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Global Change Impacts on Avalanche Protective Forests: What Do We Know and Where Do We Grow from Here?

Michaela Teich

Organizers:

Wildbach- und Lawinenverbauung Forsttechnischer Dienst

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congress messe INNSBRUCK

Protective forests reduce avalanche risk

"A protective [protection] forest is a forest that has as its primary function the protection of people or assets against the impacts of natural hazards […]."

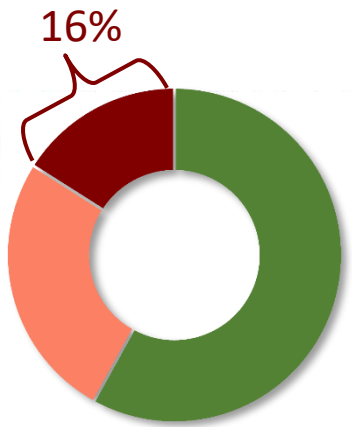
Brang et al., 2001

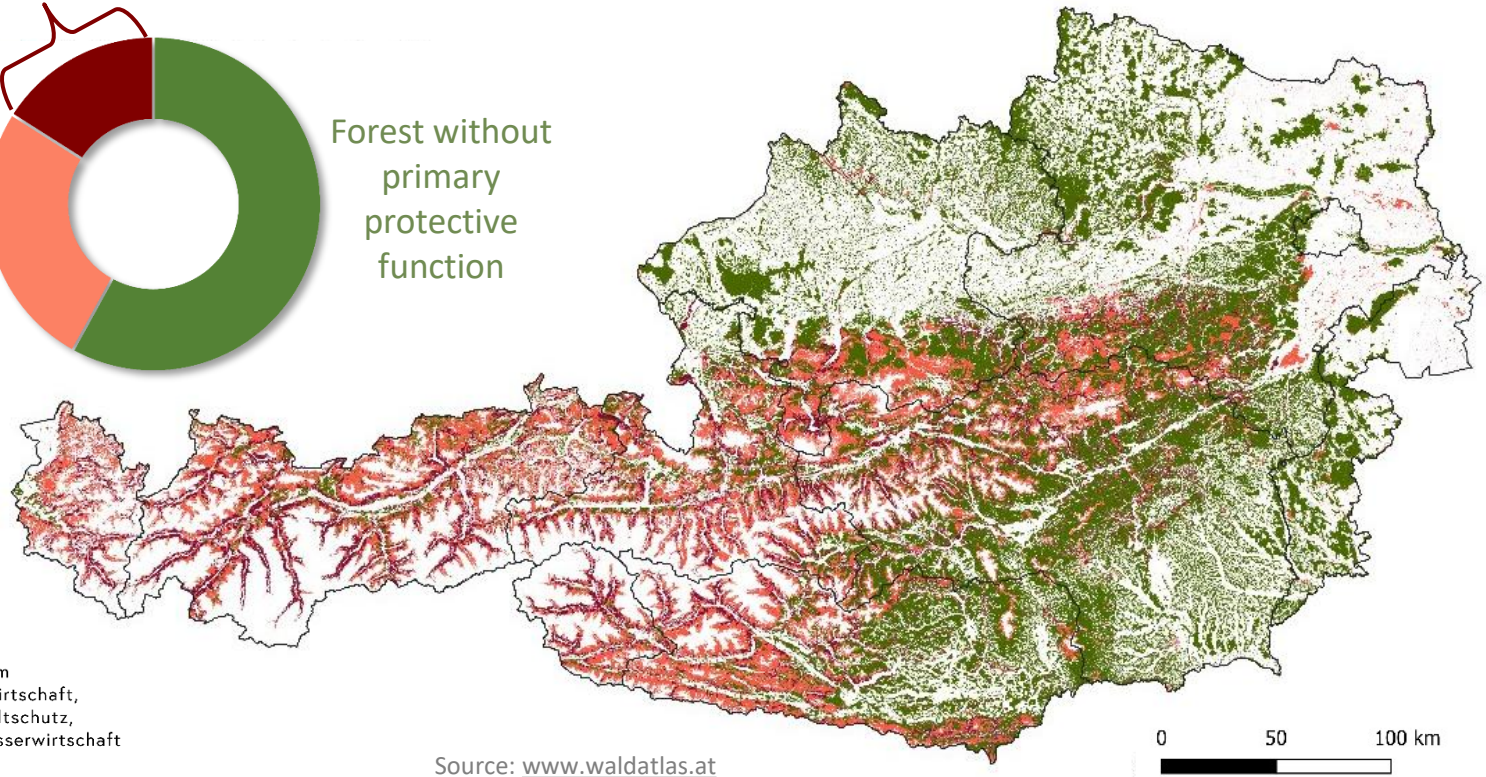
Veneto region, Italy; 05/2024

Photo: M. Teich

Protective forest cover in Austria

42% potential protective forest area (based on scientific criteria)





Source: www.waldatlas.at

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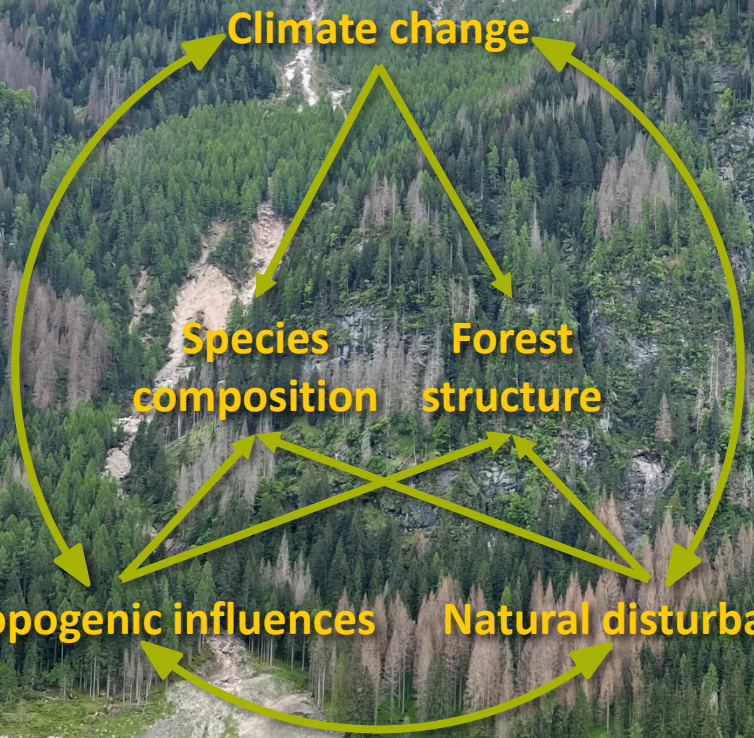
Protective forests are under pressure



Global change impacts on PROTECTIVE EFFECTS: what does science say?

Veneto region, Italy; 05/2024

Illustration adapted from: Bottero al. 2024

Photo: M. Teich

Global change impacts on avalanche protective forests: what does science say?

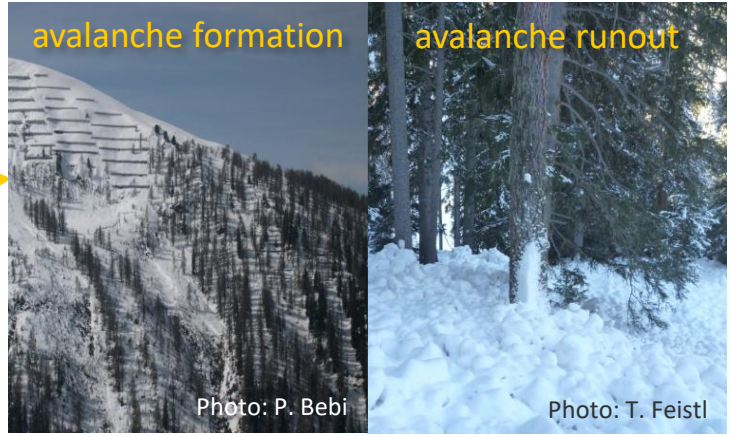
Literature review

Clarivate Web of Science™ | Google Scholar

Protective forest	forest* OR “protection forest” OR “ forest” OR “Eco-DRR” OR Natu olution
Global change	“clim ge” OR “global change” OR change OR ught OR disturbance OR future OR evolution OR “forest dynamics” OR “ecosystem dynamics” OR “dynamic” OR development*
Protective service	avalanche OR “snow avalanche” OR “risk reduction” OR “protective effect” OR “ function” OR “protection function” OR “protective capacity” OR “protective service” OR “protection service”

Forest change:

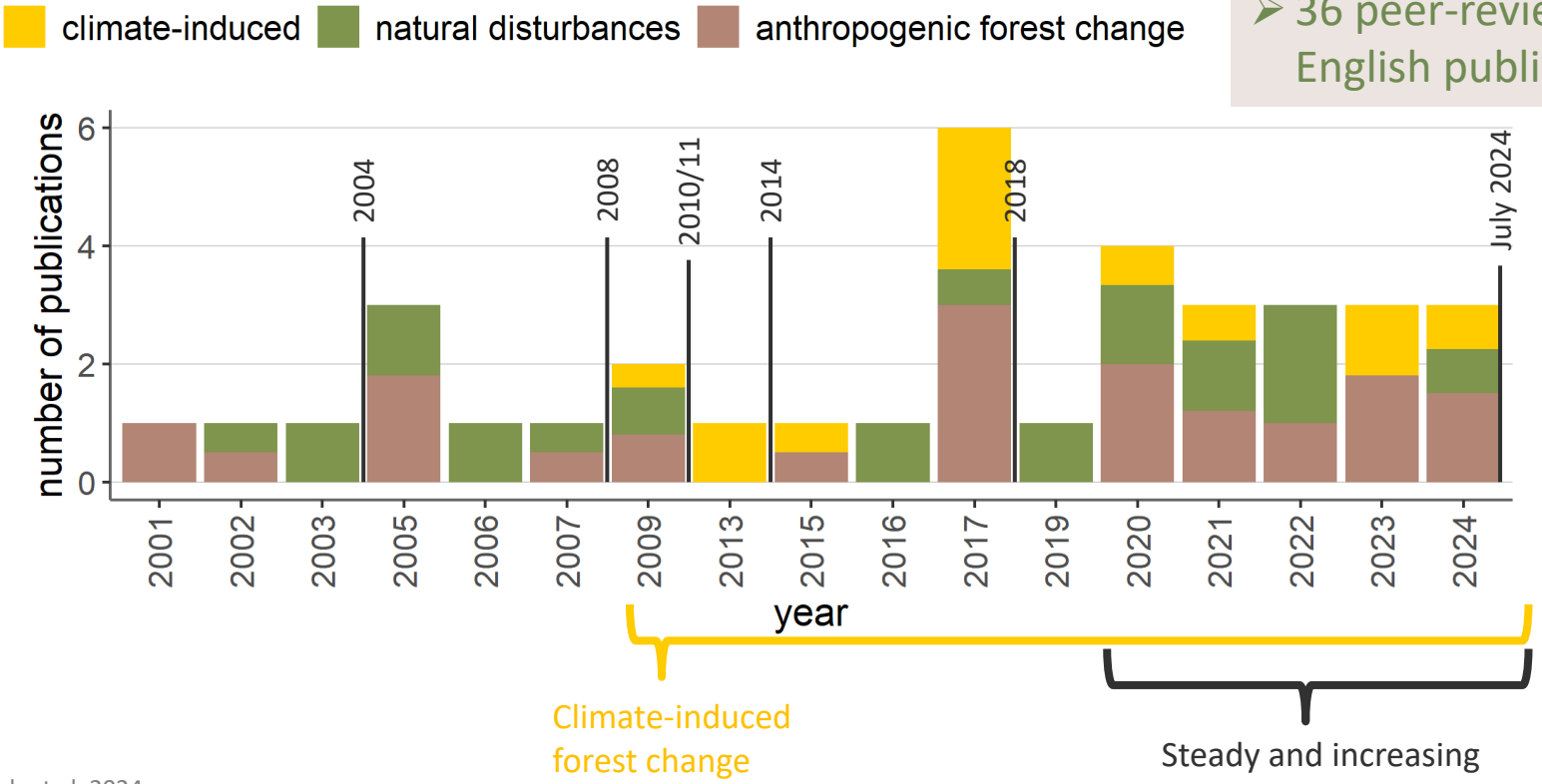
- climate-induced
- (changing) natural disturbance
- anthropogenic-driven
  (e.g., land-use change, management interventions)



Teich et al. 2024

Global change impacts on avalanche protective forests: what does science say?

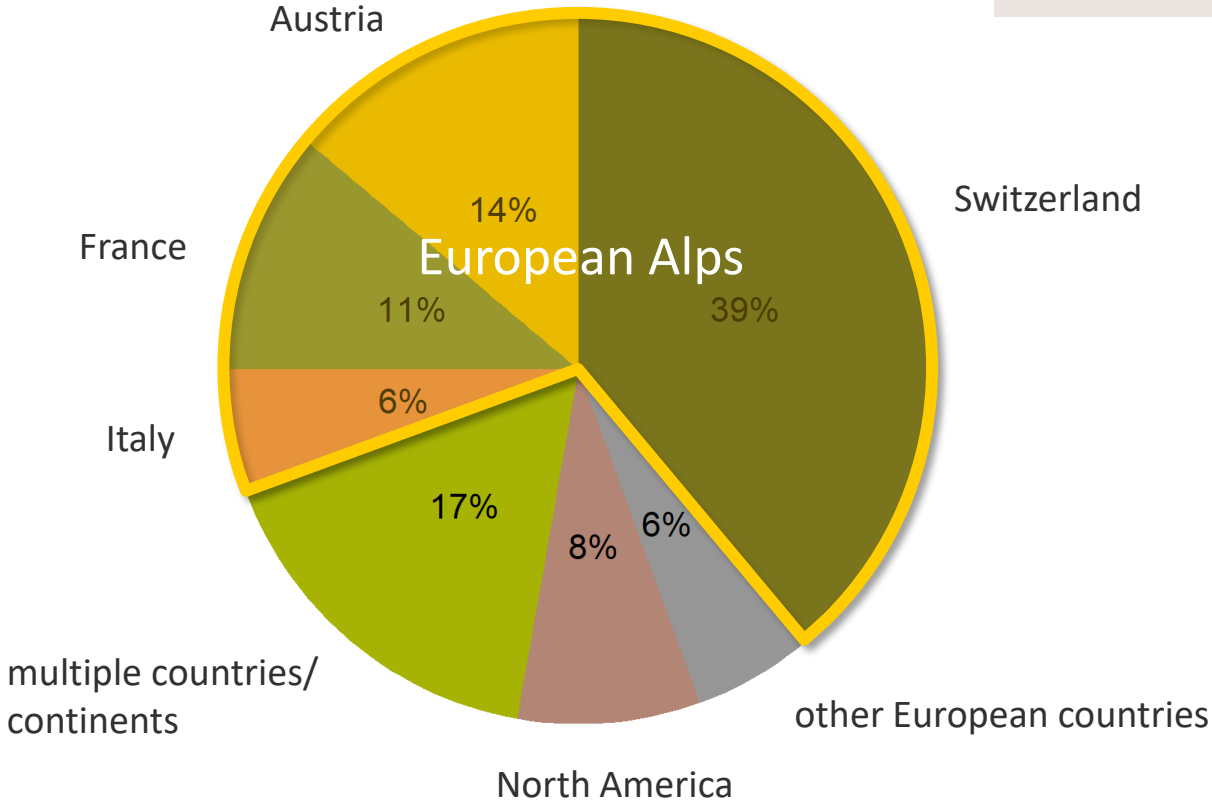
Not that much…
- 36 peer-reviewed English publications



Teich et al. 2024

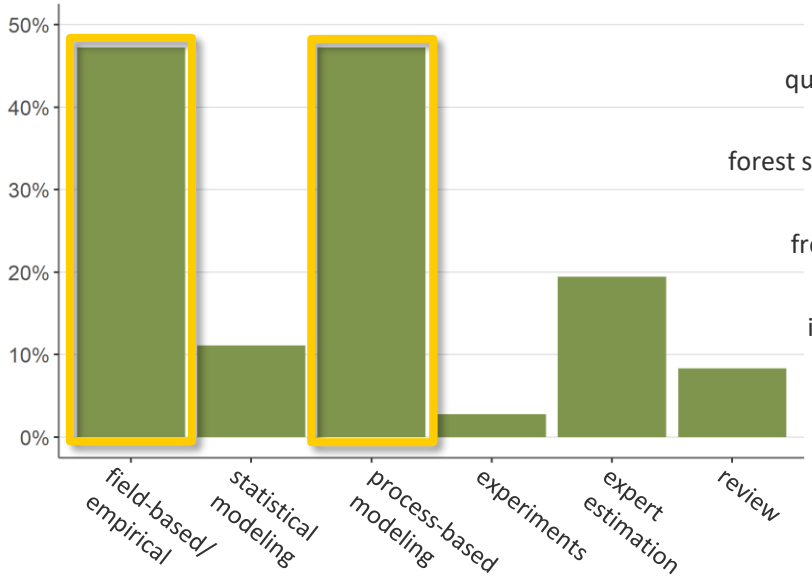
Global change impacts on avalanche protective forests: what does science say?

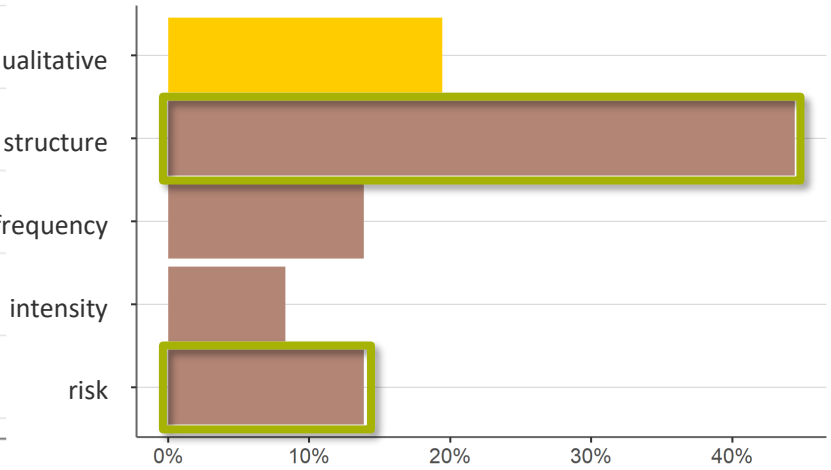
The research is not global.



Teich et al. 2024

Global change impacts on avalanche protective forests: what does science say?





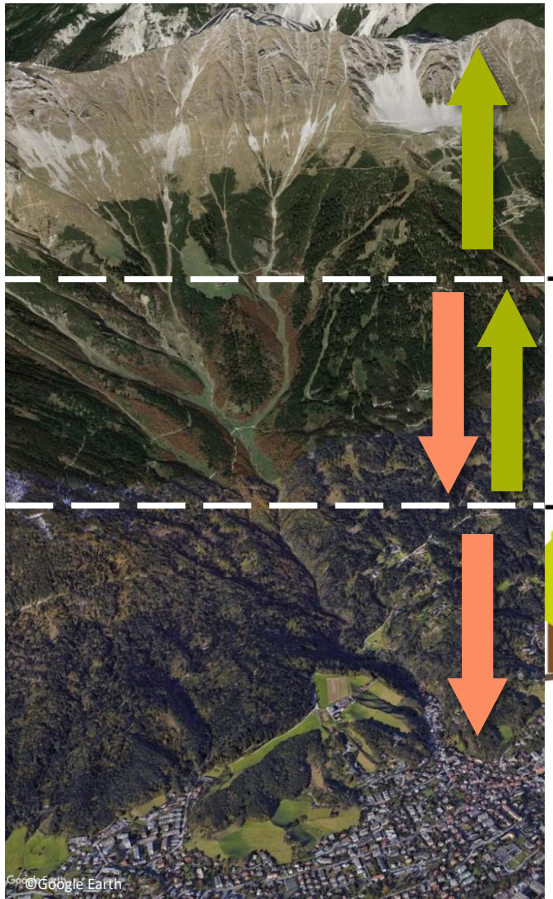
Methods:

- avalanche dynamics and forest simulation models were never combined

- 82% quantitative measures
- dimensionless protective forest indices
- only few studies considered risk

Teich et al. 2024

Climate-induced forest change: what does science say?



12 publications/
10 forest simulation studies:

It depends…

- on forest expansion and enhanced tree growth
- on local conditions and the climate scenario
- on drought, which decreases protective effects

Increasing natural disturbances counter-balance effects of enhanced tree growth!

Anthropogenic-driven forest change: what does science say?

18 publications:

It's not a clear-cut picture…

- deforestation generally has negative impacts
- re- and afforestation enhance protective effects
- but often don't occur where most needed

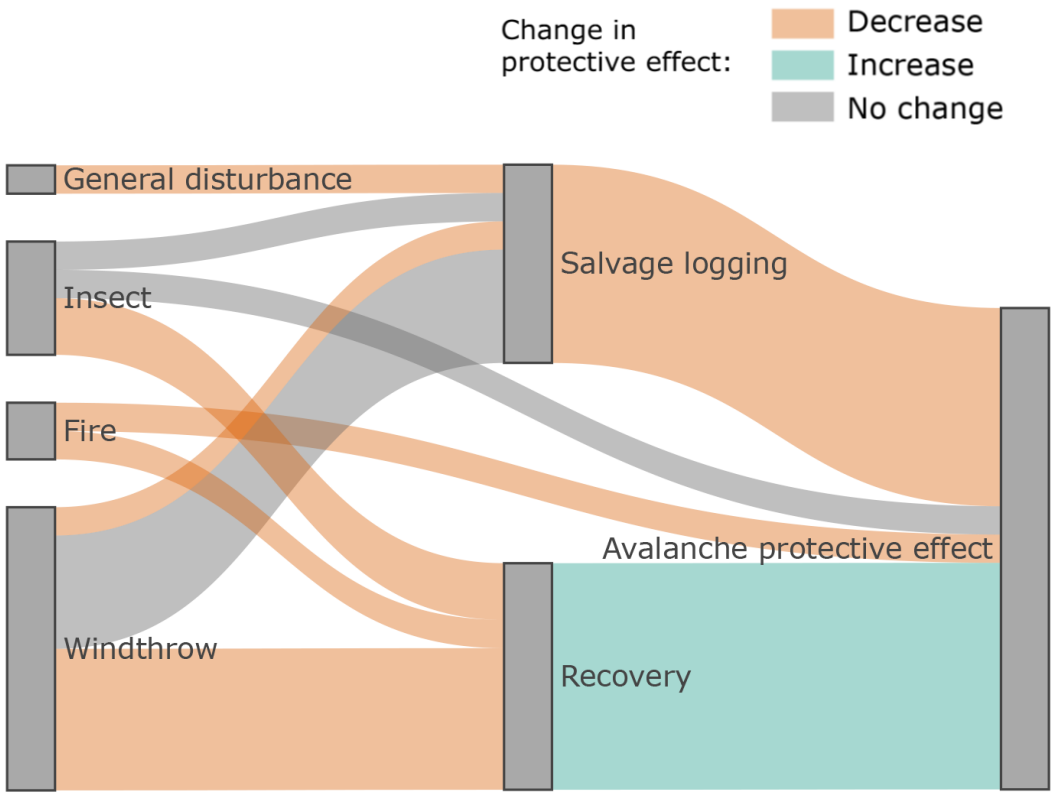
Regeneration cuts and thinning show varying effects under different climate scenarios…

- e.g., positive effects under no climate change
- but negative impacts increase as climate change intensifies

Interactions between climate change an anthropogenic influences are complex!

Teich et al. 2024

Natural disturbances: what does science say?

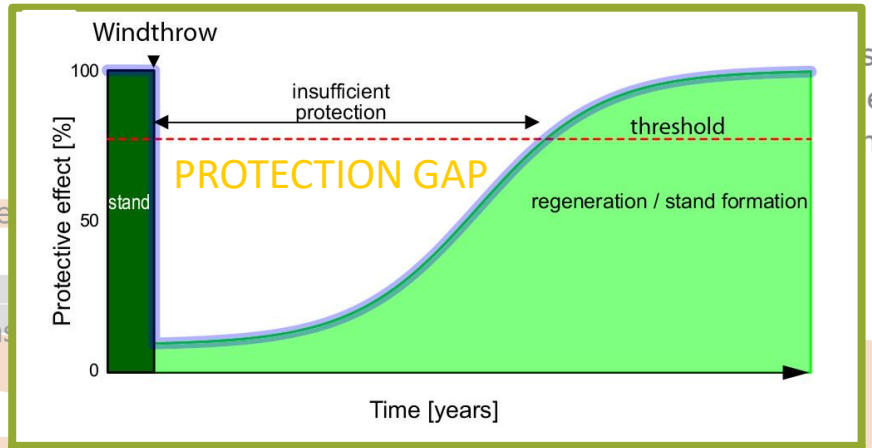


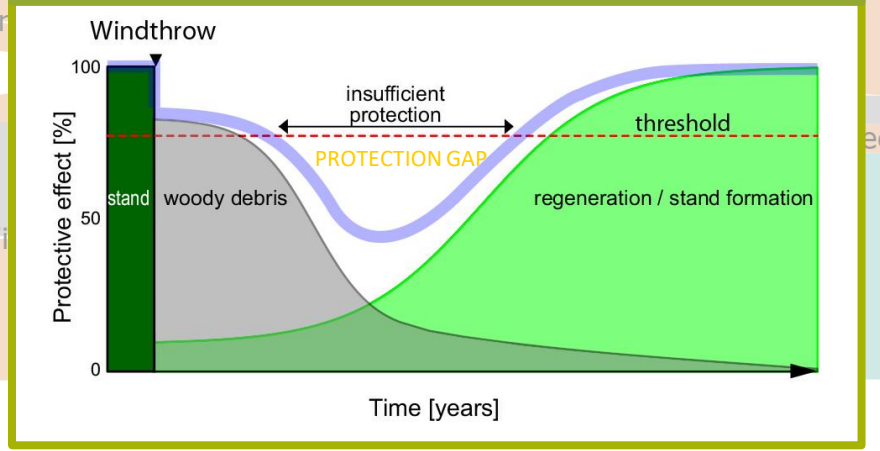
18 publications:

- natural disturbances often decrease protective effects
- management decisions influence post-disturbance protective effect

Teich et al. 2024

Natural disturbances: what does science say?





18 publications:

- natural disturbances often decrease protective effects
- management decisions influence post-disturbance protective effect

Post-disturbance management is key.

Figures: Wohlgemuth et al., 2017 (adapted)


Where do we grow from here?

Closing the gaps.

Protective effect of windthrow areas against snow avalanches

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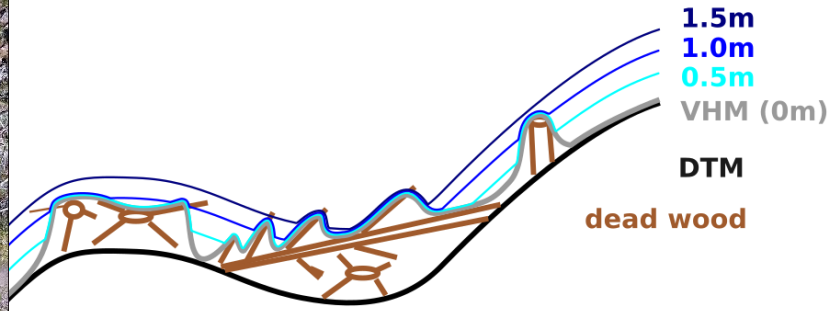
Which protective effect has a windthrow area, if „filled“ with snow?



Bührle et al. 2025

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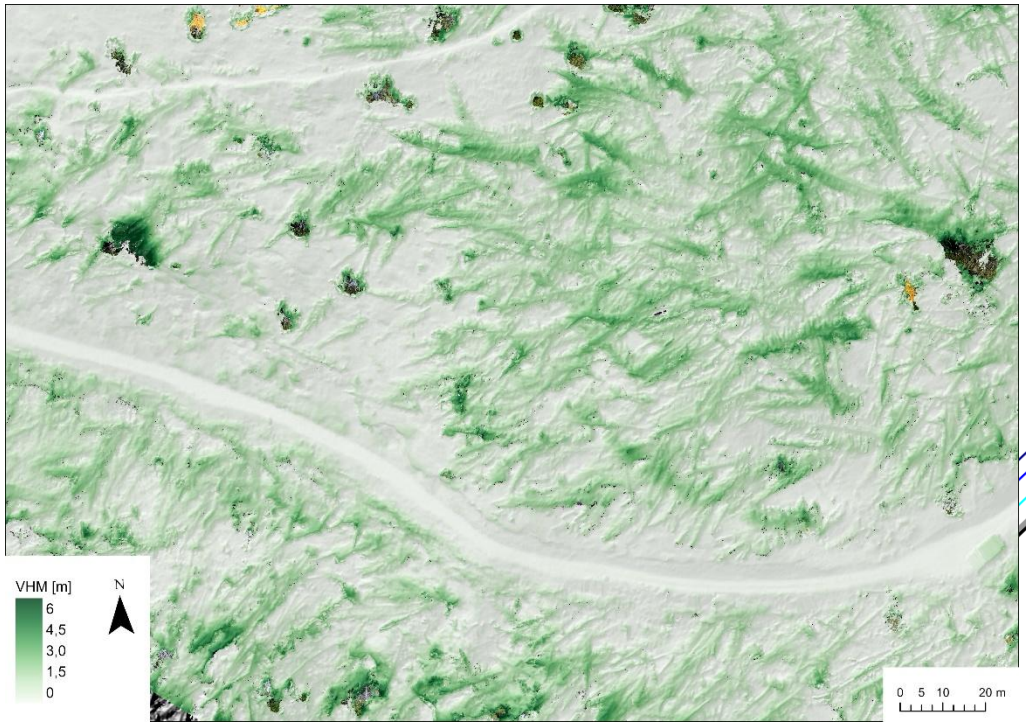
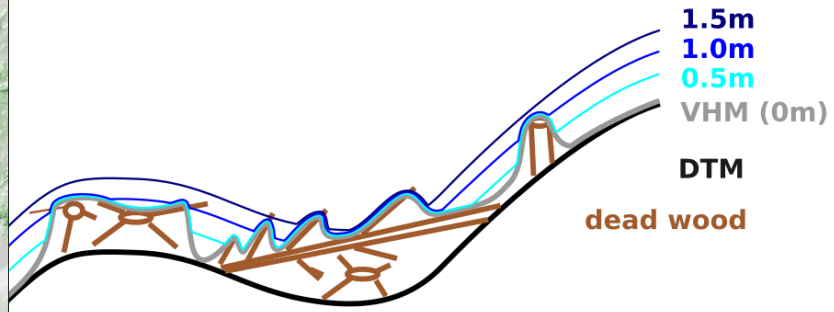


- Vegetation height model (VHM) from drone photogrammetry



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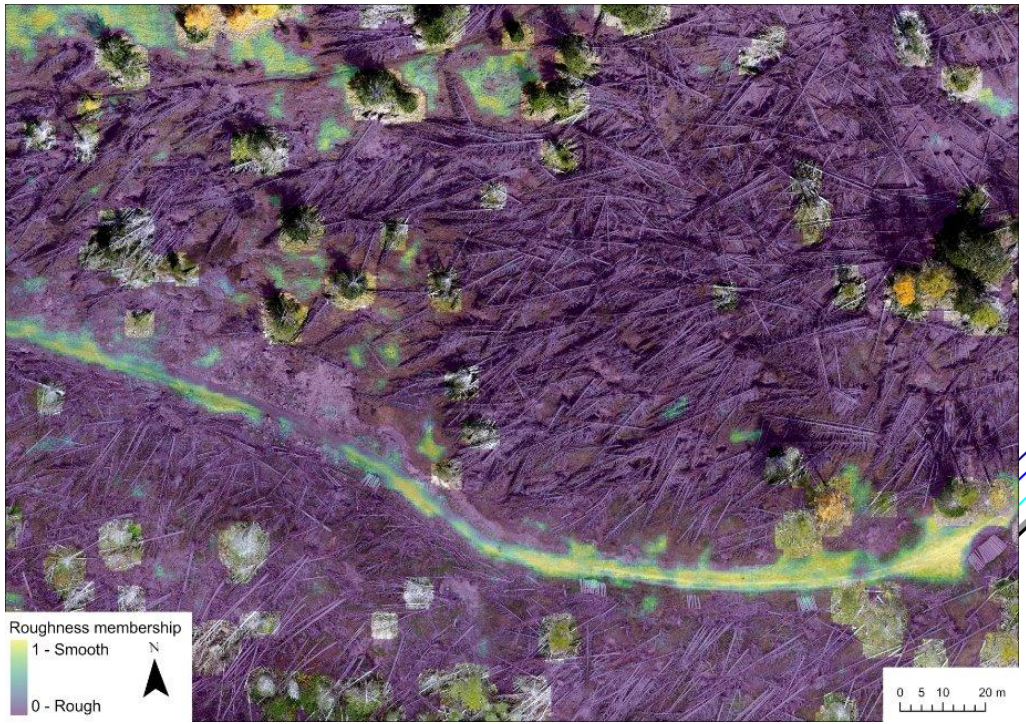
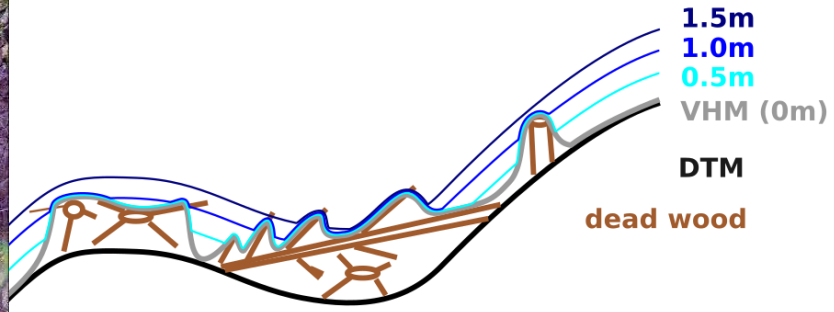


- Roughness membership (no snow)



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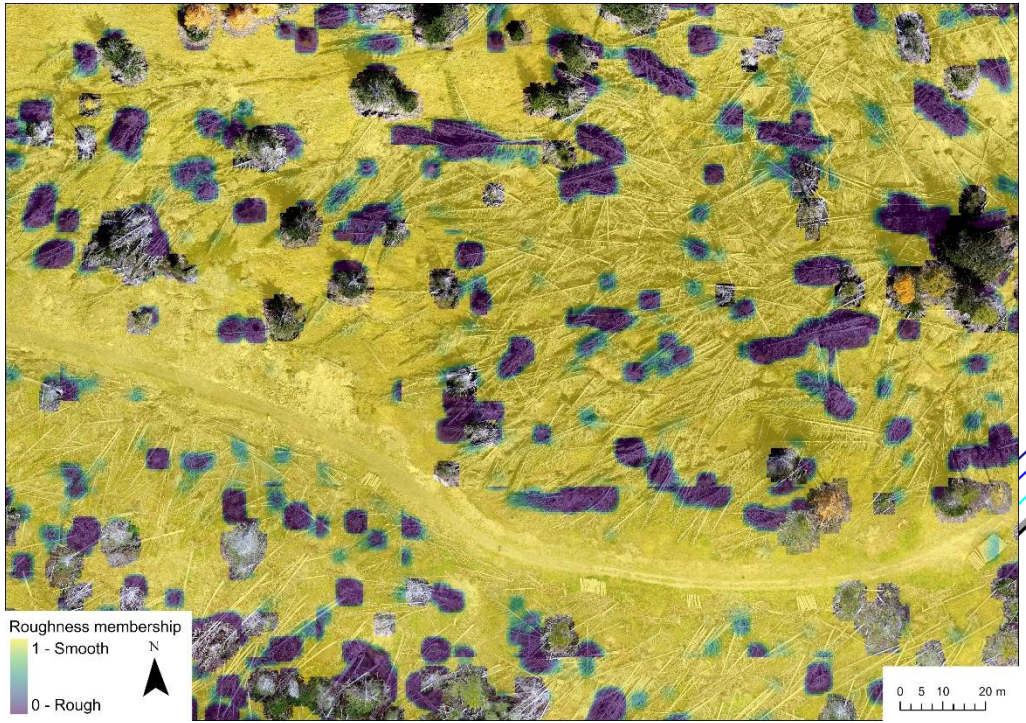
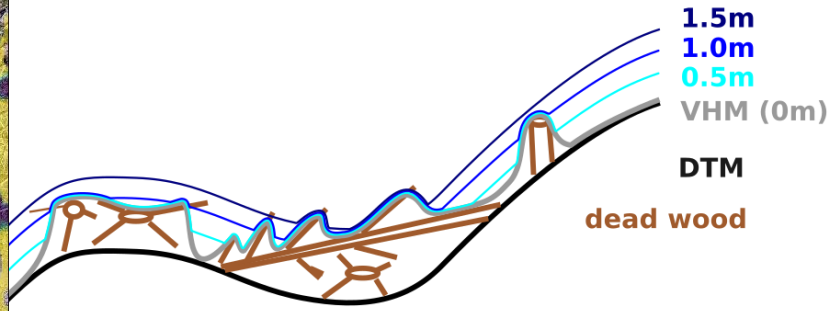


- Roughness membership (1,5 m snow depth ≈ 10-year return period)



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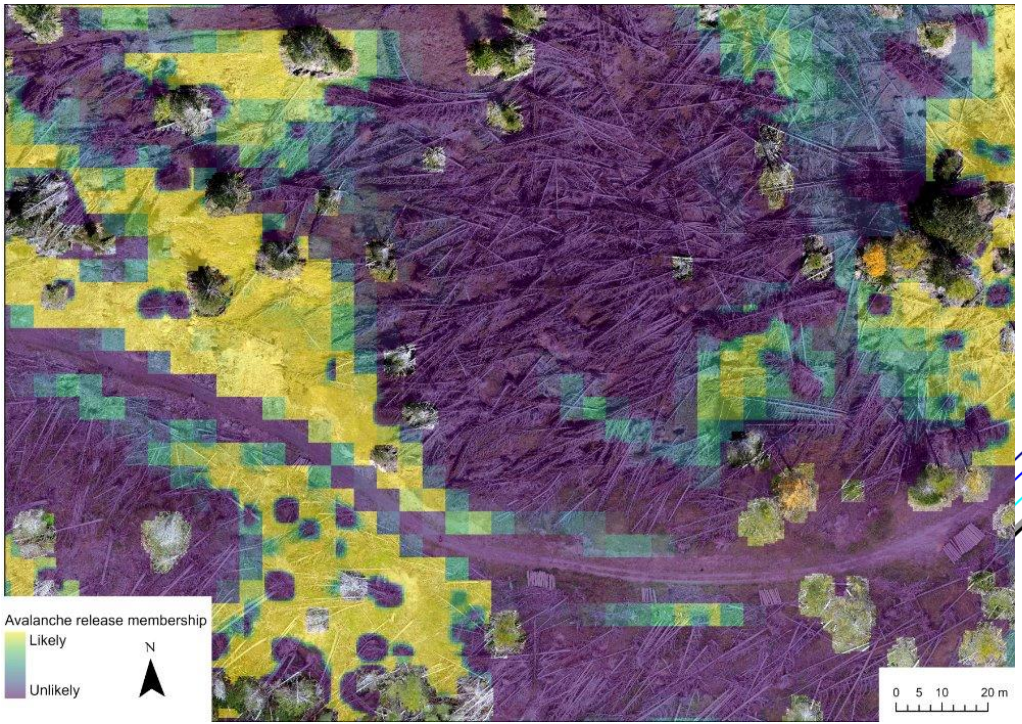
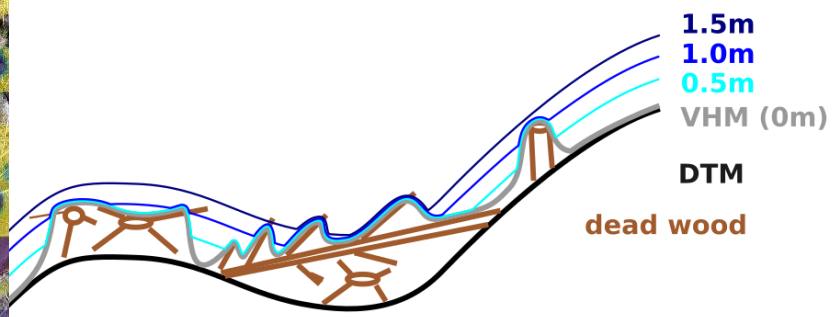


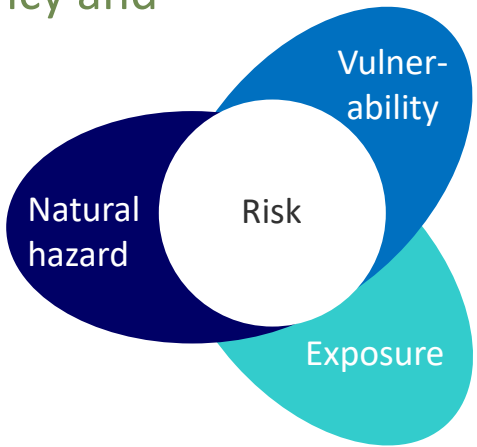
- Avalanche release membership / probability (1,5 m snow depth ≈ 10-year return period)



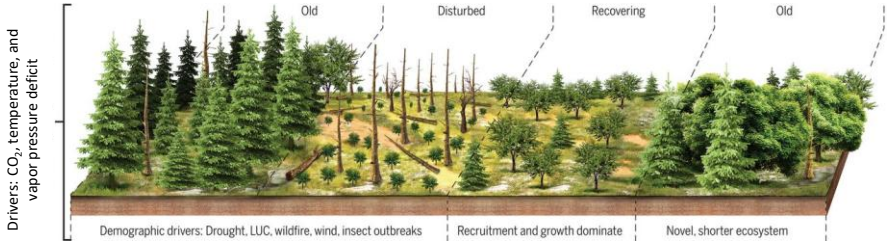
Bührle et al. 2025

Take home messages

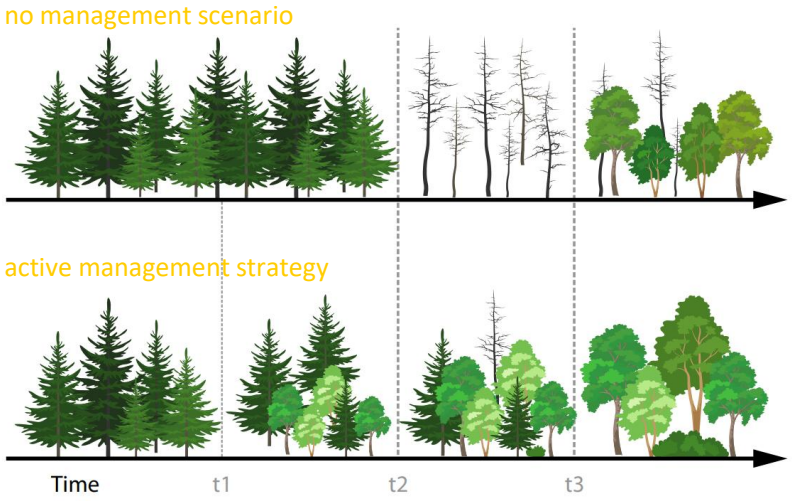
- forests change constantly
  - global change and especially disturbances determine and accelerate forest pathways
  - as do management decisions
- avalanche frequency and intensity change
- society changes



Conceptual diagram of the components of forest dynamics and the disturbances that drive them



Possible pathways of forest development under climate change



Figures: McDowell et al. 2020; Jandl et al., 2019

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Mountain protective forests under threat? an in-depth review of global change impacts on their protective effect against natural hazards

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Thank you for listening!

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