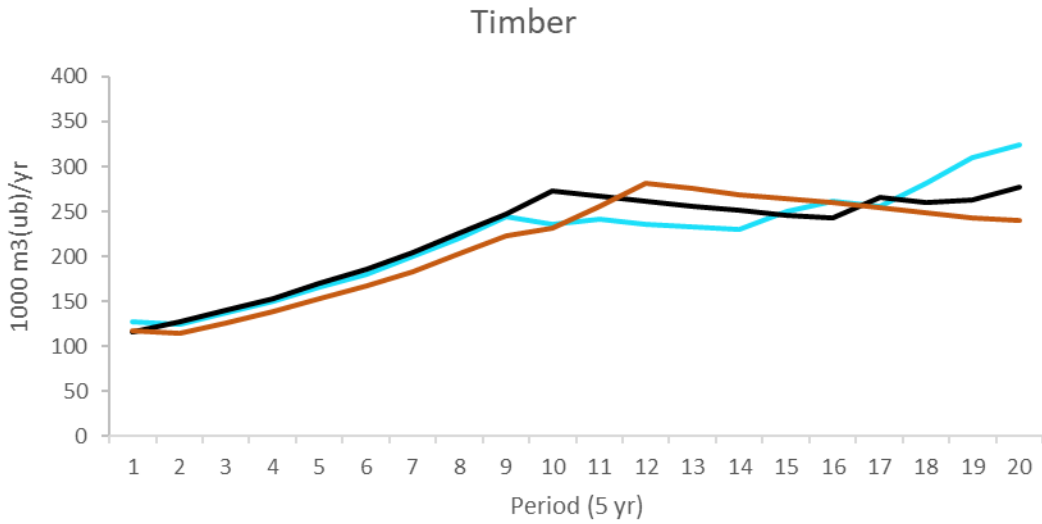


Age > 60 år &
Basal area > 18 m^2/ha

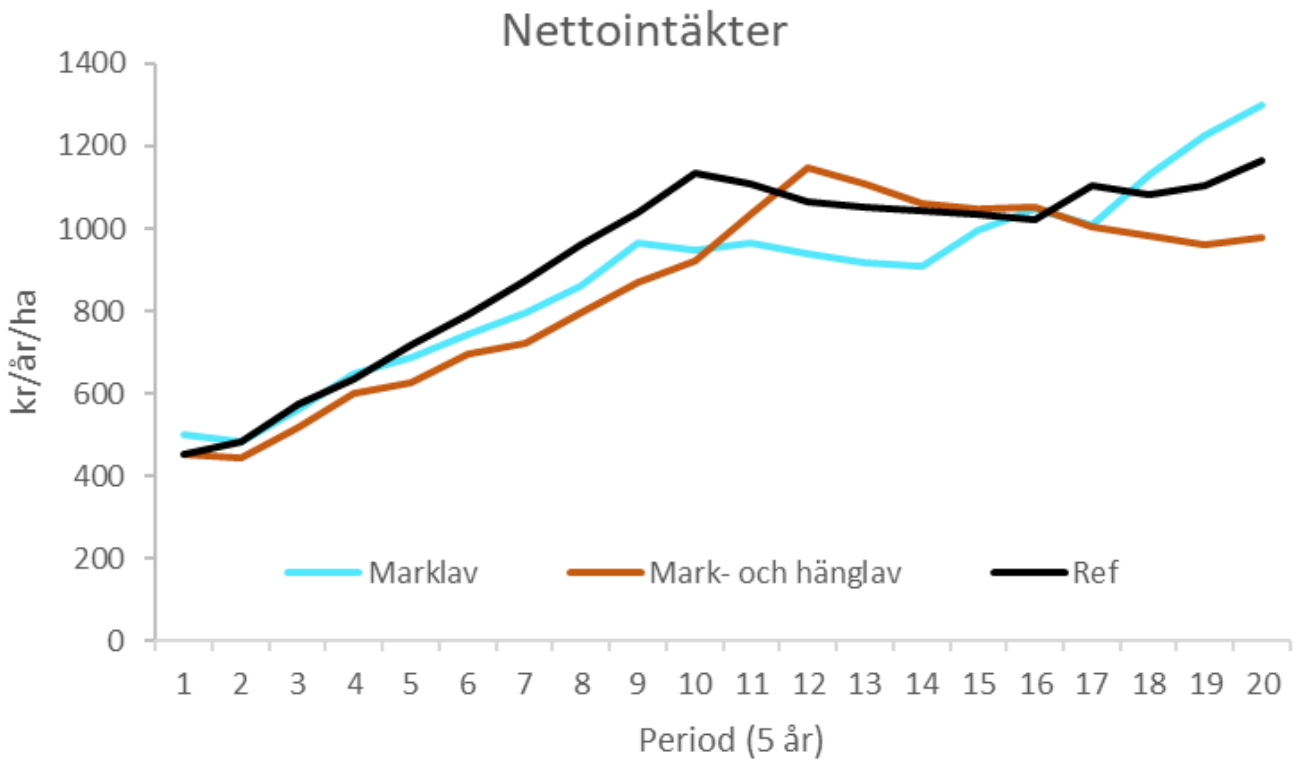
Harvest volume





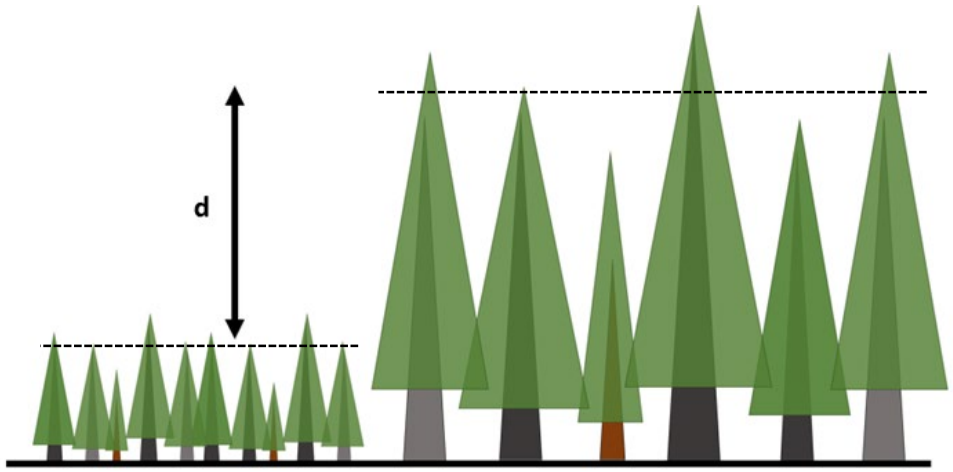


Economic analysis – Net revenues and net present value



	NPV (1000 kr/ha, discount rate 2.5 %)
Ref	33.5
Ground lichen	31.3 (94% of Ref)
Ground and arboreal lichen	30,6 (91% of Ref)

A model to reduce wind exposure in a forest property



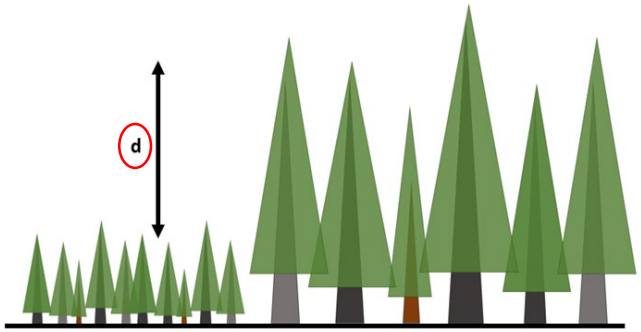
Minimization of forest edges in optimization

1. Identify vulnerable forest edges based on a user defined d value.
2. Minimize the length of the identified edges.

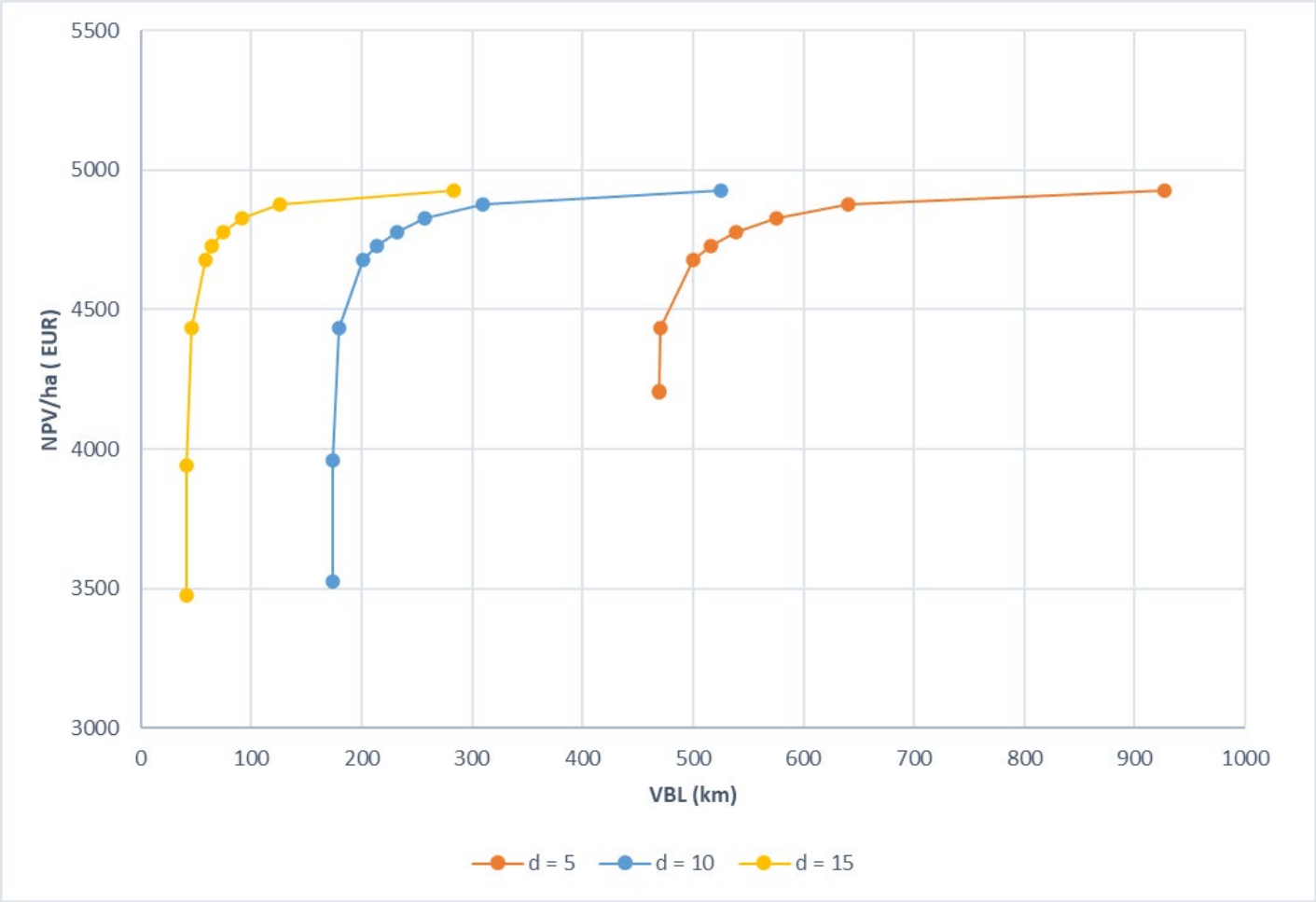
d value : maximum height difference allowed between two stands to consider the forest edge vulnerable or not.

López-Andújar Fustel et al 2021, Forest Ecology and Management

Trade-off between forest edges and NPV

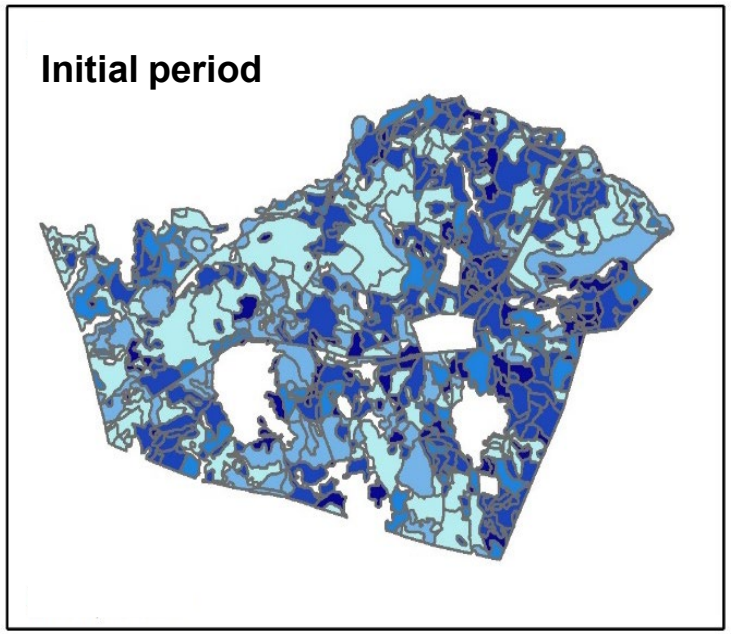


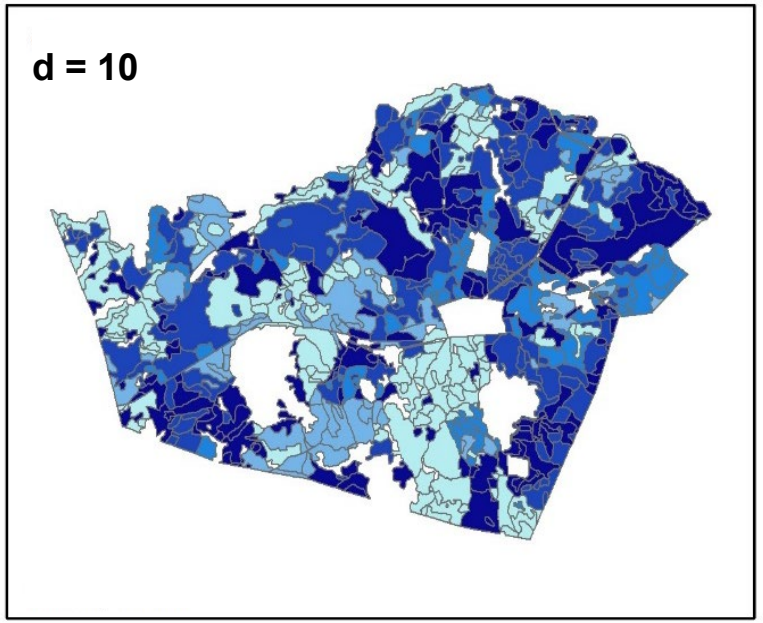
Minimization of vulnerable perimeter

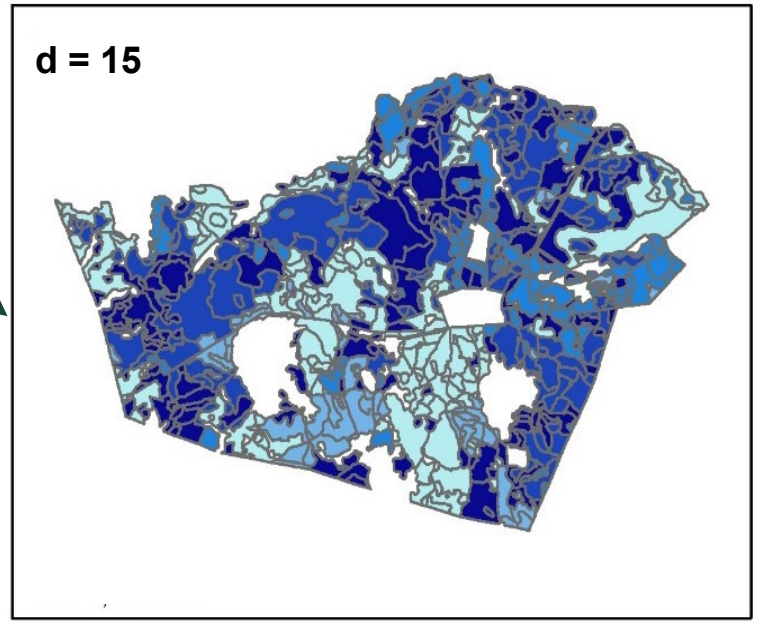


Distribution of dominant heights

After 70 years





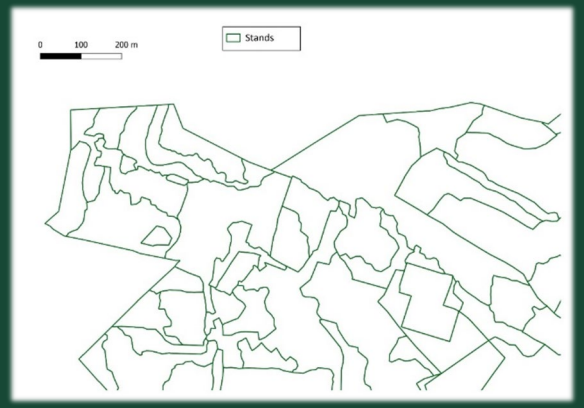


Dominant height (m)

0,0 - 5,0 | 5,1 - 10,0 | 10,1 - 15,0 | 15,1 - 20,0 | 20,1 - 33,5

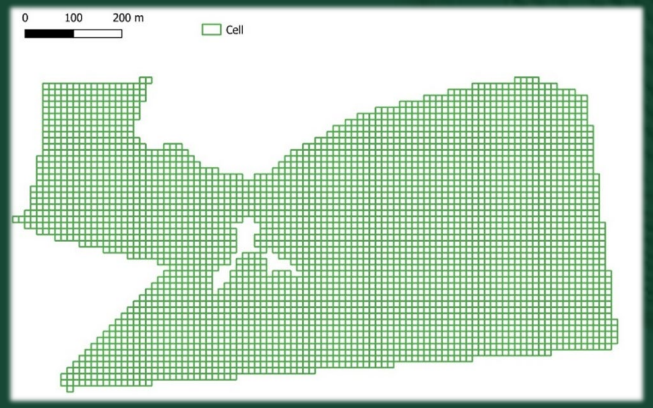
Dynamic treatment units in forest planning using cell proximity

Stand approach planning



- Stands (1-20 ha) smallest unit for modelling treatments & forest development
- Low spatial resolution
- No clustering of treatments needed
- Linear programming
- Simple problems, fast & powerful solving

DTU approach planning



- Pixels (0,015 ha) smallest unit for modelling future forest state
- High spatial resolution
- Clustering of treatments is a must
- Mixed integer programming
- Complex problems, slow solving

Wilhelmsson et al. 2021. Dynamic treatment units in forest planning using cell proximity.

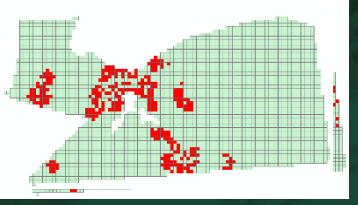
Aim & case study

Aim: present an exact solution method for DTU planning. The model aims to provide better flexibility by regarding not only immediately adjacent pixels as neighbors but rather nearby, within a specified distance

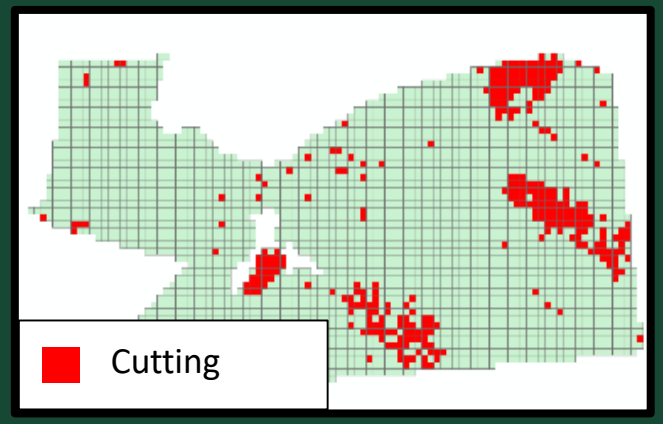
The DTU planning model decides future forest management for a 55 ha forest estate, with different degrees of clustering.

We map the treatments and apply a fixed cost to each treatment unit (with an underlying assumption on how treatment units may be formed). The performance of the model is measured in net present value from future forestry

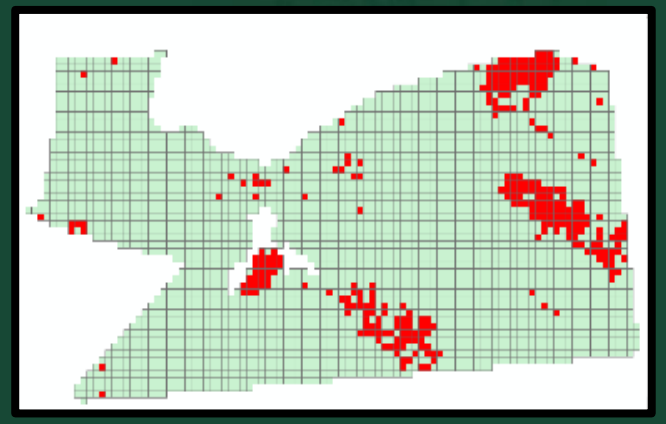
Wilhelmsson et al. 2021. Dynamic treatment units in forest planning using cell proximity.



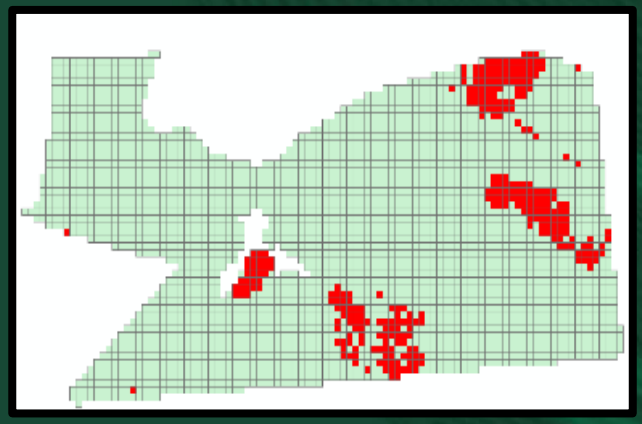
Brief results



Alternative A



Alternative B



Alternative C

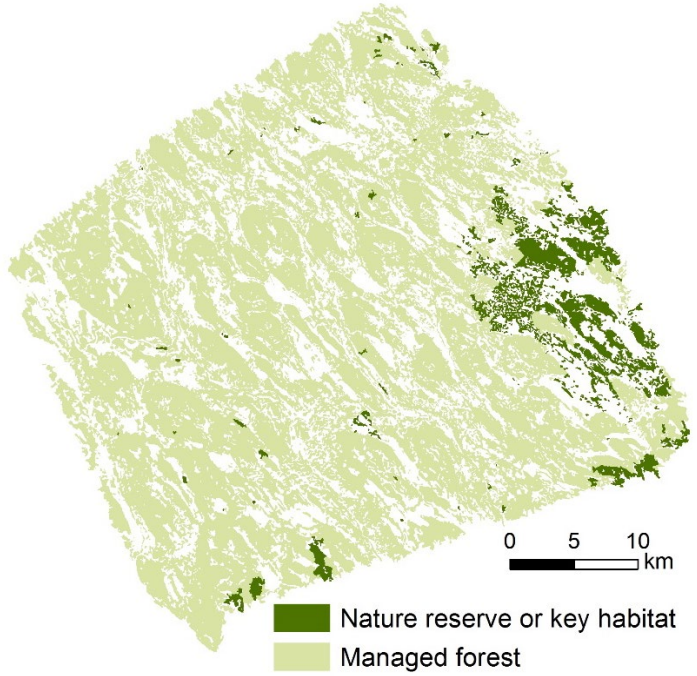
Higher degree of clustering

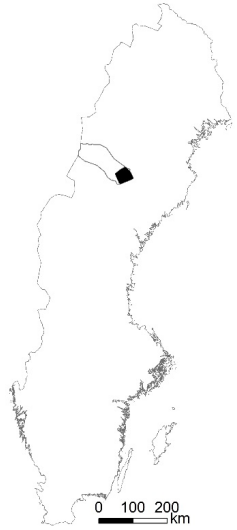
Higher net present value when including entry costs

Longer time needed to solve the problem

Wilhelmsson et al. 2021. Dynamic treatment units in forest planning using cell proximity.

Stakeholder scenarios

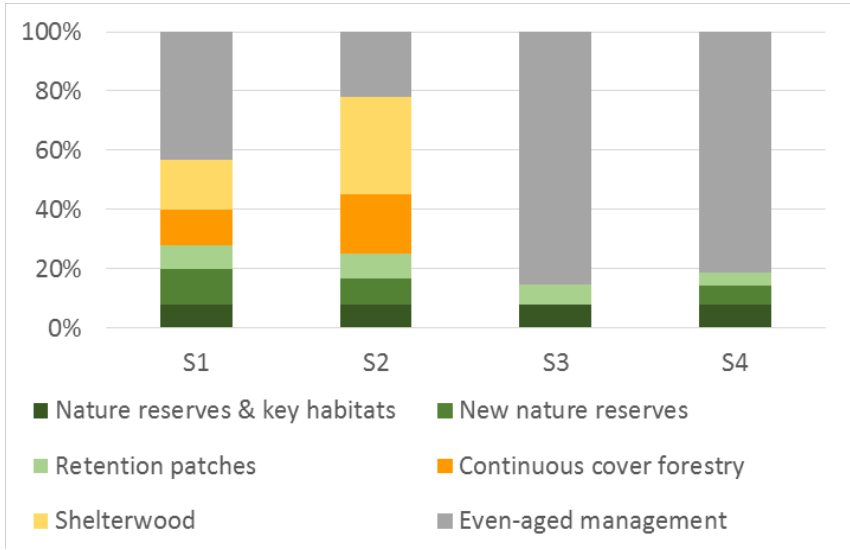




- Stakeholders formulated a forest management scenario & management objectives
- How well do the scenarios meet environmental & economic targets?

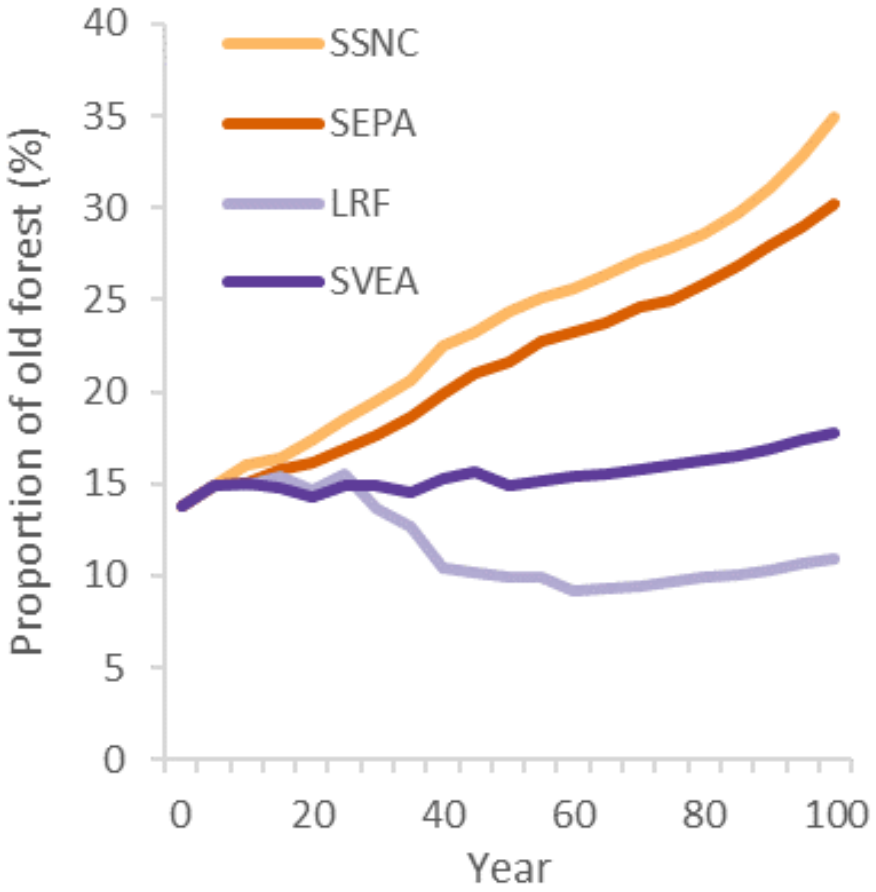
Eggers et al 2020, *Forests*

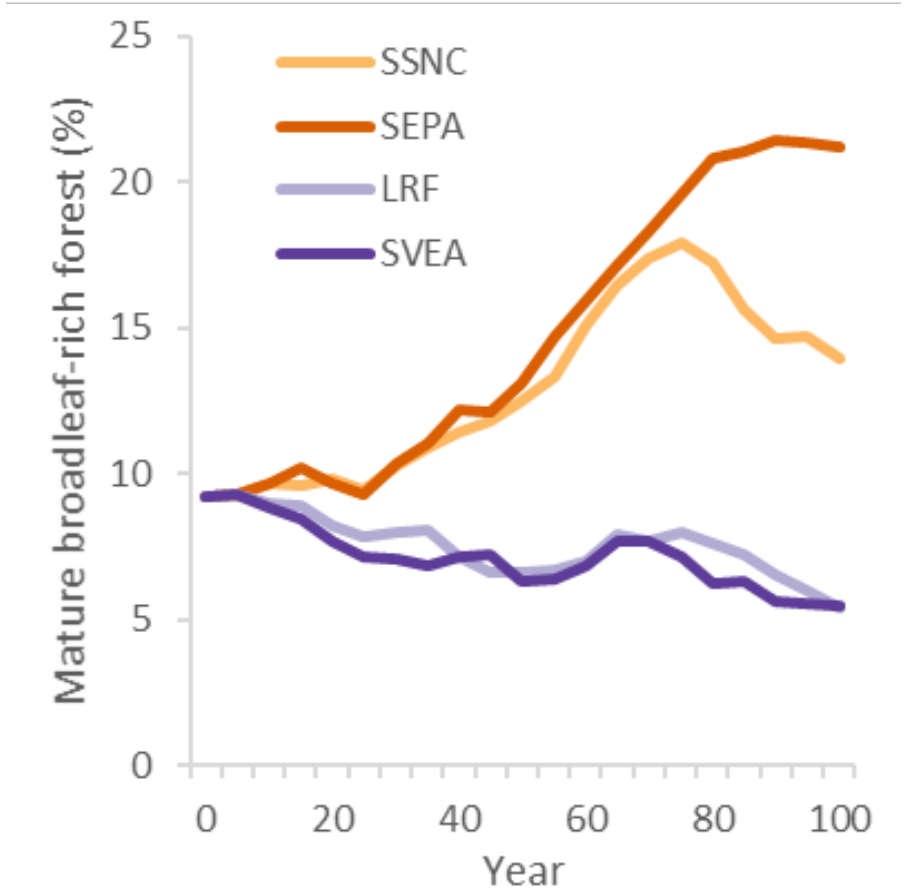
Forest management



Targets for

- Forest area under different management regimes (even-aged, uneven-aged, protected)
- Old forest area
- Share of broadleaves
- Deadwood volumes
- Evenness of harvest volumes


Proportion of old forest (%)
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Year
SSNC
SEPA
LRF
SVEA


Mature broadleaf-rich forest (%)
25
20
15
10
5
0
0
20
40
60
80
100
Year
SSNC
SEPA
LRF
SVEA

Buffer zones

- Fixed width versus dynamic (based on depth to water)
- Accounting for hot spots (small areas with high species richness and where important and sensitive biogeochemical processes are happening, Kuglerová *et al*. 2014. *Ecology)*

Results

- A buffer zone based on DTW-maps provides better protection and is cheaper compared to a buffer zone with a fixed width
- Protecting hotspots is very cost-effective since they cover a small area and host a lot of important species and functions

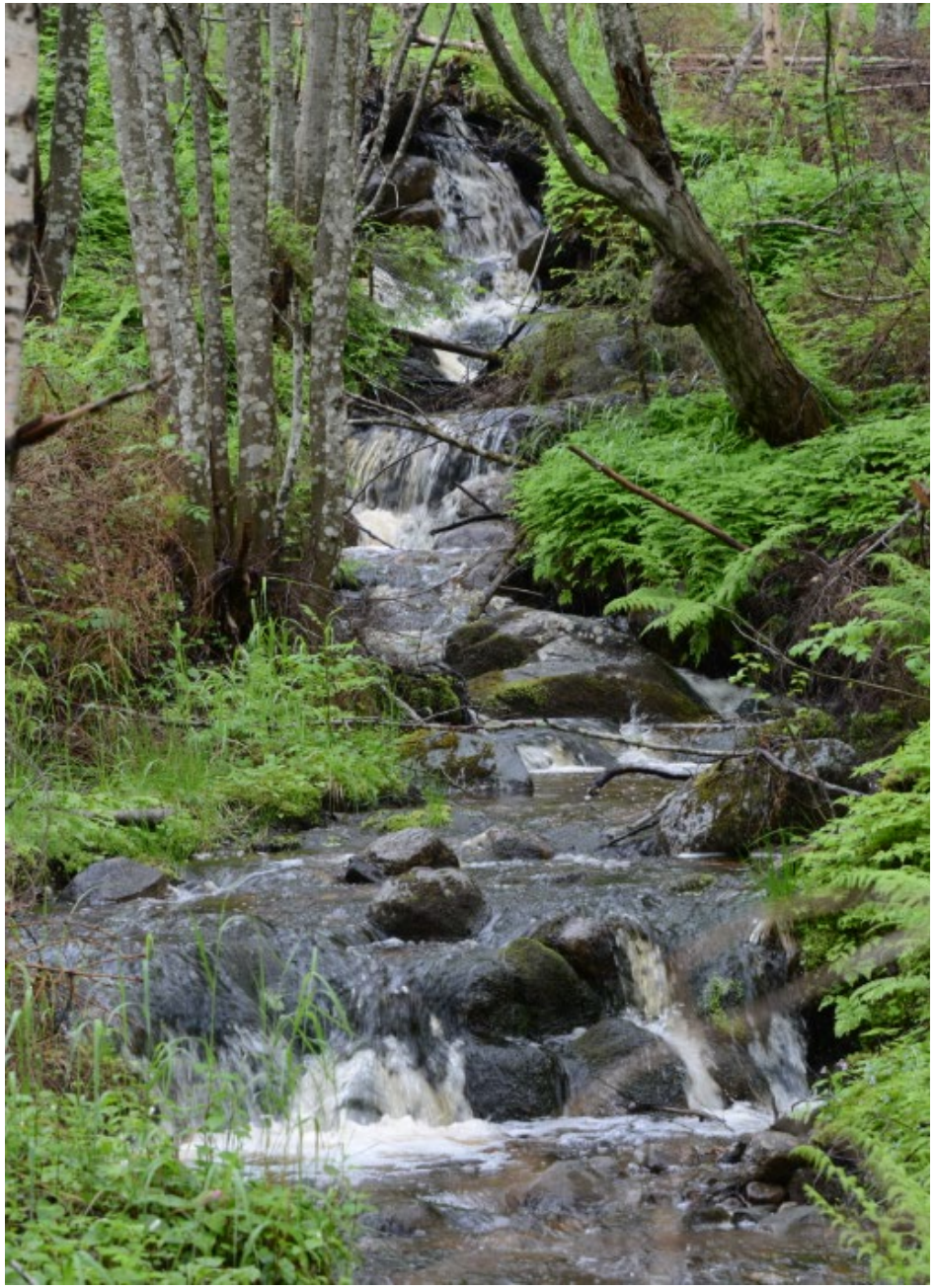


Photo: T. Lämås

Tiwari *et al*. 2016. *Water Resources research*

Thank you!

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https://www.slu.se/en/departments/forest-resource-management/program-project/forest-sustainability-analysis/contact/

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