



# Vulnerability assessment of ecosystem services and adaptive management options in Austrian mountain forests under climate change



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# Mountain forest ecosystem services



Photo: Fgarrel



Photo: Bayer. Forstverwaltung



Photo: Claude Morerod



Photo: ÖBf



Photo: die wildbach



Photo: Stand Montafon



Photo: WSL



Photo: ÖBf



# Stakeholders & ecosystem services

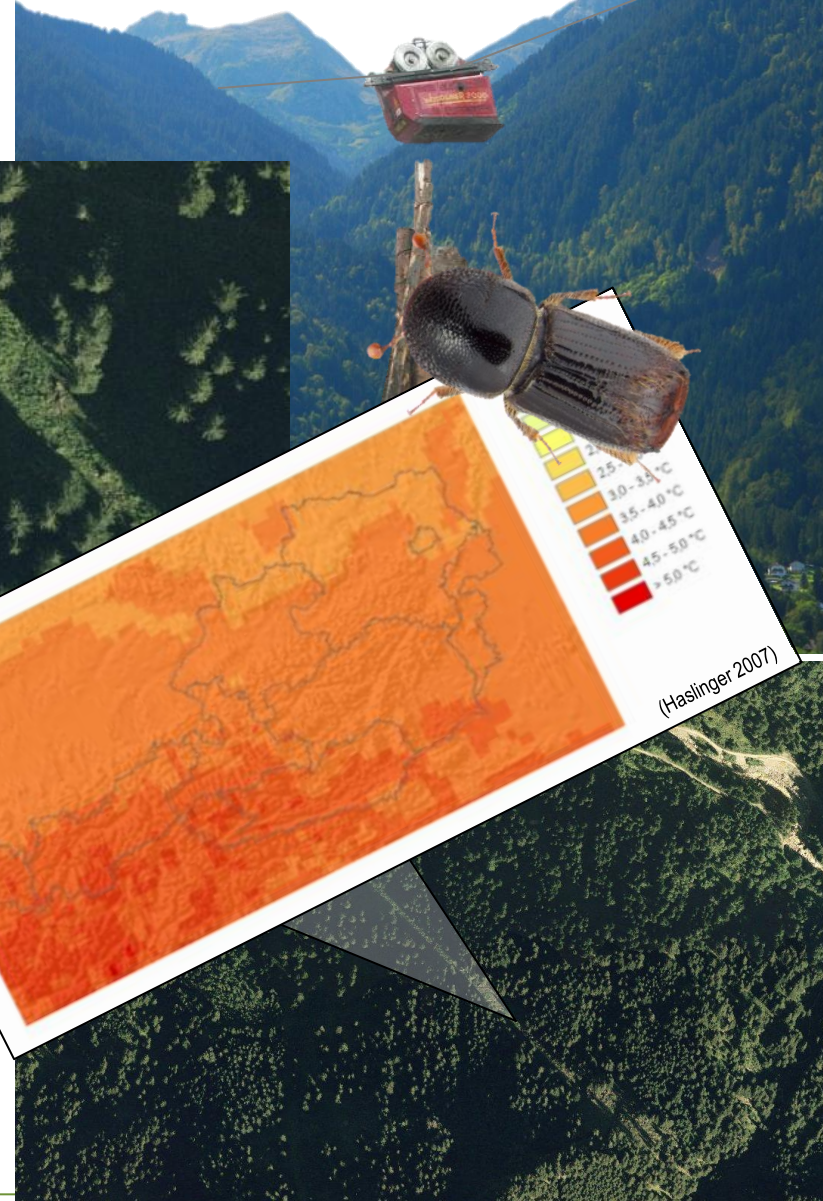
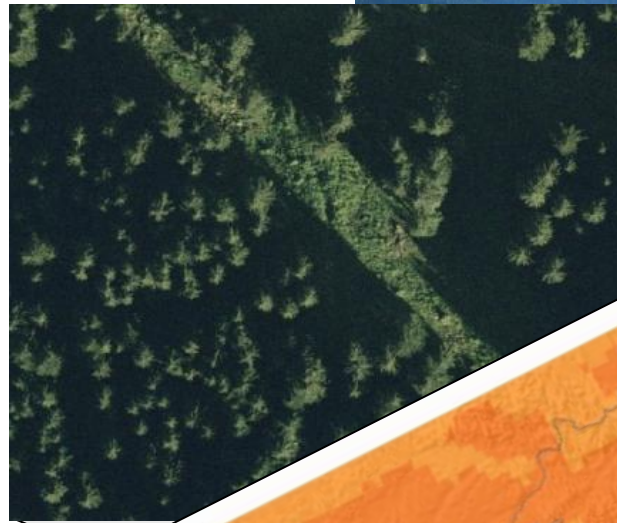
- Complex/ challenging stakeholder setting
- Internal SH
  - Stand Montafon Forstfonds
- External SH
  - Forest administration service
  - Federal service for torrent and avalanche control
  - Regional hunting cooperatives
  - Illwerke hydropower company
  - Local sawmills
  - Local citizens
  - Tourism industry
- Face to face interviews





# Business as usual mountain forest management

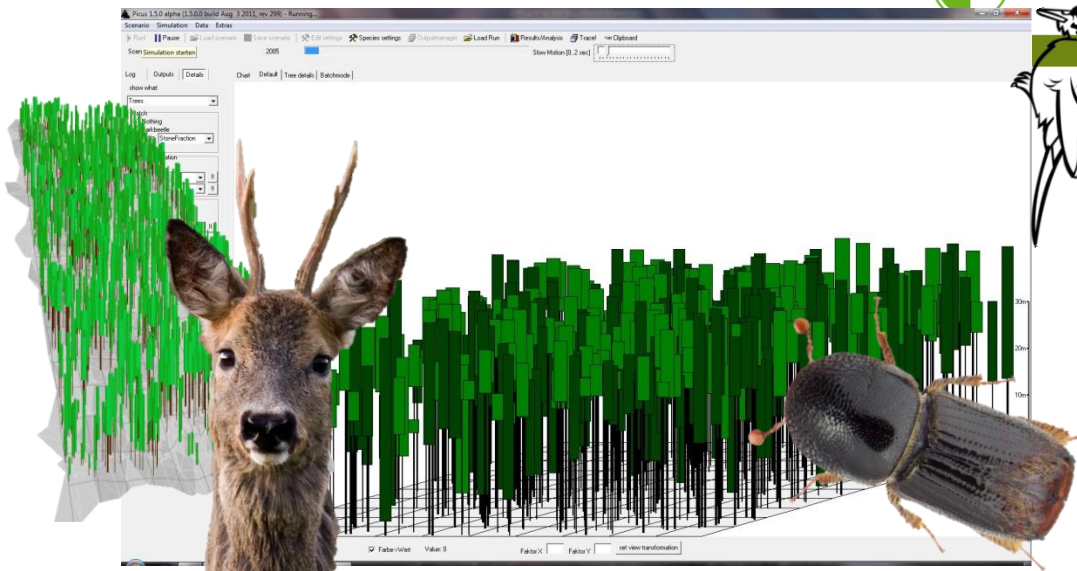
- Picea abies dominated forests (96%)
- Difficult terrain conditions
  - long distance cable yarding with skyline systems
  - crossing multiple stands on a slope
  - irregularly shaped skyline track
  - motor-manual harvesting and cut to length yarding
  - natural regeneration
- **Is BAU mountain forest management able to maintain forest ES under climate change?**





# PICUS v1.5

- Hybrid forest gap model
- Based on individual trees on 10 x 10 m patches
- Driven by G, M, R
- Disturbance sub-modules
- Model requirements



Stand and site data

Management

Climate scenarios

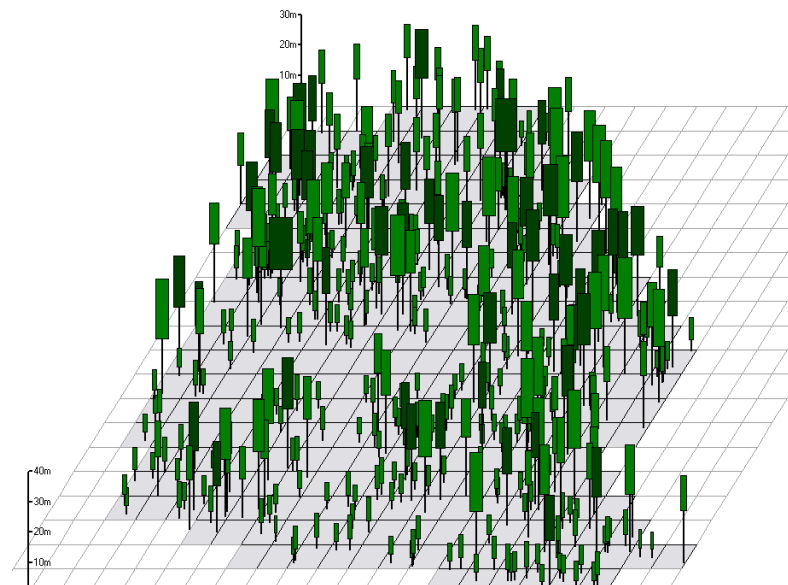
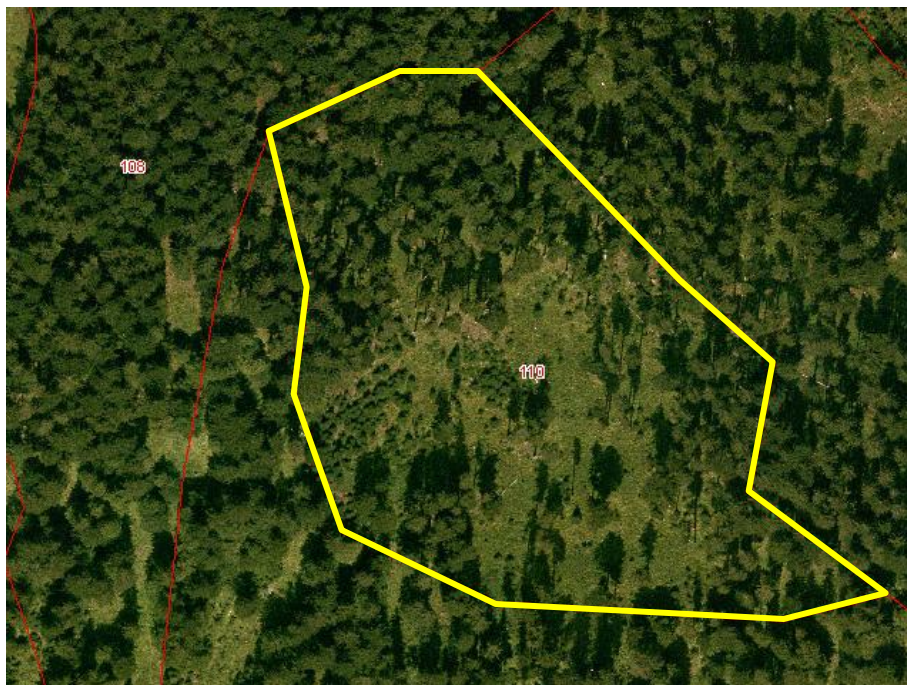
Growth

Mortality

Reproduction



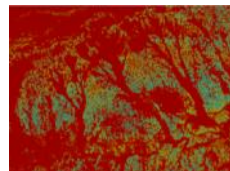
# Mountain forest structure



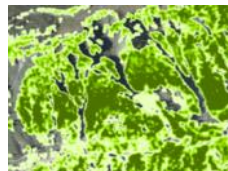
**Field data**



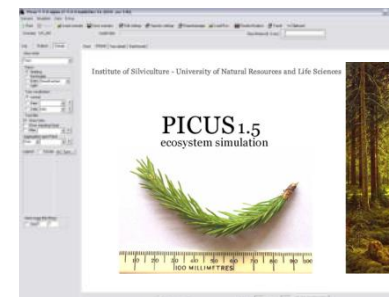
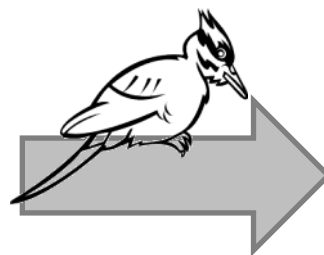
**nCM**



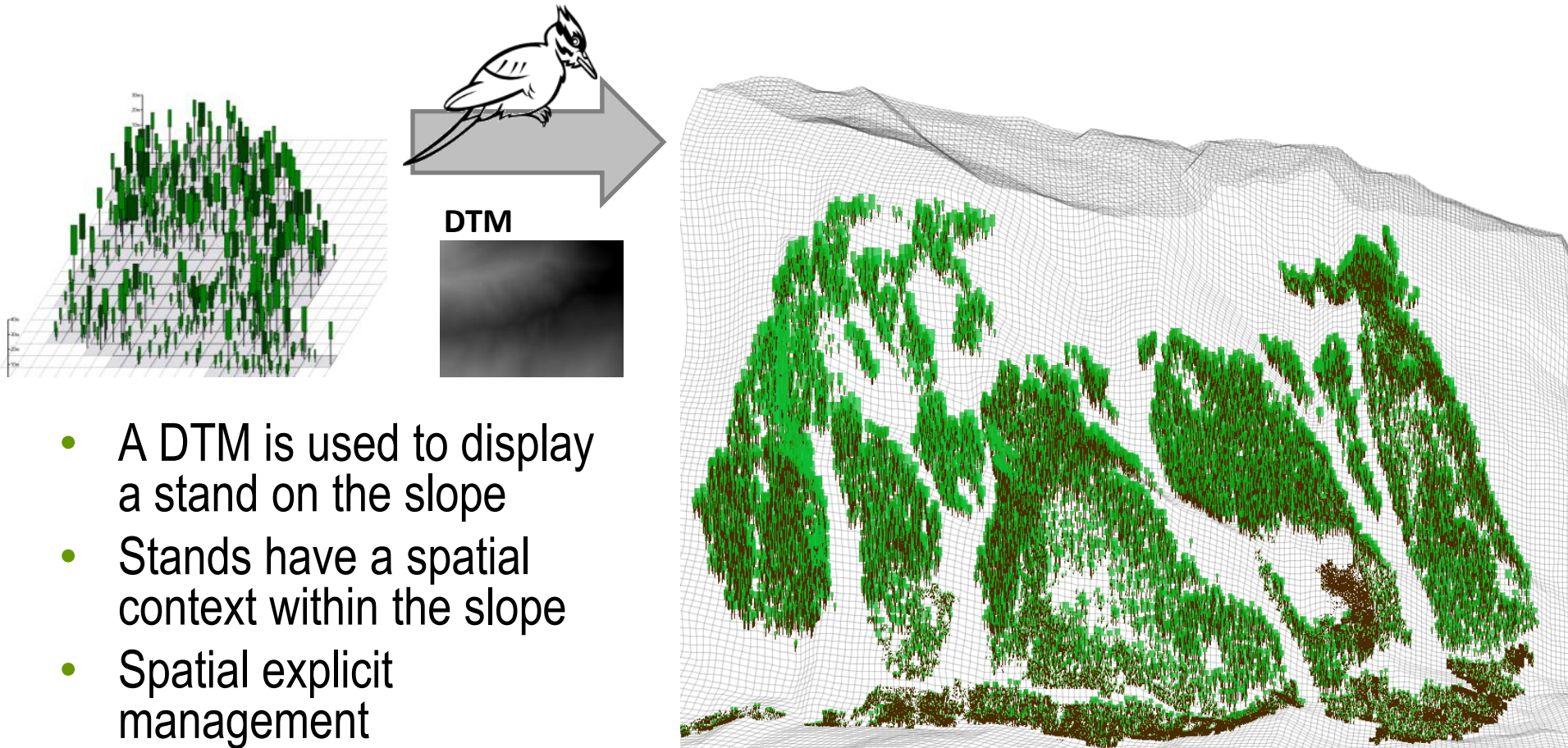
**Volume**



Hollaus et al. 2006; 2007



# From stand to slope

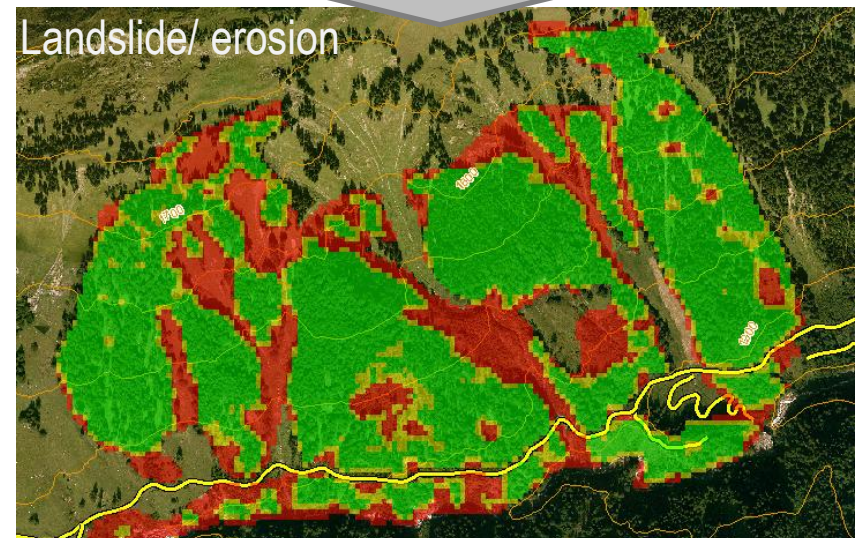
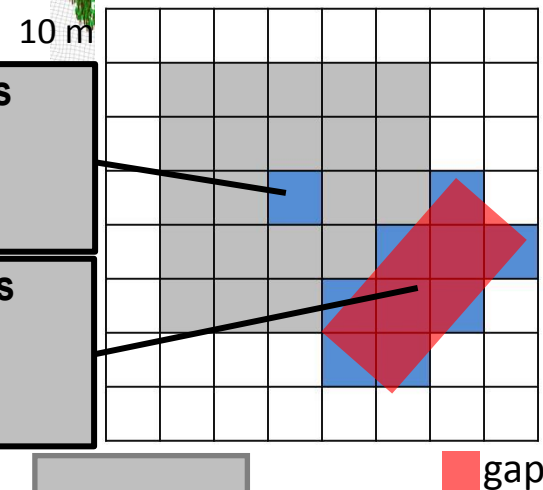
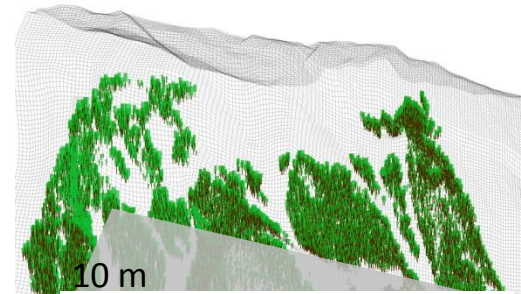


- A DTM is used to display a stand on the slope
- Stands have a spatial context within the slope
- Spatial explicit management
- Spatial explicit analysis of forest ES



# Spatially explicit ES assessment

- Concept adapted after Frehner et al. (2005) for protective function against gravitational natural hazards (snow avalanche, rock fall, landslide/erosion, flooding)
- Slope is analyzed in a 10 x 10 m resolution.
- Indicators:
  - Stem number
  - Crown cover
  - Gap length/ size
- Results in three categories:
  - requirements not met (red),
  - minimal requirements met (yellow),
  - ideal requirements met (green)

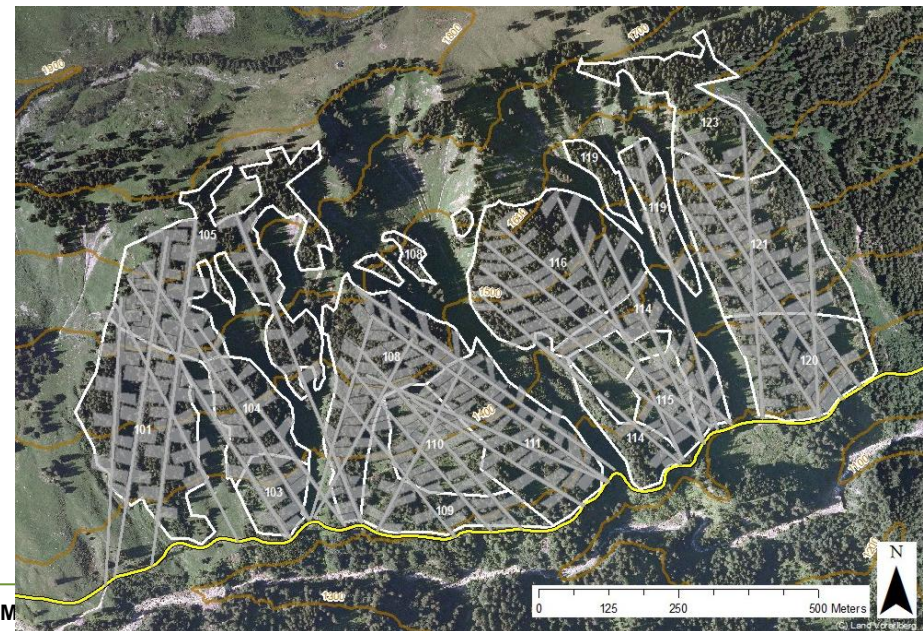
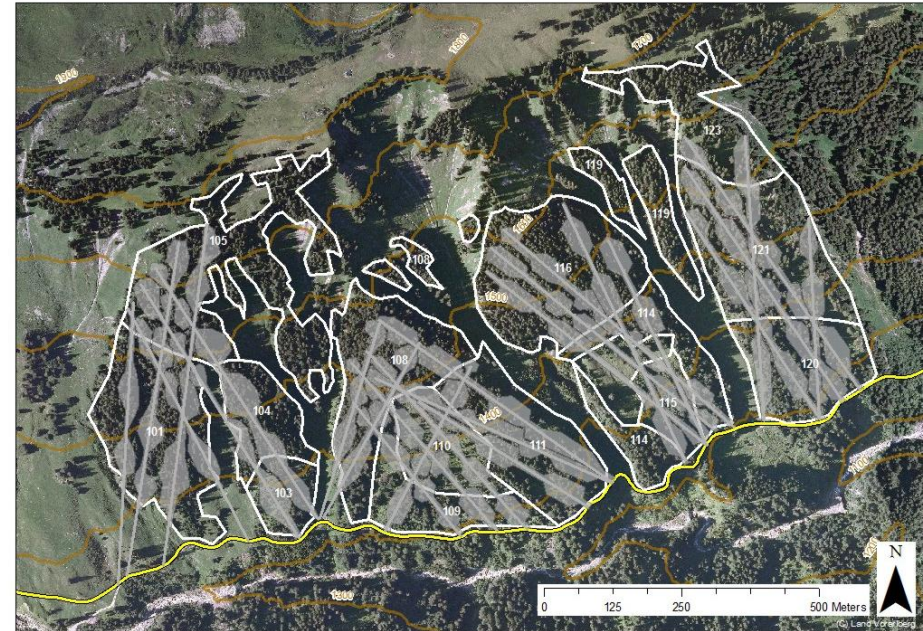


Hazard	Landslide, erosion	
Indicator	Gap area	Crown cover
Not met	> 600 m <sup>2</sup>	< 40 %
Minimal	≤ 600 m <sup>2</sup>	≥ 40 %
Ideal	≤ 400 m <sup>2</sup>	≥ 60 %



# Application

- 70 ha forests in a network of gullies and avalanche tracks
- 1160 to 1820 m a.s.l.
- Uneven-aged Norway spruce dominated stands
- Important road to hydro power plant threatened by snow avalanches and landslides
- Simulations until 2100
- 2 contrasting management scenarios
  - **BAU:** irregularly shaped slit cuts, natural regeneration, low management intensity
  - **AM:** fishbone shaped slit cuts, natural regeneration with 25% artificial regeneration of *Larix decidua*, higher management intensity

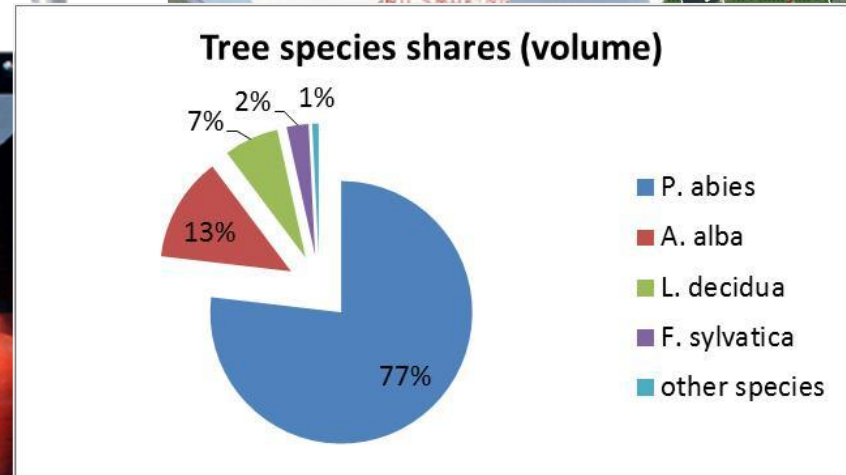
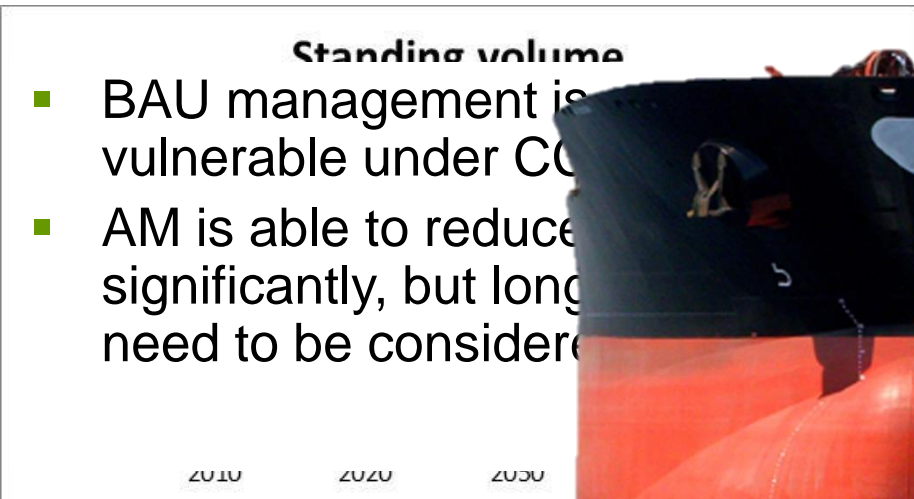
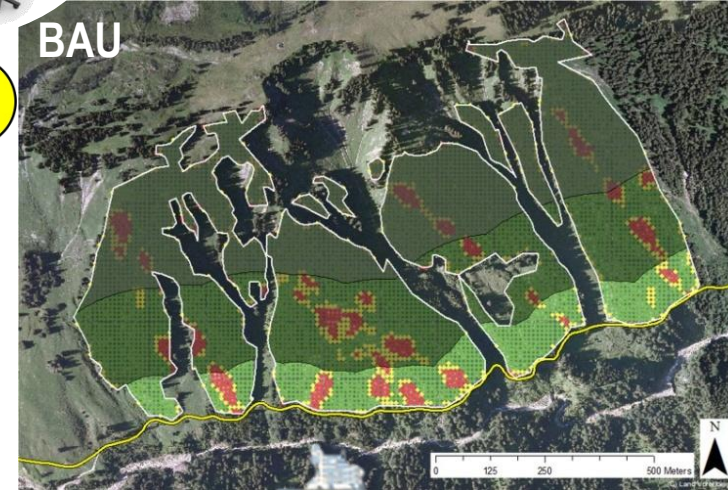




# Results



- Bark beetle damages increase up to 500% under A1B. AM performs slightly better than BAU.
- Worst case scenario A1B.
- Significantly better protection against landslides/ erosion under AM.
- Significantly better protection against snow avalanches under AM.
- 17% more harvested timber under AM.
- Standing volume increases under both management scenarios but less under AM.







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**Thank you for your attention!**

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